MINERAL REPORT 29

CANADIAN MINERALS YEARBOOK 1979

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Foreword

This issue of the Canadian Minerals Yearbook is a comprehensive report of developments in the mineral industry during 1979. In order to provide information as early as possible to all interested persons, the 49 chapters dealing with individual commodities and all other chapters were issued previously as Annual Mineral Reviews, 1979. 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, Mineral Policy Sector, Energy, Mines and Resources Canada, and by Statistics Canada, unless otherwise stated. Company data were obtained by the authors directly from company officials through 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, 1981

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Readers wishing more recent information than that contained in this volume should obtain the 1980 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 OS9. Prices subject to change without notice.

Front Cover:
Shrouded in early-morning mist, a wagon drill carries out exploratory drilling on property of United Keno Hill Mines Limited, an important lead-silver producer in the Mayo area of the Yukon. (George Hunter photo)

Front End-leaf:
Facilities of the Iron Ore Company of Canada present this busy scene at Labrador City, where ore from IOC's Carol Lake mines is concentrated and pelletized. (IOC photo by Jacques Bourdeau)

Frontispiece:
A red-hot steel slab moves toward the rollers of the plate leveller at the Steel Company of Canada Limited (Stelco) 148-inch plate mill in Hamilton, Ontario. The slab is headed away from the camera toward the leveller and cutting shear. (Stelco 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	.028 346 85

Source: Canadian Metric Practice Guide

General Review

L. TIBBO

Canada's economic performance in 1979, indeed over the last half of the 1970s, could not be considered invigorating. The year was characterized by strong increases in the inflation rate, interest rates reaching the highest levels seen in this century, continuing upward trends in oil prices, including a doubling over the course of the past year, and political instability in the Middle East, threatening future oil supplies and thus the economic prospects of all industrialized nations. Canada, as a net exporter of resource-based products, is heavily dependent on foreign markets and critically affected by the level of economic activity within her trading partners. With 25 per cent of Gross National Product (GNP) being generated by exports, the necessity for a healthy world-wide economy cannot be over-emphasized.

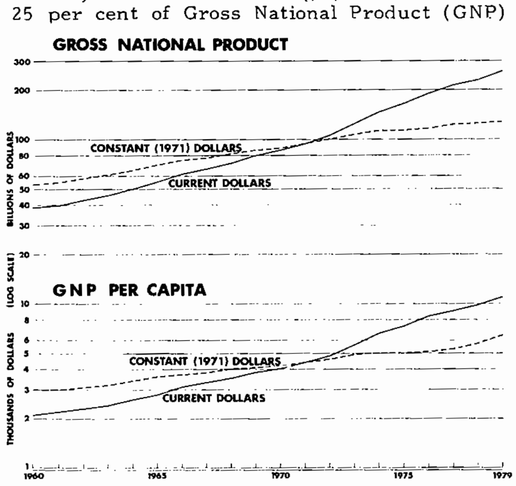


Figure 1

In Canada in 1979, the annual rate of growth of the GNP was 2.7 per cent, down from 3.4 per cent in 1978, 3.3 per cent in 1977 and 5.4 per cent in 1976. The first quarter of 1979 showed a rate of 1.6 per cent, dropping sharply in the second quarter to a negative rate of 0.6 per cent and improving slightly in the third and fourth quarters with rates of 1.3 per cent and 0.6 per cent respectively. The rate of inflation measured by the Consumer Price Index (1971=100) approached the double-digit mark late in the year at 9.5 per cent, up from 9.0 per cent the previous year, while the unemployment rate ranged between 7.5 and 8.5 per cent during the period compared with 8.4 per cent in 1978. One area where positive growth took place was the rise in employment. Approximately 10,368,000 persons were employed in 1979, up 4.0 per cent from the previous year.

These economic problems of rampant inflation and high unemployment were shared by the major industrial countries in the last half of the 70s. The United States, believed by some economists to have entered a recession in the last quarter of 1979, experienced its worst year since 1975. No country has been immune from the impact of price increases by OPEC and the cutback in the supply of oil from Iran, causing together a slowdown in world-wide activity. In the United Kingdom, consumer prices reached an annual rate of increase of 23 per cent in the last quarter of 1979, contributing to the erosion of Britain's competitive position abroad. Investment was sluggish and the balance of payments deficit on the current account approached \$U.S. 6.5 billion. West Germany experienced a very strong year compared with other nations, showing an increase in real GNP of 4.5 per cent. The inflation rate was maintained at around 4.0 per cent, but the current account deficit reached \$U.S. 6.0 billion compared with a surplus of approximately \$U.S. 9.0 billion the previous year. The effects of oil price increases were being felt, along with the high price of German exports on the world market. The annual rate of growth of the French economy reached 2.5 per cent but a slowdown in activity was apparent in the second half of the year. Accelerating prices over the year revealed an inflation rate of 10.5 per cent while the current account deficit reached \$U.S. 35 billion. Japan out-performed all other industrialized countries with a growth rate of some 6.0 per cent and a relatively low inflation rate. However, rising oil prices and a weakened worldwide demand for consumer products could have serious effects in the near future. The importance of economic health in the outside industrialized world is of great concern for the Canadian mineral industry since more than 60 per cent of its output is exported.

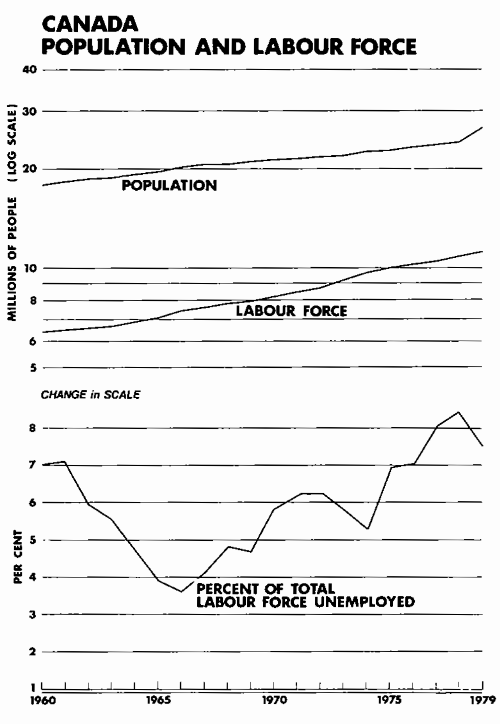


Figure 2

The performance of the Canadian mineral industry in 1979 was not representative of the economy as a whole. Both mining and mineral processing industries in Canada enjoyed one of the best years of the decade in terms of operating revenues and net profits, even though volume of output dropped for a number of major metals. The total value of mineral production reached an all-time high in 1979, exceeding \$26 billion. Table 1 compares value of mineral production for 1978 and 1979.

TABLE 1. CANADIAN MINERAL INDUSTRY, PRODUCTION, 1978 AND 1979

	1978	1979	Change
	(millions of current dollars)		
Metals	5,698	8,000	+40.4
Non-metals	1,478	1,833	+24.0
Structural Materials	1,508	1,737	+15.2
Fuels	11,577	14,529	+25.5
Total	20,261	26,098	+22.4

The value of metals increased 40.4 per cent from the previous year to \$8.0 billion. Mineral fuels showed a 25.5 per cent increase in value, reaching a high of \$14.5 billion. The value of the non-fuel mineral industry increased 33.4 per cent, from \$8.7 billion in 1978 to \$11.6 billion in 1979. Values of the leading mineral commodities were: crude oil, \$7.6 billion; natural gas, \$4.7 billion; iron ore, \$1.9 billion; copper, \$1.5 billion; natural gas byproducts, \$1.4 billion and zinc, \$1.1 billion. These numbers indicate general buoyancy in the major metal and non-metal markets.

Table 2 compares the average annual prices in Canadian funds of selected major metals from 1976 to 1979. Strong increases were exhibited in all cases.

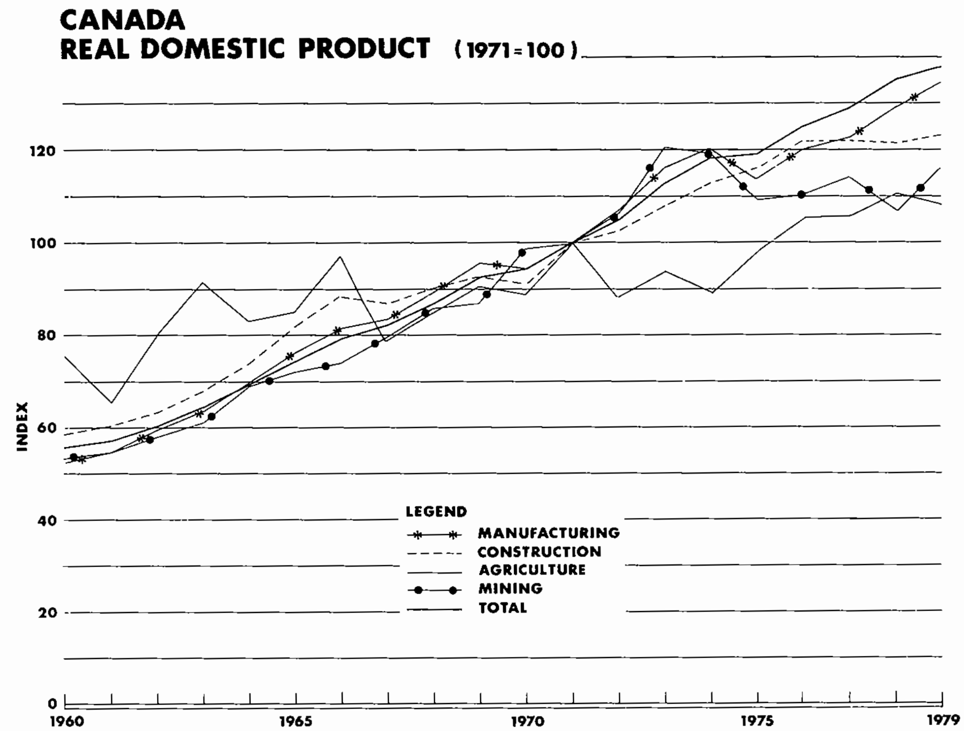


Figure 3

TABLE 2. AVERAGE ANNUAL PRICES OF SELECTED METALS IN CANADIAN FUNDS, 1976-79

	1976	1977	1978	1979
Copper, in matte (cents per pound)	65.87	67.01	74.34	107.55
Gold, London, p.m. (per troy ounce)	123.24	157.09	227.91	359.29
Lead (cents per pound)	22.65	31.48	36.82	59.92
Molybdenum, ore (per pound)	2.90	3.92	5.37	8.96
Nickel, metal (per pound)	2.22	2.45	2.47	3.17
Platinum (per troy ounce)	159.66	172.86	279.83	411.96
Silver (per troy ounce)	4.28	4.92	6.17	12.97
Zinc (cents per pound)	37.62	35.53	34.76	43.72

The copper market, once one of orderly change, was marked by price fluctuations never before experienced. With an eight-month strike that started in September 1978 at Inco Limited's Sudbury operation and a strike at the Gaspé Copper Mines, Limited operations of Noranda Mines Limited, inventories were drawn down and volume of production reduced in the first half of the year. This, combined with improved consumer demand, caused the price of copper to fluctuate over a wide range. The copper market used to be one of orderly price changes that came only three or four times a year and was even used by some analysts as a guide to industrial demand. However, the frequent price shifts in the past year reflecting unsettled domestic and international conditions and improvement in world consumption were beyond all speculation. From a level of \$Cdn. 0.86 a pound in January, by March the copper price had risen to a high of \$1.22 a pound. During the summer it stabilized to average approximately \$1.00 a pound, but in September it reached a record high of \$1.30 a pound for full-plate cathode. April, 1979 was the first month since 1974 that Canadian producer prices had averaged above \$1.00 a pound. Similar price patterns were seen on the New York Commodity Exchange and on the London Metal Exchange where the highest price levels since 1974 were recorded. The greatly increased earnings of copper producers improved substantially the prospects of new mine openings and capacity expansions.

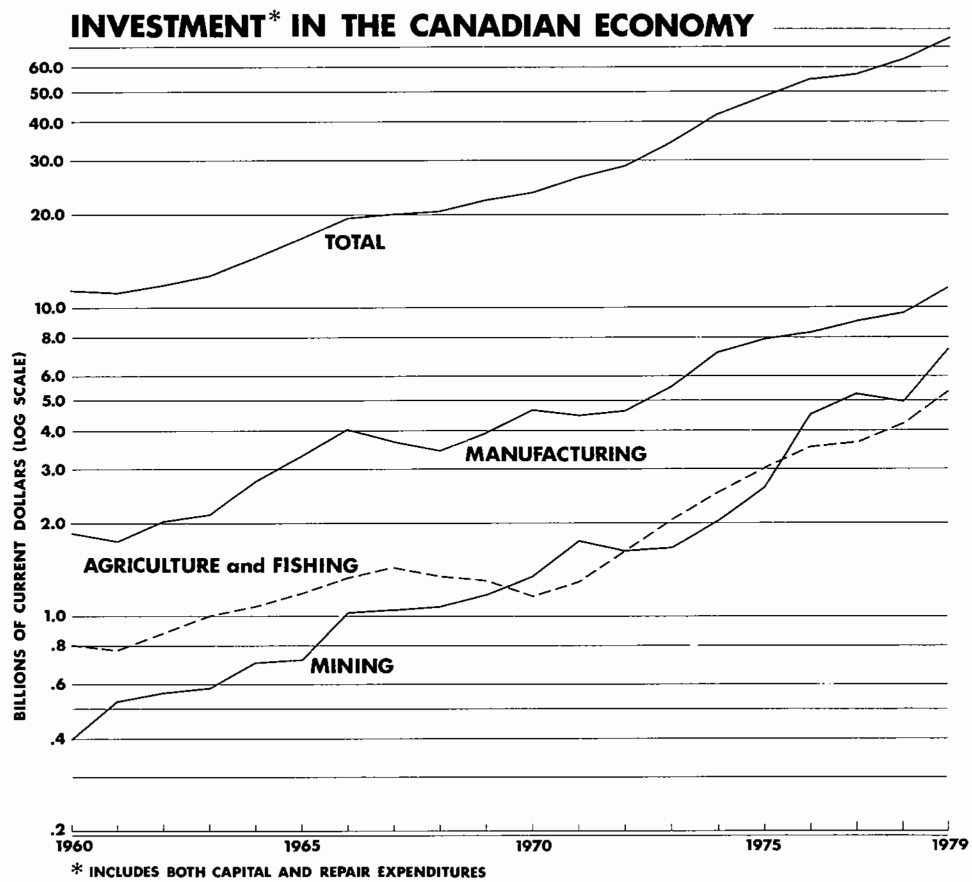


Figure 4

Price fluctuations and market volatility was most pronounced in the gold industry in 1979. Beyond all wildest predictions, the price of gold moved from a range of $U.S. 200.00-250.00 during 1978 to a high of $U.S. 445.50 in mid-December, 1979. Extreme fluctuations throughout the year led to a general feeling of uncertainty in money markets. In periods of distress, gold becomes attractive, given its ready acceptability and convertibility. The year was marked by climbing interest rates, reaching all-time highs of 13-14 per cent in September; along with a declining dollar (U.S. and Canadian) relative to the West German mark and other strong currencies. Combined with rising OPEC prices were rumours of demands for payments to OPEC countries in something other than U.S. dollars, putting further downward pressure on both Canadian and U.S. currencies.

All of these things encouraged the move away from paper currencies, thus providing the gold mining industry in Canada with a renewed vitality not felt for many years. The latter part of the year witnessed the reopening of mines long abandoned, expansion of existing mines and new exploration with an air of "gold fever". Uneconomic sites became profitable, especially given the advantage of the depressed Canadian dollar relative to the U.S. dollar. Producers enjoyed a fairly wide buffer between costs and revenues. Running a distant second to South Africa in free world production, Canada's volume decreased in 1979 by about nine per cent from 1978, but value increased during the period by 42 per cent. Gold prices reached a level whereby gold no longer could be considered a bonus by-product but could in itself generate new operations.

Following the trail of gold, other precious metals, including silver and platinum, showed substantial increases in the year. Silver production, while down 6 per cent, accounted for an 80 per cent increase in value. Platinum, although down 47 per cent in output, recorded only a 14 per cent decline in value. A large number of small investors, attracted by the inflation hedge aspect, boosted silver prices to more than double what they were in 1978.

The Inco strike at Sudbury caused repercussions not only in copper markets but in the nickel market as well. Canadian nickel production was at a low level of 131 579 tonnes in 1979 compared with 128 310 tonnes in 1978 but value of production increased 30 per cent over the period to $826.4 million. Inco Metal Company posted nickel prices for the first time since July 1977. With inventories at more "manageable" levels, most analysts agreed that 1979 record prices of over $3.00 a pound should hold.

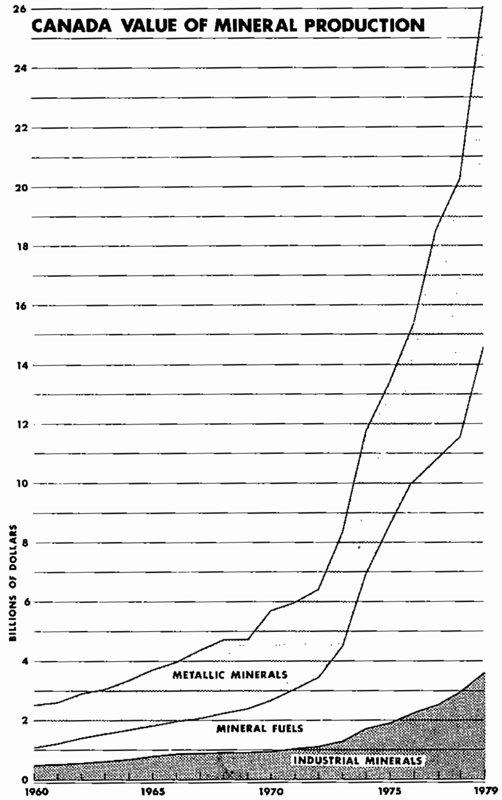
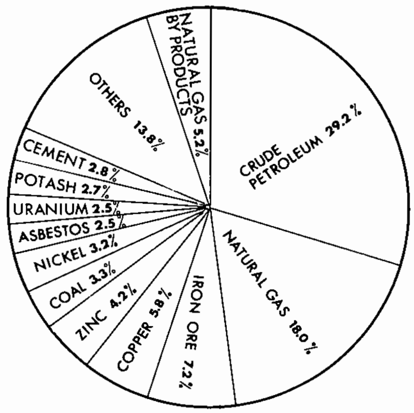


Figure 5

Record high price levels were experienced in lead, zinc and molybdenum as well. Tight market conditions along with increased world demand helped to dramatically improve the financial picture, particularly for lead and zinc. The picture was not quite so bright for iron ore, however. The industry recorded a strong increase in output of about 45 per cent over the year. Export sales hit record highs, given the exchange rate on the dollar, but the industry was still plagued by oversupply. Out of eight mines operating in Ontario up until two years previously, only four were left in 1979. Competition with U.S. producers, along

CANADA MINERAL PRODUCTION, 1979



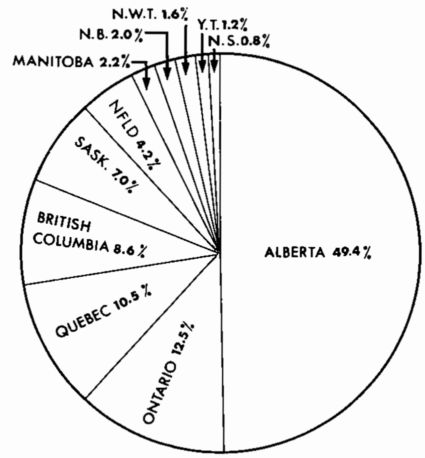


Figure 6

with high costs, forced small producers to close down and larger operators to defer any exploration or expansion plans.

Major non-metallic mineral industries enjoyed substantial increases in output, sales and exports in 1979. Production of potash reached 7 million tonnes (K_2O), up from 6.3 million tonnes in 1978, while value increased 37.8 per cent. Potash Corporation of Saskatchewan (PCS) announced a 10-year expansion plan which will increase production to almost 12 million tonnes from its current 3.5 million tonnes at an estimated cost of $2.5 billion. The plan is based on forecasts of strong growth in world demand for fertilizers.

CANADA, MINERAL TRADE

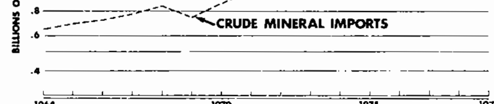


Figure 7

The value of asbestos output increased significantly in 1979 to $641 million from $532 million in 1978. The Quebec government continued expropriation plans for the take-over of Asbestos Corporation Limited, by far the largest producer in Canada. The industry continued to be subjected to pressure from many lobby groups in Canada and around the world pressing for more stringent safety and health standards. Regulations are now being considered in the United States that could restrict the use of certain fibres and asbestos-based products, making the future for the industry somewhat unknown.

Strong increases in value of output were recorded by the fuel industries. Coal, natural gas and crude oil showed increases of 10.1 per cent, 20.0 per cent and 31.0 per cent respectively with slightly smaller accompanying increases in volume. The three commodities represented 50.0 per cent of the value of Canadian mineral production in 1979 compared with 52.2 per cent the previous year. Generally speaking, most major minerals experienced a good year.

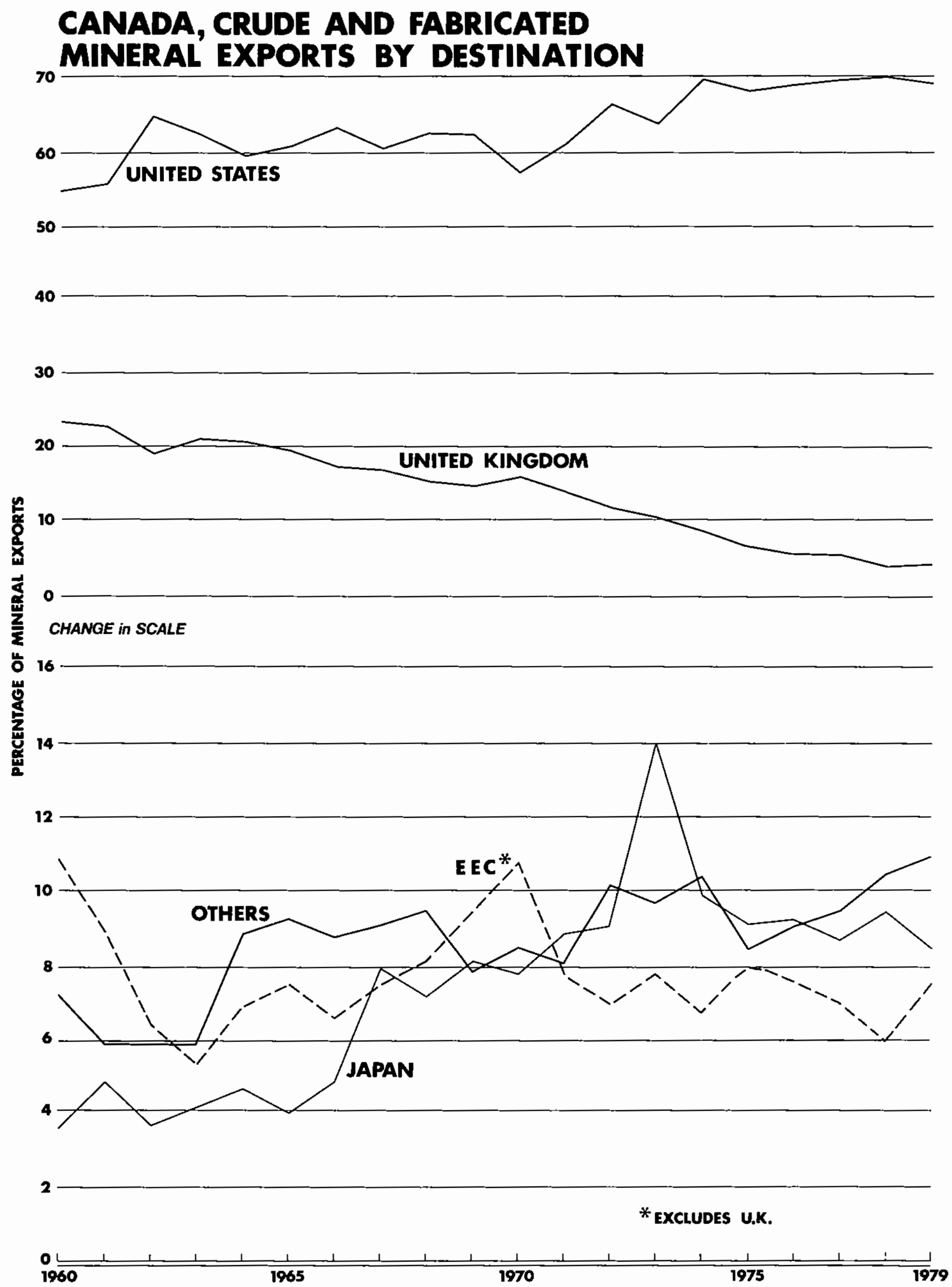

CANADA, CRUDE AND FABRICATED
MINERAL EXPORTS BY DESTINATION
PERCENTAGE OF MINERAL EXPORTS
UNITED STATES
UNITED KINGDOM
CHANGE in SCALE
EEC*
OTHERS
JAPAN
*EXCLUDES U.K.
70
60
50
40
30
20
10
0
16
14
12
10
8
6
4
2
0
1960
1965
1970
1975
1979

Figure 8

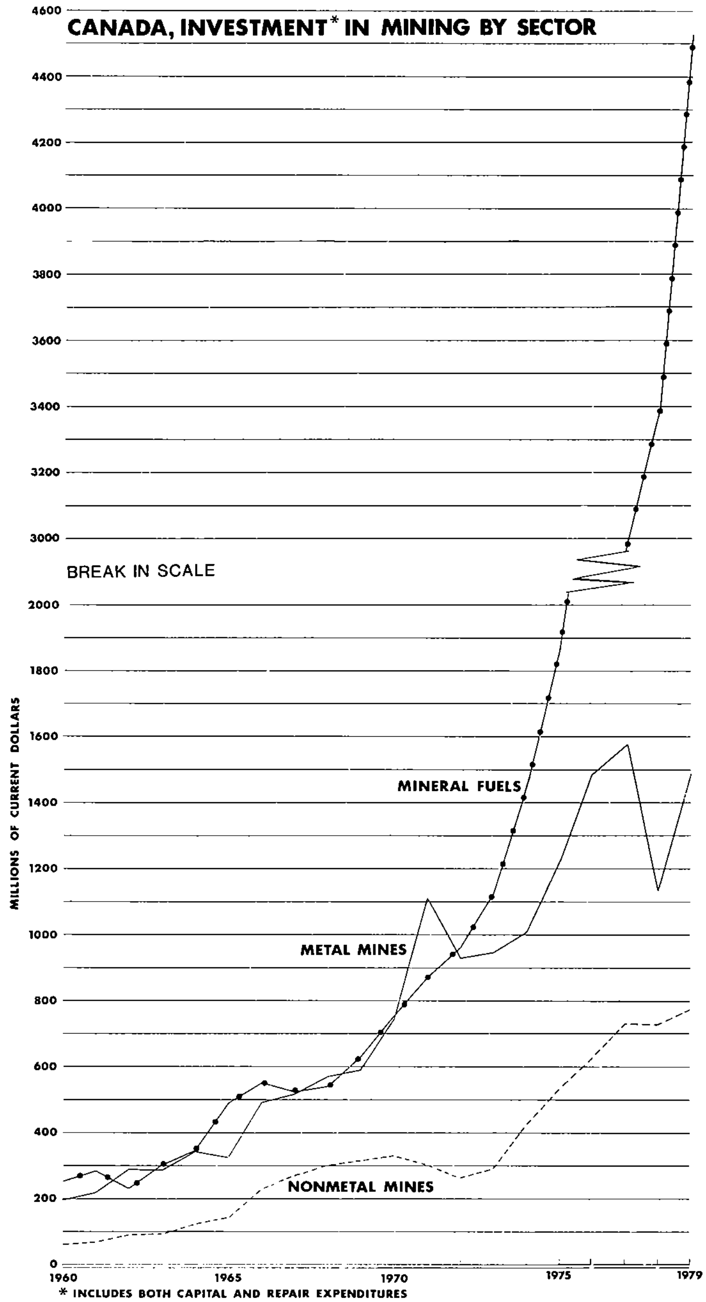

CANADA, INVESTMENT* IN MINING BY SECTOR
MILLIONS OF CURRENT DOLLARS
BREAK IN SCALE
MINERAL FUELS
METAL MINES
NONMETAL MINES
0
200
400
600
800
1000
1200
1400
1600
1800
2000
3000
3200
3400
3600
3800
4000
4200
4400
4600
1960
1965
1970
1975
1979
* INCLUDES BOTH CAPITAL AND REPAIR EXPENDITURES

Figure 9

World demand and a depreciated Canadian dollar relative to other currencies contributed to an increase in volume and value of mineral exports. Canada is the leading world exporter of non-fuel minerals. More than 60 per cent of the industry's output was exported in 1979 which accounted for approximately 17 per cent of the nation's total merchandise trade. The main markets were the industrial nations that comprise the Organization for Economic Cooperation and Development (OECD). In 1979, 68.8 per cent of total crude and fabricated minerals exports were sent to the United States, 4.3 per cent to the United Kingdom, 7.6 per cent to the EEC and 8.4 per cent to Japan. In the past 15 years, Canadian non-fuel mineral exports as a percentage of U.S. mineral imports has ranged from 30 to 35 per cent. Canada's share of the EEC market has ranged from 2.5 to 3 per cent over the same period, while approximately a 10 per cent share of the Japanese market has been maintained. The United States imports close to 95 per cent of its asbestos and potash from Canada as well as 75 per cent of its gypsum and almost 50 per cent of its iron ore.

Total value of crude and fabricated non-fuel exports reached $11.5 billion in 1979, up from $9.1 billion in 1978. Value of fuel exports reached $8.4 billion compared with 5.7 billion the previous year.

On the import side, total value of crude and fabricated non-fuel minerals reached $6.0 billion while fuels totalled $5.8 billion. The overall total for 1979 was $11.8 billion, up from $8.1 billion in 1978. In order to continue to meet these import requirements, a healthy resource base would have to be maintained through increased exploration and development.

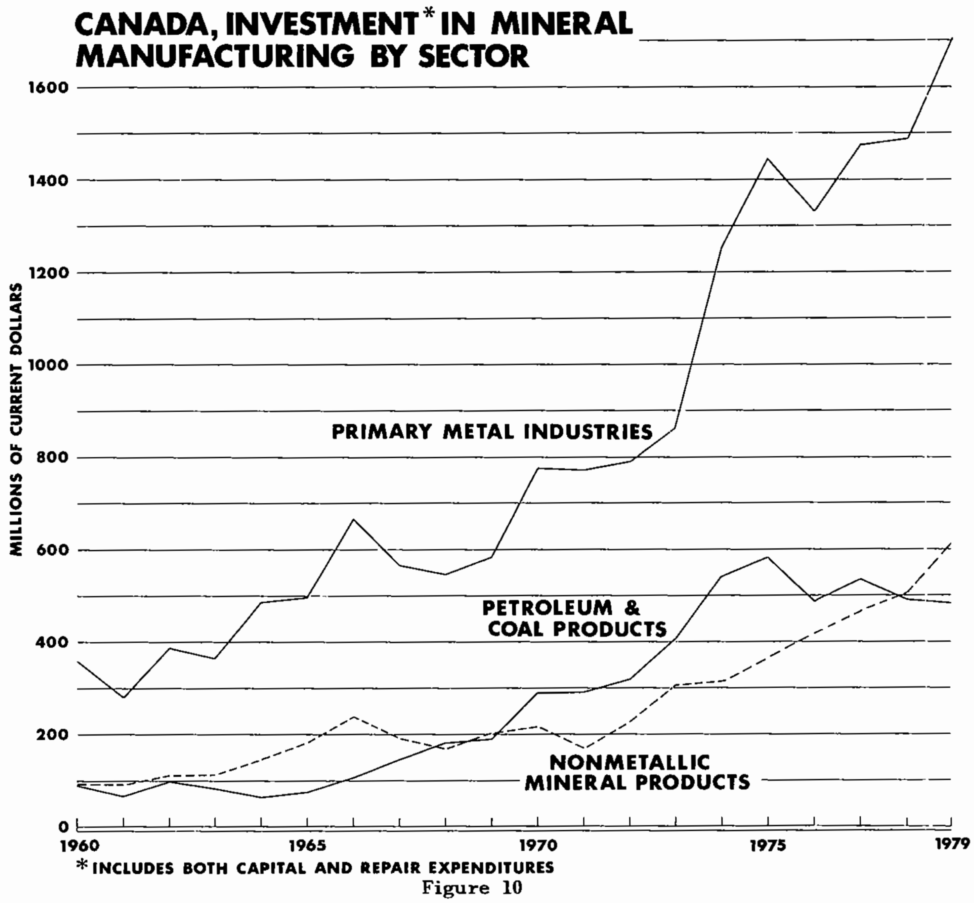


Figure 10

Total investment in the mining and mineral manufacturing sectors approached $10 billion in 1979, up from $7.7 billion last year. Investment in non-fuel industries totalled $3.6 billion. Vastly improved profits in the non-fuel sector in 1979 have led firms to undertake major expansions and new developments. Projected levels of capital spending by Canadian mines, buoyed by renewed faith in sustained higher prices for the 1980s, have reached $18 to $20 billion for the foreseeable future. Announcements appeared throughout the year of billion dollar expenditures on new developments.

Teck Corporation plans to bring its copper-molybdenum Highmont mine on stream by the end of 1980, producing 3 000 tonnes of molybdenum and 20 000-22 500 tonnes of copper per year and employing between 350 and 375 people. Noranda Mines Limited and Pamour Porcupine Mines Limited have agreed to spend $4.5 million to bring the Discovery Mines Limited and Camlaren Mines, Limited gold property into production in short order. Asbestos Corporation says it will invest $122 million by 1984 to expand mines and modernize equipment to increase production by 10 per cent. Cominco Ltd. will proceed immediately to bring its Arvik lead-zinc mine into production at a cost of $150 million, with production to begin in early 1982 and continue for 20 years. A joint venture of Noranda Mines Limited and MacDonald Mines Ltd. has announced spending plans of $5.5 million to prepare a zinc property in the Rouyn-Noranda area of Quebec to begin production in mid-1981 and create 50 to 60 jobs.

These plans have been made in a mood of cautious optimism. If recession, already apparent in the U.S., deepens, the possibility of cutbacks in imports exists, severely affecting mineral export growth. Canada is endowed with a strong resource base but growth and development is heavily dependent on growth in the industrial countries. The mineral industry is operating in a confusing environment where consumer demand for minerals is high while the outlook for the economy as a whole is bleak. Barring the possibility of a major recession throughout the industrialized world, prospects for the continued growth of the Canadian mineral industry are promising. A very important factor in determining the level of that growth will be the energy price situation.

Regional Review, Canadian Mineral Industry

P.W. ANDREWS

The value of mineral production rose strongly in all but one of Canada's provinces and territories in 1979. For the country, it reached an all-time high of $26.1 billion, an increase of 28.7 per cent over the previous year, without allowing for inflation.

While the value of output for most minerals increased in nearly all provinces and territories, the rise was due mainly to higher prices. Real growth was small or nonexistent, and for copper, gold, silver, lead, molybdenum, platinum metals and uranium, output in physical terms fell in most regions.

Figure 1 demonstrates how the distribution of mineral production in the various provinces and regions has changed over the previous 20 years. As total output has increased - from $2.5 billion in 1960 to $26.1 billion in 1979 - Quebec, Ontario and Alberta have remained responsible for about 70 per cent of it, although the emphasis has shifted between the three provinces. Alberta's share has risen from about 16 per cent to 49 per cent, while Ontario and Quebec's shares have fallen from 39 per cent and 19 per cent to 13 per cent and 8 per cent, respectively. In comparison, the shares of the other regions have not varied greatly over the two decades.

PROVINCIAL MINERAL ACTIVITIES

Newfoundland. Newfoundland's mineral production exceeded $1.1 billion in 1979. Most of the increase of 67 per cent over 1978 was from iron ore, up 61 per cent in volume and 71 per cent in value largely due to a labour dispute that affected the Labrador mines for several months in 1978.

Exploration activity in the province remained high in 1979, as it had the year before when about 9,000 claims were staked. The previous annual staking record had been about 2,500 claims. This activity was due in part to the large amount of basic geoscientific work being done by the province's Department of Mines and Energy under combined federal-provincial funding. Newfoundland has also opened to claim-staking large areas formerly held under long-term concession.

Production is planned in 1982 for the Brinco Limited-Urangesellschaft Canada Limited, Kitts-Michelin uranium deposits in east-central Labrador if permission to open the mine is obtained. Hearings to this effect took place before an environmental assessment committee late in 1979. Eventual output of about 600 000 kilograms (kg) of U_3O_8 a year is expected.*

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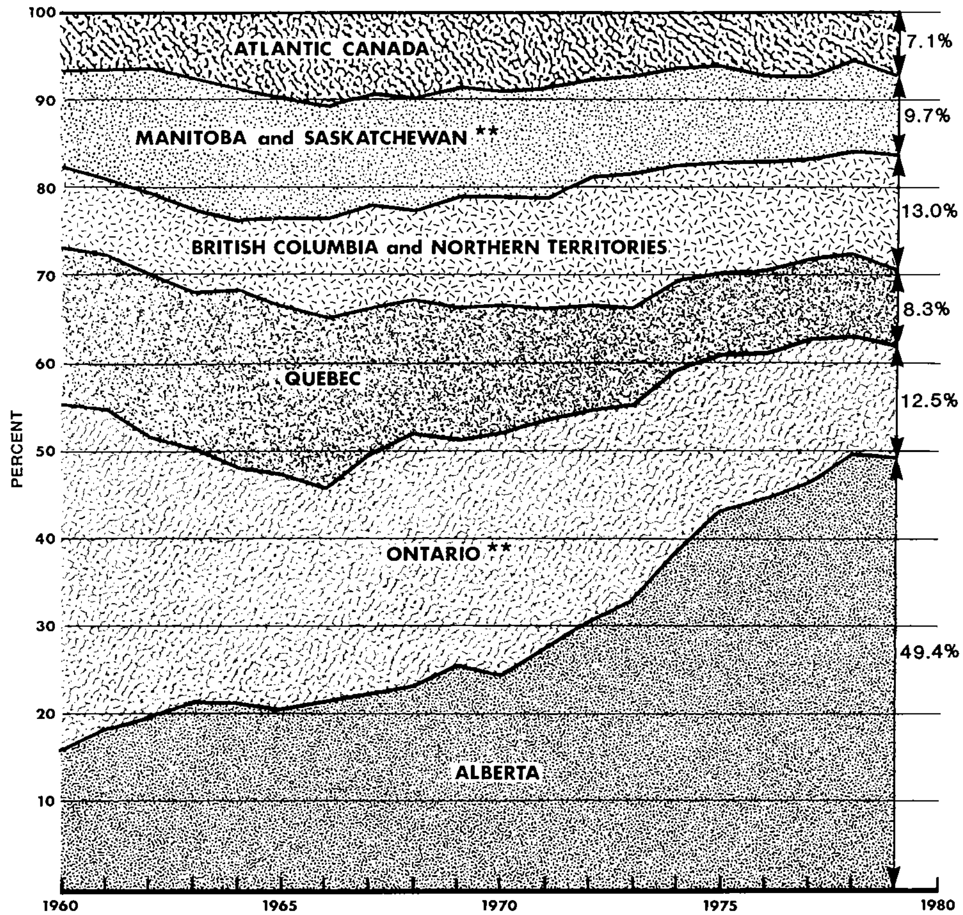
* Plans for the Kitts-Michelin deposits were shelved when the Government of Newfoundland accepted the recommendations of the Board of Assessment, which found that Brinco had not demonstrated that waste from the operation could be disposed of with complete safety and recommended that mining of the deposits not be permitted until such time as the company could so demonstrate.

PROPORTIONAL SHARE OF MINERAL PRODUCTION BY PROVINCE AND REGION, 1960-1979*



**Based upon current dollar production data reported by Statistics Canada*
***Does not include uranium prior to 1977*

Westfield Minerals Limited continued its program of exploration in the Deer Lake area. The company spent close to $1 million in 1979 stripping, trenching and diamond drilling in the search for the source of very high-grade, uranium-bearing boulders.

Layoffs continued during 1979 at ASARCO Incorporated's Buchan mine as the operation was seen to be approaching the end of its life. About 300 people were still employed at year-end, compared with 1,000 people when the mine was operating at full capacity. Exploration continues in the Buchans area, and about 60 jobs may result if a planned operation to recover barite from tailings goes ahead.

Nova Scotia. A sharp drop of half a million tonnes (t), worth $20 million, in the province's coal output, caused Nova Scotia to be the only province not to record an increase in total production value in 1979. However, this decline will likely be reversed with the opening of new properties in the near future. In addition, exploration activity continued at a high level, with uranium, base metals and tin receiving much attention.

The new Gays River zinc-lead mine of Canada Wide Mines Ltd., a subsidiary of Esso Minerals Canada, located 50 kilometres (km) northeast of Halifax, began producing in November and is expected to employ 150 people when it reaches full capacity early in 1980. The concentrator has a rated capacity of 1 360 tpd and ore reserves are estimated at 11 million t averaging approximately 7 per cent combined zinc-lead at a ratio of about 2:1. The $27 million operation has been designed for an annual production of 12 000 t of lead and 18 000 t of zinc in concentrate.

The Yava Mines Limited lead deposit of Barymin Explorations Limited on Cape Breton Island has been successfully brought into production with a mill capacity of 540 tpd of ore. Plans are to mine the higher grade (5.42 per cent lead) section containing 1 120 000 t of ore, which is sufficient for six years of production. Another section of the deposit is known to contain an additional 16 800 000 t averaging 3.44 per cent. Planned back-filling procedures will permit recovery of 90 per cent of the ore in place.

In 1979 the Nova Scotia Department of Mines issued 1,722 mineral exploration licences. In total 73,673 claims were filed, covering 1.2 million hectares, (2.9 million acres). Exploration expenditures amounted to about $5 million.

In the energy field, the Nova Scotia government announced a new $1.2 billion policy that would go a long way to replace imported oil with coal in electrical power generation by 1988. It has started with $22 million being assigned for a new coal mine off Donkin, and the first of a possible four 150-megawatt, coal-fired electrical generating units at Lingan in Cape Breton which went into service late in 1979. Another $540 million has been earmarked for new generating plants, and completion of a second unit is expected in 1980. Further work under the program calls for an experimental fluidized-bed combustion unit and creation of a regional power pool.

The worst mining disaster in 20 years took place February 24, 1979 at the No. 26 colliery of Cape Breton Development Corporation (Devco) when 11 miners were killed and 5 others seriously injured. A special investigation team concluded that methane gas and coal dust were ignited by a spark from a shearing machine.

New Brunswick. Higher prices were almost entirely responsible for the 41 per cent increase in the value of New Brunswick's mineral output in 1979 compared with 1978. Copper production, for example, rose in volume by 306 t to 10 640 t, but in value by $10.6 million to $27.6 million. The situation was similar for lead and for silver; however, physical output of the province's leading mineral, zinc, increased 5 per cent, with a 32 per cent increase in value.

There was an increase in uranium exploration during the year, with more than 20 companies active following the discovery of uranium minerals associated with the host rock in the antimony mine of Consolidated Durham Mines & Resources Limited, west of Fredericton. While first underground sampling has indicated less-than-encouraging grade of 0.20 to 0.27 per cent uranium oxide, this is still higher than at some producing mines.

The Sullivan Mining Group Ltd. and Billiton Exploration Canada Limited have agreed to develop the Mount Pleasant tungsten-molybdenum deposit at a cost estimated at $80 million. A 2 000 tpd concentrator will process 650 000 tpy of ore to produce approximately 600 t of molybdenum concentrate and 1 800 t of tungsten concentrate. This mine will be the second in Canada to produce tungsten concentrate when production begins in 1981.

The St. Lawrence Cement Company is proceeding with plans to strip-mine coal at 100 000 tpy from the Lake Stream deposit, held jointly with the government-owned Provincial Holdings Ltd., to supply fuel for its cement-producing operations in Quebec.

Noranda Mines Limited announced that it had acquired Heath Steele Mines Limited from AMAX Inc. which effectively gives Noranda control over zinc-lead-copper mining in the province.

Potash Company of America will have invested about $105 million in its potash mine near Sussex before production begins late in 1981 or early in 1982. The operation will employ about 300 people.

International Minerals & Chemical Corporation (Canada) Limited, Toronto, has sold the mining rights to a potash and salt property near Salt Springs to Denison Mines Limited. If this company decides to put the property into production, about 600 people will be employed in the development and construction phase, and about 400 permanent jobs will be created.

Quebec. The mineral industry in Quebec had a good year in 1979, with the value of total production rising 20 per cent over 1978. However, much of this increase was accounted for by a record output of iron ore, up 50 per cent in volume and 61 per cent in value from the strike-affected previous year. Production of copper, gold and silver was down, although the value of output of each metal was up.

The rise in the price of gold and other metals was responsible for several new mines coming on stream, including several gold mines in the Val d'Or-Malartic area. Excess milling capacity that had existed in the region for several years was largely used up in 1979. In the Gaspé, the copper mine of Madeleine Mines Ltd. reopened at a rated capacity of 2 300 tpd; concentrate is being trucked to Gaspé Copper Mines, Limited's Murdochville smelter. The Louvicourt zinc mine also reopened, and the go-ahead was given for the $80 million Detour copper mine and mill in northwestern Quebec. One mine closing was recorded, the Manitou-Barvue zinc mine of Louvem Mining Company Inc.

Another important factor in the upsurge in mining in Quebec was the five-year, $65 million support program for the mining industry initiated by the Quebec government in the fiscal year 1977-78. Through this program mining roads have been constructed and geoscientific data have been gathered and disseminated. The government has also provided funds for direct assistance to mining companies for the development of mining properties.

New rules were adopted by the Quebec Securities and Exchange Commission for the listing of junior mining company shares. These rules represent an important improvement over the previous situation where listing of junior mining and exploration companies on the Montreal Stock Exchange had been severely restricted by the Commission.

Little was resolved in 1979 in the on-going dispute between the Asbestos Corporation Limited and the Quebec government. The government had hoped to expropriate the Asbestos Corporation before the end of the year, but the company and its parent, General Dynamics Corporation of St. Louis, Missouri, won a court injunction from the Quebec Court of Appeals in December, preventing this from taking place. More court action is expected in 1980.

Ontario. While the value of output of Ontario's mineral industry was up by one-fifth in 1979 compared with 1978, the effects of the labour dispute at Sudbury during the first five months of the year were evident. Physical output of copper, gold, silver, platinum metals and iron ore was lower than the previous year: nickel, zinc and uranium output was about the same; each commodity showed a substantial increase in value.

There was a notable increase in exploration and development activity across the province. A staking rush took place at Kirkland Lake in September with the release of results of an airborne geophysical survey, financed jointly by the federal government and the province. Inco Limited (Inco) obtained a five-year exploration licence to 259 km^2 of ground north of Sudbury that will probably require a program of deep diamond drilling, in return for pledging to spend $500,000 annually.

Surface and underground development programs were under way at the end of the year on both old and new properties; for example, at the old Echo Township property of Goldlund Mines Limited near Dryden that dates from the 1940s, and at the new Owl Creek gold deposit discovered recently close to Texasgulf Canada Ltd.'s Kidd Creek mine, where an incline is being driven to explore the property.

Past producers being reactivated include the Renabie gold mine, 310 km northwest of Sudbury, which closed in 1970, and the old Panel mine at Elliot Lake, which Rio Algom Limited dewatered, recovering 21 000 kg of U_3O_8 in the process. The company also plans to bring the Stanleigh mine into production in 1983. At Bancroft, Rare Earth Resources Limited intends to produce from several small properties.

Two long-established iron mines closed in 1979. At Atikokan, Steep Rock Iron Mines Limited laid off 463 people, closing an operation that had been brought on stream during World War II. The National Steel

TABLE 1. CANADA, PROVINCES AND TERRITORIES, LEADING MINERALS, 1979

	Value of production ($ million)	Proportion of total mineral production (%)	Change from 1978 (%)
Newfoundland			
Iron ore	963.9	85.7	70.9
Zinc	50.5	4.5	38.3
Asbestos	36.2	3.2	97.2
Copper	19.5	1.7	2.8
Total mineral production	1,124.5	100.0	66.6
Prince Edward Island			
Sand and gravel	2.0	100.0	-3.6
Total mineral production	2.0	100.0	-3.6
Nova Scotia			
Coal	99.7	47.6	-17.4
Gypsum	26.4	12.6	7.1
Salt	23.1	11.0	16.4
Total mineral production	209.6	100.0	-0.5
New Brunswick			
Zinc	206.1	43.0	31.7
Lead	96.2	20.1	63.1
Silver	78.1	16.3	96.2
Copper	27.6	5.8	62.3
Total mineral production	479.6	100.0	41.2
Quebec			
Iron ore	543.3	25.1	61.0
Asbestos	505.7	23.4	14.9
Copper	185.1	8.6	28.3
Stone	190.2	8.8	-6.8
Total mineral production	2,165.0	100.0	20.5
Ontario			
Nickel	566.3	17.4	19.3
Copper	457.5	14.0	41.2
Uranium	375.8	11.5	3.3
Iron ore	287.2	8.8	-6.9
Total mineral production	3,264.5	100.0	21.0
Manitoba			
Nickel	262.3	40.0	63.1
Copper	138.2	21.2	39.6
Petroleum	48.4	7.4	5.4
Cement	45.3	7.0	31.8
Total mineral production	652.7	100.0	42.0

TABLE 1. (Cont'd.)

	Value of production ($ million)	Proportion of total mineral production (%)	Change from 1978 (%)
Saskatchewan			
Potash	735.2	39.2	45.7
Petroleum	729.0	38.9	5.6
Uranium	240.4	12.8	-5.3
Total mineral production	1,873.8	100.0	18.4
Alberta			
Petroleum	6,486.9	50.3	31.2
Natural gas	4,418.9	34.3	23.1
Natural gas byproducts	1,408.3	10.9	36.3
Coal	238.2	1.9	-7.3
Total mineral production	12,889.1	100.0	27.8
British Columbia			
Copper	645.3	24.1	43.4
Coal	488.1	18.2	30.4
Natural gas	348.8	13.0	30.8
Molybdenum	321.2	12.0	91.5
Total mineral production	2,676.8	100.0	42.2
Yukon Territory			
Zinc	109.5	36.6	47.8
Lead	103.4	34.5	60.7
Silver	54.2	18.1	90.5
Total mineral production	299.2	100.0	36.8
Northwest Territories			
Zinc	205.6	47.3	42.9
Lead	80.1	18.4	40.8
Gold	61.9	14.2	35.2
Total mineral production	435.0	100.0	40.5
Canada			
Petroleum	7,451.9	28.6	28.2
Natural gas	4,855.8	18.6	23.8
Iron ore	1,807.4	6.9	48.0
Copper	1,511.2	5.8	39.4
Natural gas byproducts	1,449.0	5.6	36.2
Zinc	1,060.1	4.1	29.7
Nickel	828.6	3.2	30.4
Potash	653.9	2.5	14.2
Cement	735.2	2.8	45.7
Uranium	616.2	2.4	-0.2
Total mineral production	26,081.4	100.0	28.7

Source: Energy, Mines and Resources Canada.

Corporation of Canada, Limited closed its Moose Mountain mine at Capreol in June and 260 jobs were affected. In November 1979, Caland Ore Company Limited of Atikokan laid off 185 of its 450-man workforce. Kerr Addison Mines Limited is in process of closing its Agnew Lake uranium property, near Espanola, with about 435 workers affected. More than 2.1 million man-days were lost in the strike at Inco, which started September 15, 1978 and ended June 5, 1979, establishing a Canadian record.

In Ontario, the April budget dropped the marginal mining tax rate from 40 per cent to 30 per cent, raised the basic exemption from $100,000 to $250,000 and introduced the Small Business Development Corporation Act under which the province may make a direct payment to a small company of up to 30 per cent of equity to finance various activities, including mineral exploration and development. The Ontario Geological Survey completed publication of its 1:250,000 scale mineral potential map series and set up a Northern Industrial Minerals Study on talc-magnetite and asbestos deposits of the Timmins-Kirkland Lake area.

In December a development agreement for southeastern Ontario was signed by the federal government and the province. Under the $50 million agreement, $4 million was earmarked for geoscientific work.

Manitoba. The mining industry in Manitoba had been sluggish in 1978; mineral production had declined 18 per cent from 1977, mainly because of a large drop in nickel output and a lesser decrease in the production of zinc. These minerals and copper normally account for about three-quarters of Manitoba's mineral production.

There was some improvement in 1979. Value of nickel output rose 63 per cent to $262 million, actual production was up 10 per cent. Total provincial mineral production was $653 million, about $90 million ahead of the 1977 level.

The upturn in mineral exploration that began in 1978 continued in 1979 with increased staking and drilling. The major companies in Manitoba - Inco, Hudson Bay Mining and Smelting Co., Limited and Sherritt Gordon Mines Limited - mounted increased exploration programs. Many others were also active, with base metals, uranium and gold receiving the lion's share of attention.

Development activity that took place during 1979 included the start-up in June by Hudson Bay of its $33 million concentrator at the Stall Lake mine. This operation will cut the material shipped annually from the Snow Lake area to Flin Flon for further processing from about one million t of copper-zinc ore to about 160 000 t of concentrate. The concentrator provides jobs for 50 people.

Sherritt Gordon Mines Limited continued to develop its underground copper-zinc mine at Ruttan and to drill extensively at both this property and its Fox mine.

With higher tantalum pentoxide prices, Tantalum Mining Corporation of Canada Limited announced in November that it would spend $1 million to expand its processing plant from 180 000 tpy of ore to 250 000 tpy. Improvements in technology will enable the company to start processing tantalum-bearing tailings. Also, a feasibility study is planned for a lithium processing plant at the mine site.

In the provincial budget introduced in May, Finance Minister Donald Craik announced that the government would replace the then-incremental royalty rates of 15 per cent and 35 per cent with a single rate of 18 per cent. This would reduce maximum potential income taxation and resource charges facing the mining industry from more than 73 per cent to about 56 per cent. The legislation also included a major incentive for investment in new and existing facilities through an investment credit equal to 5 per cent of such new investment, provided the credit does not reduce by one-half the royalty rates otherwise payable.

Saskatchewan. In Saskatchewan, the value of output of fuels, the largest sector of the mineral economy increased slightly in 1979 compared with the previous year. Potash, with an output nearly as large as the fuel sector, increased strongly; but both value and volume of uranium production declined. Copper and gold followed the pattern of the other provinces, i.e., higher value and lower output.

Exploration and development activity were at high levels in the uranium sector during 1979. In the Midwest Lake area, Esso Minerals Canada, Canadian Occidental Petroleum Ltd. and Asamera Oil Corporation Ltd. each reported favourable results in extensive diamond drilling programs. Key Lake Mining Corporation has a lake-dewatering program and is submitting an environmental impact report to the government. At Cluff Lake, over 40 per cent of construction has been completed on the $110 million Amok Ltd. project in which the Saskatchewan Mining Development Corporation is negotiating a 20 per cent interest at an estimated cost of $66.9 million. Public hearings were to begin in January 1980 on Eldorado Nuclear Limited's application to construct a uranium hexafluoride (UF_6) plant near Saskatoon.

Cenex Limited, operator of a small mine at Uranium City, was placed in receivership in November. The property, which only started shipping ore in March 1979, has been on a standby basis since a fire earlier in the year.

The Saskatchewan potash industry and the province continue to work toward an agreement on the replacement of all existing royalties, taxes and fees with a single payment based on a basic charge on production and a graduated profits tax for a specified period of time. The companies will be required to drop outstanding court actions and compensate the province for all unpaid taxes. The initial phase of a major expansion program by the Potash Corporation of Saskatchewan that will increase its mine capacity from 3.5 million to 11.3 million t is nearing completion. Other expansions are expected to follow once the new taxation scheme has been settled.

Alberta. Output in both physical and monetary terms was higher for all parts of Alberta's fuel industry in 1979, compared with 1978. This trend is likely to continue as two new nonconventional oil recovery projects could come on stream in the mid-1980s to add to the nonconventional oil that is being produced at the present time by Suncor Inc. (formerly Great Canadian Oil Sands Limited (GCOS)) and Syncrude Canada Ltd. Approval has been granted by the Alberta Energy Resources Conservation Board for both the $5 billion Alsands oil sands project and the $6.5 billion Cold Lake heavy oil project. Before development can start on these projects, final approval is needed from the Alberta Cabinet.

A commitment has been received from Esso Minerals Canada that coal will be used to generate the energy needed for the Cold Lake project. For this purpose, application has been made to develop a mine in the Judy Creek area. No new coal mines were brought on stream in Alberta in 1979.

Uranium exploration activities continued to be intense in the Lake Athabasca area, but as yet no significant discoveries have been reported. Within the 8.5 per cent of the Athabasca basin that lies in northeastern Alberta, 24 uranium leases covering 85 215 hectares and 19 uranium prospecting permits covering 142 346 hectares have been registered. The Geological Survey of Canada has published airborne gamma-ray spectrometric maps of the area.

British Columbia. Increases in value were recorded for most minerals produced in British Columbia in 1979. Copper, gold, silver and lead were up in both volume and value; molybdenum was up 92 per cent in value, but down 18 per cent in volume due to labour difficulties.

Encouraged by favourable prices and currency exchange rates, mining companies are going ahead with a number of new developments. At Alice Arm, 140 km northwest of Prince Rupert, AMAX Inc. is spending $135 million to reopen the former British Columbia Molybdenum Limited mine by early 1982 at a production rate of more than 3 600 tpy of molybdenum. In the Highland Valley, Teck Corporation is developing at a cost of

TABLE 2. EMPLOYMENT IN MINING[1] BY PROVINCE, 1979

	No. of Workers	As % of total prov. labour force
Newfoundland	5,800	4.2
Nova Scotia	5,000	2.0
New Brunswick	3,000	1.5
Prince Edward Island[2]		
Quebec	24,200	1.1
Ontario	29,700	0.9
Manitoba	5,600	1.6
Saskatchewan	8,100	3.0
Alberta	51,500	6.4
British Columbia	15,000	1.6
Yukon & Northwest Territories	3,100	4.6
All Canada	151,000	1.7

Source: Statistics Canada. Catalog. No. 78-008.
[1] Mining, including milling. [2] Sand and gravel extraction by firms classified in industries other than mining.

$150 million the Highmont copper-molybdenum deposit, which, when completed in late 1980, will be capable of an annual production of 22 700 t of copper and 2 000 t of molybdenum. Near Stewart, Esso Resources Canada Limited is investing $20 million to reopen the former Granduc copper mine, which has been closed since June 30, 1978. Start-up is expected in mid-1980 at an output of about 20 000 tpy. Opening of the Sam Goosly silver-copper-gold deposit near Houston has been delayed by labour problems. It is being developed by Placer Development Limited at a cost of $85 million, with annual projected output of 6 400 t copper, 1 700 t antimony, 177 000 kg silver and 340 kg gold, and had originally been scheduled for start-up in mid-1980.

Among copper producers, Noranda Mines Limited will expand facilities at its Bell Copper mine at Granisle from 13 600 tpd to 15 400 tpd by 1981, at a cost of $19 million, extending the expected life of the mine from 1982 to 1988. Lornex Mining Corporation Ltd. is planning to expand its copper-molybdenum mine in the Highland Valley, which has a rated capacity of over 40 000 tpd, by as much as 50 per cent.

The Birch Island project of Denison Mines Limited and the Blizzard development of Norcen Energy Resources Limited are awaiting the outcome of the Royal Commission of Inquiry into uranium mining in British Columbia. The provincial government has warned that no uranium mining will be permitted until proven safe.

Encouraged by the upsurge in the price of gold during 1978, Erickson Gold Mining Corp. has started up a lode mine at 140 tpd near Stewart; while the Mosquito Creek Gold Mining Company Limited is developing a 90 tpd mine at Wells and Carolin Mines Ltd. recently announced plans to develop a 1 500 tpd mine near Hope, to be completed in early 1981.

Two major exploratory projects were announced near the end of 1979. One is the Trout Lake molybdenum property of Newmont Exploration of Canada Limited and Esso Minerals Canada near Revelstoke, the other is on what could be a huge porphyry-copper deposit on Gambier Island in Howe Sound, by 20th Century Energy Corporation. Exploration on this property is being strongly resisted by residents of the area.

Several mines were affected by management-labour disputes during 1979. A strike that began on September 15, 1978, involving 550 members of the United Steelworkers of America at the Cassiar Asbestos Corporation Limited mine, was settled on January 15, 1979. On February 6, the strike-lockout situation that began May 26, 1978 between Gibraltar Mines Limited and 400 members of the Canadian Association of Industrial, Mechanical and Allied Workers, was finally ended with the help of mediation by the provincial government. The 8½ month strike at the Endako molybdenum mine of Placer Development Limited was resolved on November 1, 1979, also with the help of provincial mediation.

A number of coal sales contracts and coal mine development intentions and expansions were announced in 1979. Denison Mines Limited will ship 25 to 30 million t of metallurgical coal to Romania from the Quintette deposit beginning in 1982. Kaiser Resources Ltd., Fording Coal Limited and Crows Nest Industries Limited contracted with the Korea Electric Company for a combined total of 800 000 t annually, beginning in 1982. Norco Resources Ltd. expects to conclude soon a 25-year contract with the Taiwan Power Company for 200 000 tpy beginning in 1982, and increasing to 1.0 million tpy by 1986, from its Bowron River property near Prince George. Integral to future coal exports from northeastern B.C. will be the construction of port facilities and other infrastructure at Prince Rupert, for which the companies have requested federal and provincial participation. In southeastern B.C., mine expansion and a new mine development were proposed by Kaiser Resources Ltd., while Elco Mining Limited and Crows Nest Industries Limited have each proposed new coal mines.

Northwest Territories. While no new mines were brought on stream in the Northwest Territories in 1979, production decisions were announced for three deposits. Arvik Mines Ltd.'s large Polaris zinc-lead-silver deposit, located on Little Cornwallis Island, is expected to start operating in 1982 at a rate of 2 000 tpd. A new company, Frontier Gold Mines Limited, is being formed to bring the relatively small, but high-grade, O'Brien gold deposit near Cullaton Lake into production. The Camlaren gold mine is scheduled for production in the spring of 1980 by Noranda Exploration Company, Limited and Pamour Porcupine Mines, Limited.

Large capital expenditure programs were carried out at several operating mines. Canada Tungsten Mining Corporation Limited doubled mine and mill capacity from 500 to 1 000 tpd; Pine Point Mines Limited erected a $21 million dragline, and a $6 million project was started to upgrade the flotation circuit in the mill; Con-Rycon Mines Limited completed the construction of the mile-deep Robertson shaft.

Exploration expenditures were also high in 1979 at close to $40 million, spent mainly in the search for uranium in sedimentary rocks in areas such as Baker Lake, Nonacho Lake and Dismal Lake. Tungsten exploration was largely confined to the area near Cantung, and there was base-metal exploration activity in the Izok Lake and Pine Point areas.

Judgment in the Baker Lake hearing was handed down November 15 recognizing the Inuit right and title to hunt and fish over most of the area under question but did not disallow mining activities. In the hearing, the Inuit had tried to obtain a permanent injunction to prevent further mining exploration and development in the Baker Lake area.

Of major interest to both the Northwest Territories and the Yukon was the submission to the Minister of Indian Affairs and Northern Development (IAND) on August 31 of the final report of the 15-member joint industry-government committee that had been examining ways to encourage mining in the north. Recommendations by the committee included changes to tax regulations, improved administrative practice, reorganization of IAND and the establishment of a permanent committee similar in form to this first one.

Yukon Territory. Mining forms the major non-government component of the Yukon's economy, and in 1979 a total of three nonfuel mines were operating in the territory. Cyprus Anvil Mining Corporation acquired significant additional reserves with the purchase of the Grum, Swim and Vangorda lead-zinc deposits that should allow its operations at Faro to continue to the end of the century and beyond. Higher silver prices in 1979 permitted United Keno Hill Mines Limited to increase reserves by lowering its cut-off grade substantially. Whitehorse Copper Mines Ltd. continued an active exploration program in the area of its mine, but reserves continued to decline and the mine is expected to close in the early 1980s.

Mining exploration continued at a steady pace in 1979, with expenditures totalling about $20 million and the main focus on lead-zinc, followed by tungsten, uranium and gold-silver. Activity was strong in the MacMillan and Howards Pass regions as well as the area around Faro.

In the Bonnet Plume area 210 km north of Mayo exploration continued on the coal deposit discovered in 1977, and 381 million t of measured, indicated and inferred coal have now been outlined. The chances of finding more coal at the location are regarded as good. The deposit is being evaluated for on-site power generation.

The ban on the issuance of new exploration licences over a 38 850 km^2 area of the northern Yukon continued in 1979. The area is being studied as a site of a possible wilderness park and the ban will not be lifted until a decision has been made on the precise location and size of the park.

The Dempster highway was officially opened in the summer, improving access to the Mackenzie Delta and Beaufort Sea as well as the Eagle Plains and Peel River areas. The White Pass and Yukon Railway continued to have financial difficulties, and an application for federal government aid, which had been previously rejected, is again being considered.

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 the minerals in a region to achieve socio-economic benefits.

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

The programs carried out under the mineral 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 detailed regional 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 1979 three field seasons had elapsed and very good progress had been realized in the geological and geochemical surveys. Also, an aggregate resources inventory is being carried out, 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, $13,500,000 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. On April 1, the agreement entered its final year, and by year-end, negotiations for a new agreement were essentially complete.

New Brunswick. The Canada-New Brunswick Subsidiary Agreement on Minerals and Fuels was signed in June 1976. The estimated total cost is $11,314,000 over a five-year period, with a sharing ratio of 80:20. The agreement covers a wide variety of projects. In 1979 work continued on inventories of coal, uranium, peat and aggregates. Gravity studies were made on parts of the Carboniferous basin, and detailed regional geological mapping was done in the west-central part of the province. Detailed follow-up geological mapping in selected areas in the northern and southern parts was also carried out. A start was made on the evaluation of oil shales in the Albert Formation. Further work was carried out on the development of processing technology that would allow higher recoveries from the complex base-metal assemblages in deposits located in the Bathurst area, and some progress was made on obtaining some preliminary industry support for the next stages of development.

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. Work supported by the program included the construction of 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 1979 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, work continued on the $491,000 geoscientific and mineral deposit program in Renfrew County and the Upper Ottawa Valley. Under the same sub-agreement, $2.3 million was allocated to the Kirkland Lake Incentive Program to carry out an airborne geophysical survey, mapping and other geoscientific studies. The airborne electro-magnetic survey was flown during 1979 and the results were released in September.

In December 1979, a $50 million development sub-agreement covering eastern

Ontario was signed by the federal and provincial governments. Under this agreement is a $4 million minerals program involving geological mapping, mineral deposit surveys and other geoscientific work. The cost sharing ratio of both sub-agreements is 50:50.

Manitoba. The four-year Canada-Manitoba Subsidiary Agreement on Mineral Exploration and Development terminated on March 31, 1979. Geoscientific surveys and work on base metals, uranium, industrial minerals and pegmatite minerals was carried out.

Saskatchewan. The two-year Canada-Saskatchewan Interim Subsidiary Agreement on Mineral Development, with a total funding of $2,469,500, entered its final year on April 1, 1979. The program continued systematic Precambrian and Quarternary geological mapping, metallogenic studies on uranium and base metals and the computerization of geochemical and mineral deposits data. A peat resource study was started and funds were provided for a mass spectrometer to be installed in a new geochronology laboratory.

Canadian Reserves of Selected Mineral Commodities

(Data available as of 1979)

J. ZWARTENDYK

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 1979 - 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**	15 840 400 tonnes[1]
	Nickel	7 069 900 tonnes
	Lead	8 911 000 tonnes
	Zinc	26 451 600 tonnes
	Molybdenum	461 600 tonnes
	Silver	29 398 tonnes
	Gold	409 582 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, 1979. 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.

(C) Asbestos 43 million tonnes

This represents the quantity of fibre recoverable (about 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 69 000 million tonnes of KCl product.

(E) Uranium

Mineable at uranium prices:	"Reasonably Assured" Measured (tonnes U)	"Reasonably Assured" Indicated (tonnes U)
up to $Cdn.130/kg U	73 000	157 000
$130 to $200/kg U:	4 000	25 000

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

[2] R.T. Whillans and D.A. Cranstone, MR 186, **Canadian Reserves of Copper, Nickel Lead, Zinc, Molybdenum, Silver and Gold, as of January 1, 1979,** 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.**

The tonnages refer to uranium contained in recoverable ore. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices of $130/kg U or less[4].

(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].

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4 Energy, Mines and Resources Canada, **Uranium in Canada: 1979 Assessment of Supply and Requirements,** EP80-3, 1980.

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

Aluminum

D. PEARSON

World demand for primary aluminum was strong in 1979. Production increased 3.3 per cent to 15.1 million tonnes (t) and consumption increased 3.4 per cent to 15.8 million t. Smelter operations were well below designed capacity levels, however.

High energy costs in Japan forced the closure of 530 000 t of smelter capacity and its smelters operated at only 80 per cent of capacity. A three-month strike at three Aluminum Company of Canada, Limited (Alcan) smelters in Quebec reduced output to 70 per cent of national capacity. Production was also reduced in India because of reduced power supplies. As a result, world producer stocks decreased from 2.0 million t in January to 1.5 million t at the end of the year.

In response to strong consumption, the aluminum industry reactivated idle capacity and some smelter expansion projects. The largest growth in new smelter capacity is taking place in countries such as Canada, Australia and Brazil which have abundant energy resources.

The North American producer price of primary ingot was U.S. 55 cents a pound at the beginning of 1979 and rose to 66 to 66.5 cents a pound by year-end, when the U.S. free market price was 73 to 74.5 cents a pound.

CANADA

Economic deposits of bauxite are found mainly in tropical countries. One Canadian company imports bauxite from some of those countries, chemically extracts the aluminum oxide (alumina) and smelts it electrically to obtain aluminum. The current trend is for the bauxite producing countries to refine and export alumina, and Canada now imports large quantities of alumina for its smelters. Imports in 1979 totalled 2.2 million t of bauxite, mainly from Guinea, Guyana and Brazil, and 953 000 t of alumina from Australia, Jamaica, the United States and elsewhere.

PRODUCTION

Canadian primary aluminum production in 1979 was 860 286 t compared with 1 048 469 t in 1978. Two companies operate primary smelters in Canada: the Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminium Limited of Montreal, and Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of Richmond, Virginia.

Alcan operates four smelters in the Province of Quebec at Jonquière, Isle Maligne, Shawinigan and Beauharnois, and one at Kitimat, British Columbia (Table 5).

TABLE 1. CANADA, ALUMINUM PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979p	
	(tonnes)	($000)	(tonnes)	($000)
Production	1 048 469	..	860 286	..
Imports				
Bauxite ore				
Guinea	1 053 317	23,677	841 267	20,937
Guyana	813 904	15,265	648 816	13,189
Surinam	105 756	9,961	87 438	10,050
Brazil	-	-	320 045	7,458
Australia	54 549	4,874	53 058	5,083
United States	28 947	2,865	31 389	3,813
Sierra Leone	329 625	4,783	151 024	2,721
Other countries	46 414	859	16 634	593
Total	2 432 512	62,284	2 149 671	63,844
Alumina				
Australia	445 350	73,116	468 365	79,784
United States	163 697	38,401	154 758	40,141
Jamaica	334 512	59,477	178 550	32,555
West Germany	92 576	20,736	95 444	23,539
Japan	-	-	55 711	8,436
Other countries	20 055	2,149	60	41
Total	1 056 190	193,879	952 888	184,496
Aluminum and aluminum alloy scrap	27 162	10,927	30 682	13,837
Aluminum paste and aluminum powder	5 639	7,920	5 894	10,400
Pigs, ingots, shots, slabs, billets, blooms and extruded wire bars	11 481	13,926	23 984	43,139
Castings	1 090	4,639	984	6,023
Forgings	439	3,129	1 110	11,953
Bars and rods, nes	2 781	6,524	17 030	35,717
Plates		25,729	13 557	35,361
Sheet and strip up to .025 inch thick	19 909	37,462	20 508	46,544
Sheet and strip over .025 inch up to .051 inch thick	12 553	27,640	12 302	33,142
Sheet and strip over .051 inch up to .125 inch thick	21 678	39,689	28 153	57,856
Sheet over .125 inch thick	24 354	42,719	35 897	68,566
Foil or leaf	691	1,533	442	1,417
Converted aluminum foil	..	9,925	..	15,953
Structural shapes	2 447	8,727	2 989	16,110
Pipe and tubing	1 601	4,275	1 452	5,601
Wire and cable, not insulated	1 672	4,163	3 885	9,712
Aluminum and aluminum alloy fabricated materials, nes	..	30,835	..	59,999
Total aluminum imports	..	279,762	..	471,330
Exports				
Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars				
United States	489 679	608,462	333 013	479,900
Japan	168 819	200,902	72 483	110,434
People's Republic of China	76 597	89,999	33 956	49,084

TABLE 1 (cont'd)

	1978		1979p	
	(tonnes)	($000)	(tonnes)	($000)
Exports (cont'd)				
Thailand	12 328	16,027	13 924	21,519
Netherlands	2 711	3,349	12 361	18,767
Brazil	19 043	22,161	10 693	18,026
Israel	13 757	17,461	10 921	17,778
Portugal	5 113	6,468	10 945	17,378
Hong Kong	12 103	15,953	7 948	12,170
South Korea	2 188	2,954	7 916	11,562
Malaysia	3 769	4,974	5 858	9,561
Other countries	56 483	73,616	30 486	49,068
Total	862 590	1,062,326	550 504	815,247
Castings and forgings				
United States	1 516	10,176	3 814	22,485
West Germany	30	2,417	96	3,154
United Kingdom	14	1,124	43	2,956
France	5	493	8	558
Other countries	23	564	40	1,074
Total	1 588	14,774	4 001	30,227
Bars, rods, plates, sheets and circles				
United States	20 979	33,566	12 233	28,422
Pakistan	1 549	2,229	1 511	2,424
Venezuela	1 877	4,145	734	1,892
Trinidad-Tobago	120	231	492	1,173
Netherlands	-	-	223	640
Dominican Republic	70	97	259	606
Nigeria	3	11	87	247
Argentina	-	-	81	209
Japan	48	48	69	200
United Kingdom	65	417	53	174
Other countries	3 529	4,707	569	1,658
Total	28 240	45,451	16 311	37,645
Foil				
United States	763	1,708	205	556
Mexico	-	-	36	105
Trinidad and Tobago	4	10	4	10
Venezuela	29	59	1	4
Jamaica	-	-	1	1
Other countries	7	16		
Total	803	1,793	247	676
Fabricated materials, nes				
United States	6 595	10,486	10 840	21,040
Morocco	-	-	2 004	2,811
Saudi Arabia	1	2	356	1,552
Venezuela	627	1,903	374	1,526
United Kingdom	412	983	389	1,110
Jamaica	2	26	408	889
Brazil	-	-	327	477
Other countries	1 607	2,818	761	2,306
Total	9 244	16,218	15 459	31,711

TABLE 1 (cont'd)

	1978		1979P	
	(tonnes)	($000)	(tonnes)	($000)
Ores and concentrates				
United States	26 678	7,340	22 287	6,619
France	837	322	765	337
United Kingdom	1 411	435	861	313
Italy	1 712	482	579	203
Brazil	21	22	122	108
Norway	32	10	171	75
Other countries	1 966	659	689	343
Total	32 657	9,270	25 474	7,998
Scrap				
United States	42 934	34,531	49 750	50,217
Japan	11 893	11,203	14 216	18,296
West Germany	1 112	674	1 569	959
Italy	637	237	1 239	935
France	-	-	881	861
Spain	368	194	1 071	653
Sweden	-	-	425	477
Taiwan	18	3	705	332
Other countries	740	551	482	428
Total	57 702	47,393	70 338	73,158
Total aluminum exports	..	1,197,225	..	996,662

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

Combined rated capacity of the smelters is 904 000 tpy. The Kitimat smelter celebrated a quarter century of operations with record production for the year of 271 000 t. Canadian Reynolds Metals Company, Limited has one smelter located at Baie Comeau, Quebec, with a rated capacity of 158 800 t.

Alcan's smelters at Jonquière, Isle Maligne and Beauharnois were closed during a three-month strike lasting from June 4 to September 4, when a settlement was reached with the members of the Federation des Syndicats du Secteur Aluminum. The contract included a basic wage increase of $3.07 to bring the rate to $10.66, plus a cost of living allowance. An illegal 16-day strike at Alcan's Shawinigan smelter was settled on November 28.

Construction of a smelter at Grande Baie, 30 kilometres (km) east of Jonquière, Quebec, to be built in three stages, proceeded on schedule. The first 57 000 t potline is half complete and is due to come on stream in late-1980. Construction of the second 57 000 t potline is to start early in 1980 and it will be operational late in 1981. A decision was made in December to proceed with the third potline, which is expected to begin operations in mid-1982. Completion of the 171 000 t smelter at Grande Baie will increase Alcan's total capacity to 1.2 million tpy.

Alcan proposes to expand its existing smelter capacity in British Columbia by building three new smelters over the next ten to 15 years, and by completing the Kemano hydro-electric power complex. The power plant would drastically reduce the flows of the Nechako, Morice and Nanika river systems. Objections to the project have been voiced by residents and the federal Department of Fisheries.

Alcan Smelters and Chemicals Limited announced the construction of a new $46 million replacement of the carbon plant at Jonquière to be completed by 1982.

TABLE 2. CANADA, PRIMARY ALUMINUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-79

	Production	Imports	Exports	Consumption[1]
	(tonnes)			
1970	962 541	12 179	761 671	250 150
1975	878 056	18 302	512 050	293 280
1976	628 049	22 556	510 751[r]	322 206
1977	973 524	20 788	655 353	332 393
1978	1 048 469	11 481	862 590	380 290
1979[p]	860 286	23 984	550 504	399 049

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Excluding aluminum metal used in the production of secondary aluminum.
[p] Preliminary; [r] Revised.

In October, it was announced that the alumina plant at Jonquière would be updated by replacing the rotary kilns with fluid bed calciners. This replacement will save energy and improve the working environment.

At Guelph, Ontario, Alcan is building a $7.5 million foundry alloy plant with an initial capacity of 11 000 t. This facility will service the auto industry which has increased its demand for castings in its efforts to reduce the weight of automobiles. This plant is expected to be in operation in 1980.

Canadian exports of aluminum ingot decreased in 1979 to 550 504 t compared with 862 590 t in 1978 and 655 353 t in 1977. The United States continued to be Canada's best customer, taking 333 013 t, or 60.5 per cent of total exports. Exports to Japan decreased to 72 483 t, (13.2 per cent) but the level was still above the average shipments over the previous five years.

Value of aluminum exports in all forms, including ore and scrap, was $996 million compared with $1,197 million in 1978. The value of imports of aluminum metal in all forms rose sharply to $471 million in 1979 from $280 million in 1978.

CONSUMPTION

It is estimated that 399 049 t of primary aluminum were consumed in Canada in 1979, an increase of about 5 per cent over 1978. Consumption of secondary aluminum was 35 527 t compared with 52 246 t in 1978.

WORLD REVIEW

World production of bauxite was estimated at 85 million t in 1979, only slightly more than the 84.1 million t produced in 1978 and 84.8 million t in 1977. Australia continued to be the largest producer with 30.6 per cent of the total, followed by Guinea with 15 per cent and Jamaica with 14 per cent. Alumina production of the non-communist world, as reported by the International Primary Aluminium Institute, was 23.7 million t, an increase of 2.8 per cent over 1978.

World primary aluminum production in 1979 is estimated at 15.1 million t, an increase of 3.25 per cent over the 14.6 million t produced in 1978. Non-communist world producer stocks of primary aluminum decreased 529 000 t between 1978 and end of 1979, when they were 1.5 million t. Consumption of aluminum by non-communist countries rose 4.3 per cent to 12.6 million t, while that of central-economy countries rose marginally to 3.2 million t.

Production of primary aluminum in the United States is estimated to have increased by about 4 per cent to 5.0 million t in 1979. Estimated apparent consumption increased approximately 2 per cent to 6.2 million t.

Electric power limitations, especially in the Pacific northwest, continued to plague the U.S. aluminum industry. Nevertheless Aluminum Company of America (Alcoa) was able to restart idle potlines at its Evansville, Indiana, and Point Comfort, Texas plants. Alumax, Inc. is continuing construction of

TABLE 3. CANADA, CONSUMPTION OF ALUMINUM AT FIRST PROCESSING STAGE, 1976-79

	1976	1977	1978	1979P
	(tonnes)			
Castings				
Sand	1 142	1 277	1 496	1 792
Permanent mould	17 116	17 711	14 483	11 680
Die	20 899	20 538	23 234	26 293
Other	16	65	65	148
Total	39 173	39 591	39 278	39 913
Wrought products				
Extrusions, including tubing	83 814	84 019	87 625	99 438
Sheet, plate, coil and foil	134 527	134 278	159 720	166 049
Other wrought products (including (rod, forgings and slugs)	53 889	61 318	81 833	80 910
Total	272 230	279 615	329 178	346 397
Other uses				
Destructive use (deoxidizer), non-aluminum base alloys, powder and paste	10 803	13 187	11 834	12 739
Total consumed	322 206	332 393	380 290	399 049
Secondary aluminum[1]	52 246	51 260	44 627	35 527

	Metal entering plant		On hand December 31	
	1978	1979	1978	1979
Primary aluminum ingot and alloys	345 589	344 215	87 763	92 794
Secondary aluminum	35 574	49 402	3 280	3 832
Scrap originating outside plant	52 151	47 367	1 143	17 052
Total	433 314	440 984	92 186	113 678

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Aluminum metal used in the production of secondary aluminum.
P Preliminary.

its $400 million, 179 000 t smelter near Charleston, South Carolina and is expected to start production sometime in 1980 from two potlines. Plans for a third potline have been shelved.

Anaconda Company, Aluminum division began production from a new 54 000 t potline at Sebree, Kentucky, raising capacity at the plant to 163 000 tpy.

Kaiser Aluminum & Chemical Corporation plans to upgrade its smelters at Tacoma, Washington and Chalmette, Louisiana at an estimated cost of $30 million.

Martin Marietta Aluminum is increasing its smelter capacity to 160 000 tpy at Goldendale, Washington. Work is expected to be completed in 1981 at a cost of $125 million.

Japan experienced problems in supply during the year. This is the result of a government-authorized cartel formed in 1978 to relieve the industry from rising smelter inventories by cutting back on production. As the year progressed, the domestic demand for aluminum increased beyond the industries' estimates, making it necessary to increase imports by 11.1 per cent over that

TABLE 4. WORLD PRIMARY ALUMINUM PRODUCTION AND CONSUMPTION, 1978 AND 1979

	Production		Consumption	
	1978	1979P	1978	1979P
	(000 tonnes)			
United States	4 358.1	4 549.5	4 975.9	5 132.0
Europe[1]	3 526.8	3 613.5	3 582.2	3 866.7
Japan	1 057.7	1 010.4	1 655.0	1 756.3
Canada	1 048.5	860.3	380.3	340.0
Australia and New Zealand	414.5	424.5	207.3	216.3
Asia (excluding Japan and People's Republic of China)	454.2	443.6	672.1	689.0
Africa	336.3	401.0	139.0	143.0
Mexico and South America	406.6	668.0	445.5	432.8
Sub-total	11 602.7	11 970.8	12 057.3	12 576.1
Central economy countries[e]	3 039.6	3 147.9	3 174.1	3 180.0
Total	14 642.3	15 118.7	15 231.4	15 756.1

Sources: World Bureau of Metal Statistics; Energy, Mines and Resources Canada; Statistics Canada; U.S. Bureau of Mines, Mineral Commodity Summaries, 1980.
[1] Includes Yugoslavia.
[e] Estimated; P Preliminary.

of 1978. Imported metal came mainly from New Zealand, the United States, Russia, Bahrain and Canada. Canadian exports to Japan, however, dropped 57 per cent due to the strike at the Alcan smelters. Japanese consumption is estimated to have been 1.76 million t in 1979, while production was about 1.01 million t.

Australia is the world's largest producer of bauxite and alumina. Its production of bauxite in 1979 was 27.6 million t, accounting for 30.6 per cent of the world total, and alumina production was 7.4 million t, equivalent to about one-quarter of world production. A number of projects to increase alumina production were announced during the year. These include a 500 000 tpy alumina refinery at Wagerup in Western Australia, an increase of 300 000 tpy over the capacity originally proposed; and the Worsley Project with an initial capacity of 1 million t and the capability of being doubled. The latter project is estimated to cost $1 billion and will be financed by a consortium consisting of Reynolds Metals Company (40 per cent), Billiton N.V. (30 per cent), The Broken Hill Proprietary Company Limited (20 per cent) and Japanese interests (10 per cent).

Four companies disclosed intentions to build smelters in Australia. Alumax, Inc. is to build a $535 million facility near Newcastle; Comalco Limited is proposing a 400 000 tpy smelter at Gladstone, Queensland at an estimated cost of $A 1.0 billion; Aluminum Company of America (Alcoa) is planning to build a new plant at Victoria at an estimated cost of $350 million and will increase the capacity of its Point Henry smelter to 165 000 t from 100 000 t by 1981; and Alcan Australia Ltd. will double its 45 000 t facility at Kurri Kurri, New South Wales by early 1981. A feasibility study for a 250 000 tpy smelter in Gladstone, Queensland is also being carried out by Alcan. This three-stage project would be completed in 1983 and cost an estimated $U.S. 300 million.

Brazil is emerging as a potentially large producer of bauxite, alumina and aluminum. In the Trombetas region, Alumina do Norte S.A. (Alunorte) plans to produce 720 000 tpy of alumina, and Aluminio Brasileiro Ltd. (Albras) is constructing an associated 280 000 tpy aluminum smelter near the coastal town of Belem. The first 86 000 t potline is expected to be on stream in 1981. Bauxite shipments from the project to Alcan's

Jonquière plant began in August. Alcan's new Saramenha smelter in Bahia, Aluminio do Brasil S.A. is expected to begin operation at 86 000 tpy in 1981 and reach full capacity of 290 000 t in 1983. Also, Alcan is doubling its existing 28 000 t smelter at Aratu to 58 000 t, with completion scheduled for 1981. Aluminio do Nordeste S.A. (Alune) proposes to build a 100 000 t smelter in Recife. This company is owned 70 per cent by the Brazilian government and 30 per cent by private Brazilian interests.

Construction of an 800 000 tpy alumina extraction plant in Ireland proceeded on schedule during 1979 and the $500 million plant is expected to be operational by 1982. This is the largest project ever undertaken in Ireland. The cost of $500 million is to be financed by Aughinish Finance, a company owned by Alcan Ireland Ltd. (40 per cent), Billiton Aluminium Ireland Limited (35 per cent) and Anaconda Ireland Company (25 per cent). Bauxite will be imported from Guinea and Brazil.

TABLE 5. CANADA, ALUMINUM PRODUCTION SMELTER CAPACITY, 1979

	tonnes
Aluminum Company of Canada Limited (Alcan)	
Quebec	
Jonquière	432 000
Isle-Maligne	73 000
Shawinigan	84 000
Beauharnois	47 000
British Columbia	
Kitimat	268 000
Total Alcan capacity	904 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie Comeau	158 800
Total Canadian capacity	1 062 800

Source: Compiled from various company reports by Energy, Mines and Resources Canada.

The bauxite levy in Jamaica has been renegotiated to a production-based formula to encourage full production. The formula is related to aluminum ingot price and is retroactive to July 1, 1979. Production quantities below 85 per cent of each company's present capacity, will be levied at the current rate of 7.5 per cent. Over this minimum, a reducing sliding scale of levy will apply for each 200 000 t of production.

In Indonesia, eight major aluminum companies have applied to the government on a joint venture basis to build a 544 000 tpy alumina plant on Bintan Island on the east coast of Sumatra, or at Kuala Tanjung in North Sumatra. The refinery's production will go to the 204 000 t Asahan smelter which is scheduled for completion in 1984.

China plans to develop a bauxite-mining and aluminum-processing centre in Guangxi province in the southwestern part of the country. It has asked for technical expertise from Alcoa, Alcan and Pechiney Ugine Kuhlmann to help plan the project.

TECHNOLOGY

Rapidly escalating energy costs have prompted research on new energy saving technology. One of the promising areas of research has been the Alcoa process. This process uses the conventional Bayer method to convert bauxite to alumina, which is then converted to aluminum chloride in a chemical plant before being smelted in an electrolytic cell.

Sumitomo Aluminium Smelting Co., Ltd. has licensed its Soderberg prebake anode process in many countries. Details of this energy saving process (employed in the Soderberg cell) are unavailable. The process is reported to reduce power requirements to 13 500 - 14 000 kWh/t compared with normal power consumption of about 15 000 kWh/t.

Another reported energy saving technique, using the conventional Hall electrolytic cell, is the substitution of titanium diboride for the cathode, either as a solid or as a coating. This method, which is still experimental, could improve energy efficiency of the Hall cell by between 10 and 20 per cent and is accomplished simply by retrofitting existing cells.

Western world dependence on bauxite imports, and the uncertainty of the International Bauxite Association's pricing policies, has resulted in research on non-bauxitic substitutes. This research work is continuing both in Canada and abroad.

OUTLOOK

The Canadian aluminum industry entered 1980 from a high-activity base (recovery from the three-month strike) and relatively low domestic inventories. Consequently, it is expected that smelter production rates will be at or near capacity levels during the year.

Domestic demand for primary aluminum in 1980 is expected to be 4.5 per cent above that of 1979, with world demand growth at about 6.0 per cent. However, a deeper U.S. recession than currently expected could decrease the growth in world demand below 5.0 per cent.

Prices for aluminum ingot are expected to remain firm, and reach somewhat higher levels at about U.S. 70 cents a pound in 1980.

In the longer-term, Canada's cost advantage in electrical energy will continue to sustain the industry's competitive position as offshore electrical power and petroleum costs continue to rise. As a result, the rate of growth in Canadian primary aluminum production capacity should continue to at least equal the growth rate in total world capacity.

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	12.5%	30%	free
35305-1	Aluminum pipes and tubes	free	12.5%	30%	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina)	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
32910-1	Remains free								
35301-1	1¢	.9¢	.8¢	.6¢	.5¢	.4¢	.3¢	.1¢	free
35302-1	2¢	2.4%	2.3%	2.3%	2.3%	2.2%	2.2%	2.1%	2.1%
35303-1	12.5%	11.9%	11.4%	10.8%	10.3%	9.7%	9.1%	8.6%	8.0%
35305-1	12.5%	11.9%	11.4%	10.8%	10.3%	9.7%	9.1%	8.6%	8.0%
92820-1	Remains free								

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
417.12	Aluminum compounds: hydroxide and oxide (alumina)	Remains free								
601.06	Bauxite	Remains free								
618.01	Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch, per pound	3.2%	3.1%	3.1%	3.0%	2.9%	2.8%	2.8%	2.7%	2.6%
618.02	Other unwrought aluminum, excluding alloys, per pound	1.0¢	0.8¢	0.7¢	0.6¢	0.5¢	0.3¢	0.2¢	0.1¢	free
618.04	Aluminum silicon, per pound	2.5%	2.4%	2.4%	2.4%	2.3%	2.3%	2.2%	2.2%	2.1%
618.06	Other aluminum alloys, per pound	1.0¢	0.8¢	0.7¢	0.6¢	0.5¢	0.3¢	0.2¢	0.1%	free
618.10	Aluminum waste and scrap, per pound[1]	2.5%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

[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 1979 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 1979 was $549,000, substantially below the 1978 value of $2,083,895. Sharply lower demand for antimonial-lead because of changes in the technology of lead-acid batteries was responsible for the lower output. The value of antimony contained in ores and concentrates produced in 1979 was $7,726,000 compared with $6,067,371 in 1978. 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 1979 totalled 794 241 kilograms (kg) of which the United Kingdom supplied 81.3 per cent, the United States 8.7 per cent and Belgium and Luxembourg 8.7 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 1979 was reported to be about 106 tonnes (t) compared with 459 t in 1978. The only other company with facilities to produce antimonial-lead alloy in Brunswick Mining and Smelting Corporation Limited, which operates a lead plant at Belledune, New Brunswick. Secondary smelters recover 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 at its Lake George property near Fredericton, New Brunswick. A decline has been driven below the seventh level and a sub-drift established to develop the ore

TABLE 1. CANADA, ANTIMONY PRODUCTION, IMPORTS AND CONSUMPTION 1978 and 1979

	1978 (kilograms)	1978 ($)	1979P (kilograms)	1979P ($)
Production				
Antimonial lead alloy	459 523	2,083,895	106 000	549,000
Antimony in ores and concentrates	..	6,067,371	..	7,726,000
Total	..	8,151,266	..	8,275,000
Imports				
Antimony oxide				
United Kingdom	741 171	2,831,000	645 871	2,637,000
United States	34 836	125,000	68 900	258,000
Belgium-Luxembourg	119 476	364,000	69 491	256,000
France	11 204	42,000	9 979	41,000
Total	906 687	3,362,000	794 241	3,192,000

	1978 Antimony Metal	1978 Antimonial lead alloy[1]	1979 Antimony Metal	1979 Antimonial lead alloy[1]
	kilograms			
Consumption[2]				
Antimony used for, or in the production of:				
Antimonial lead	212 134	...	217 937	...
Babbit	27 132	6 412	19 487	8 636
Batteries	..	878 415	..	1 216 610
Solder	22 907	..	14 500	..
Type metal	..	..	..	..
Other commodities	71 348	..	87 814	..
Total	347 906	1 000 732	351 627	1 343 961
Held by consumers on December 31[2]	101 814	91 049	41 764	183 075

Sources: Statistics Canada; Energy, Mines and Resources, 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; ... Not applicable.

zone on this level. Further development will be done by driving a decline at the west end of the zone to evaluate potential ore in that section of the mine. To explore for further ore reserves an extensive diamond-drill program, of over 6 000 metres (m), has been outlined to test the more favourable zones on the property. Proven ore reserves at the end of the fiscal year 1979 were 108 700 t averaging 3.59 per cent antimony. During the fiscal year ending June 30, 1979, the concentrator, rated at a capacity of 360 t of ore per day, treated 100 168 t of ore to produce 4 337 t of concentrate averaging 65.7 per cent antimony. In fiscal year 1978, the concentrator treated 93 964 t of ore to produce 3 880 t of concentrate averaging 65.6 per cent antimony. The concentrates were of premium quality and were shipped to Europe, the United Kingdom and the United States.

In 1979 Placer Development Limited acquired control of Equity Mining Corpor-

TABLE 2. CANADA, CONSUMPTION AND CONSUMERS' STOCKS OF ANTIMONY[1], 1965, 1970, 1975-79

	Consumption		On hand at end of year	
	Antimony Metal	Antimonial lead alloy[2]	Antimony Metal	Antimonial lead-alloy[2]
	(kilograms)			
1965	299 206	1 258 828	109 241	60 771
1970	518 007	635 212	131 501	91 563
1975	454 164	723 155	116 760	170 478
1976	437 998	1 038 234	30 338	224 664
1977	370 867	1 204 416	27 932	132 262
1978	347 906	1 000 732	101 814	91 049
1979	351 627	1 343 961	41 764	183 075

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

ation's Sam Goosly silver-copper property near Houston, British Columbia for a total payment of $7,430,000. Under an agreement with Equity, Placer acquired a 70 per cent interest in Equity Silver Mines Limited, a company formed to take over ownership of the property. Placer has the responsibility for bringing the property into production and for its operation. Designed capacity of the plant is about 4 500 t of ore per day. Estimated cost of the mine facilities is $107,000,000, of which $37,500,000 had been expended to the end of 1979. Redesign of the leaching plant substantially increased the overall construction costs and delayed the start-up of this section of the process. The concentrator is expected to be in operation in the latter part of 1980 and the leaching plant in the first half of 1981. The company estimates antimony output will be about 1 700 t per year, an appreciable addition to Canada's antimony production. The property is essentially a silver mine and will produce an estimated 177 t of silver per year and 6 400 t of copper per year.

WORLD REVIEW

Increasing use of the lead-calcium automotive battery and the low antimonial-lead battery has reduced 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 1979 was estimated by the American Bureau of Metal Statistics to be 71 300 t. Production in 1978 was 66 906 t.

The world's major primary antimony producers in decreasing order of output in 1979 as shown in Table 3, were, the People's Republic of China, Bolivia, the Republic of South Africa and the U.S.S.R. In 1979 these four countries accounted for about 67 per cent of the world total. Other countries with significant output were Canada, Thailand, Yugoslavia, Mexico, Turkey, Australia and Morocco.

Consolidated Murchison Limited operates the world's largest antimony mine, near Gravelotte in northern Transvaal, Republic of South Africa. The company processed 534 500 t of ore in 1979 averaging 2.60 per cent antimony per t compared with 563 150 t averaging 2.29 per cent in 1978. Improved techniques were responsible for the mining of higher grade ore in 1979. Mine output was 20 066 t of antimony concentrates and cobbed ore grading 57.88 per cent antimony in 1979, compared with 16 290 t grading 57.78 per cent in 1978. Mill recovery improved substantially from 73 per cent in 1978 to 82.6 per cent in 1979. The concentrates contained some gold - 225 kg in 1979. The company is carrying out a continuing surface and underground exploration and development program to maintain ore reserves. Part of the antimony concentrates produced is treated at the nearby plant of Antimony Products (Proprietary) Limited, in which Consolidated Murchison holds a 30 per cent interest, for the production of crude anti-

TABLE 3. WORLD MINE PRODUCTION OF ANTIMONY, 1977-79

	1977	1978	1979p
	(tonnes)		
People's Republic of China[e]	12 000	12 000	15 420
Bolivia	15 156	12 672	13 020
Republic of South Africa	11 535	10 478	10 980
U.S.S.R.[e]	7 900	7 900	8 160
Canada[1]	3 200	3 000	2 990
Thailand	5 238	2 873	2 900
Yugoslavia	2 248	2 760[e]	2 810
Mexico[2]	2 698	2 457	2 450
Turkey	2 438	2 440[e]	2 450
Australia[3]	1 574	2 100	2 090
Morocco	1 409	2 110	2 090
Italy	808	931	950
Peru	823	895	820
United States	553	907	650
Czechoslovakia[e]	300	300	270
Guatemala	918	230	230
Others	2 597	2 853	3 020
Total	71 395	66 906	71 300

Sources: The United States Department of the Interior, U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 6, June 1979, for 1977 and 1978; Non-Ferrous Metal Data 1979, American Bureau of Metal Statistics Inc. for 1979.
[1] Estimated on the basis of value of production. [2] Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[3] Antimony content of antimony ore and concentrates, lead concentrates, and lead and zinc middlings.
p Preliminary; e Estimated.

TABLE 4. INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES BY CLASS OF MATERIAL PRODUCED, 1977-79

	1977	1978	1979p
	(tonnes, antimony content)		
Metal Products			
Ammunition	125	121	230
Antimonial lead	2 663	2 569	858
Bearing metal and bearings	240	253	168
Cable covering	15	19	15
Castings	12	14	-
Collapsible tubes and foil	15	15	22
Sheet and pipe	51	35	28
Solder	200	187	104
Type metal	75	73	8
Other	94	103	38
Total	3 490	3 389	1 471
Nonmetal Products			
Ammunition primers	12	12	16
Fireworks	8	4	3
Flameproofing chemicals and compounds	5 230	5 311	3 524
Ceramics & glass	1 403	1 142	797
Pigments	363	372	217
Plastics	1 364	1 321	652
Rubber products	429	230	35
Other	241	150	-
Total	9 050	8 542	5 244
Total reported	12 540	11 931	6 715
Grand Total	12 540	11 931	9 903[1]

Sources: U.S. Bureau of Mines, Mineral Industry Surveys.
[1] Estimated 100 per cent coverage based on reports from respondents that consumed 66 per cent of the total antimony in 1978.
p Preliminary; - Nil.

mony oxide. The remainder is exported to the United Kingdom, Europe and the United States. Antimony Products is adding two units to its production line and when completed will be capable of treating 80 per cent of the concentrate production.

Bolivia is one of the world's major producers of antimony. Production was estimated at 13 020 t in 1979, slightly above the 12 672 t produced in 1978. The antimony smelter of Empresa Nacional de Fundiciones (ENAF) at Vinto, which was designed to produce 5 000 t of antimony metal per year, operated at about 75 per cent of capacity. Surplus antimony concentrates are exported to the United States, Europe and Japan. No concrete action has been taken on the proposal to build a second 5 000 t per year antimony smelter, near Potosi.

China is the world's largest producer of antimony metal and is a major supplier to European and Japanese markets. Late in 1979 the Chinese established a stock of metal in Rotterdam to supply the European market.

The new Winogradi antimony mine in Loznia, Serbia, Yugoslavia is expected to open in late 1980. According to reports the mine should produce about 1 900 t of antimony concentrates per year.

Anzon America Inc. announced that it would undertake a two-year modernization program at the Laredo, Texas antimony trioxide plant which it acquired from N L Industries, Inc. in 1978. Anzon is a subsidiary of Lead Industries Group Ltd., a United Kingdom company.

Consumption of primary antimony in the United States, the non-communist world's largest consumer, was estimated by the United States Bureau of Mines to be 9 903 t in 1979 and was equivalent to about 14 per cent of the world primary antimony production. In 1978 consumption was 11 931 t, equivalent to about 18 per cent of the world's antimony production. The United States depends on foreign supplies, particularly Bolivia, Canada, Mexico and Chile for ore and concentrates; the People's Republic of China for antimony metal and the Republic of South Africa, China and France for antimony oxide. The Republic of South Africa was the largest overall supplier of antimony in 1979 with 6 136 t, followed by Bolivia and the People's Republic of China with 2 886 t and 2 625 t, respectively.

In 1979 there were no sales of antimony by the United States General Services Administration from the nation's strategic and critical stockpile. The stockpile goal as of November 30, 1979 was 18 262 t of antimony. At the end of 1979 the stockpile contained 36 948 t, leaving a surplus 18 686 t which requires congressional approval for disposal. The disposal policy of strategic metal stockpile surplus is under discussion by the United States Congress but no consensus has been reached.

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 technoligical developments the antimony content in battery alloy has been progressively reduced in recent years, from about 12 per cent to between 2.5 per cent and 6 per cent. Use of antimony in this sector is expected to continue to decline over the next five to ten years through a replacement of antimony by calcium and other lead alloying agents.

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

The demand for antimony in the short term is expected to remain near its present level or to increase slightly. Changes in the antimonial lead-acid battery technology which led to the introduction of maintenance free batteries that use either a non-antimonial lead or low-antimony-lead alloy has drastically reduced the demand for antimony in this application in North America. The new type battery has not as yet made any significant penetration into the Japanese and western European battery markets. The declining demand for antimonial-lead automobile batteries could be offset somewhat by growth in demand for other types of batteries that use antimony, such as batteries used in industrial plants. In the short term stocks of antimonial lead in the hands of the secondary refiners could increase because the new antimonial lead battery contains about 60 per cent less antimony than the older battery. This surplus could last at least until the new antimonial lead batteries begin to enter the secondary market.

The use of antimony in flame retardants is expected to 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 covers a number of other applications, such as childrens' sleepwear, bedding products, carpet fibres and other textiles in the United States. About 50 per cent of the antimony consumed in the United States is used in flame retardants.

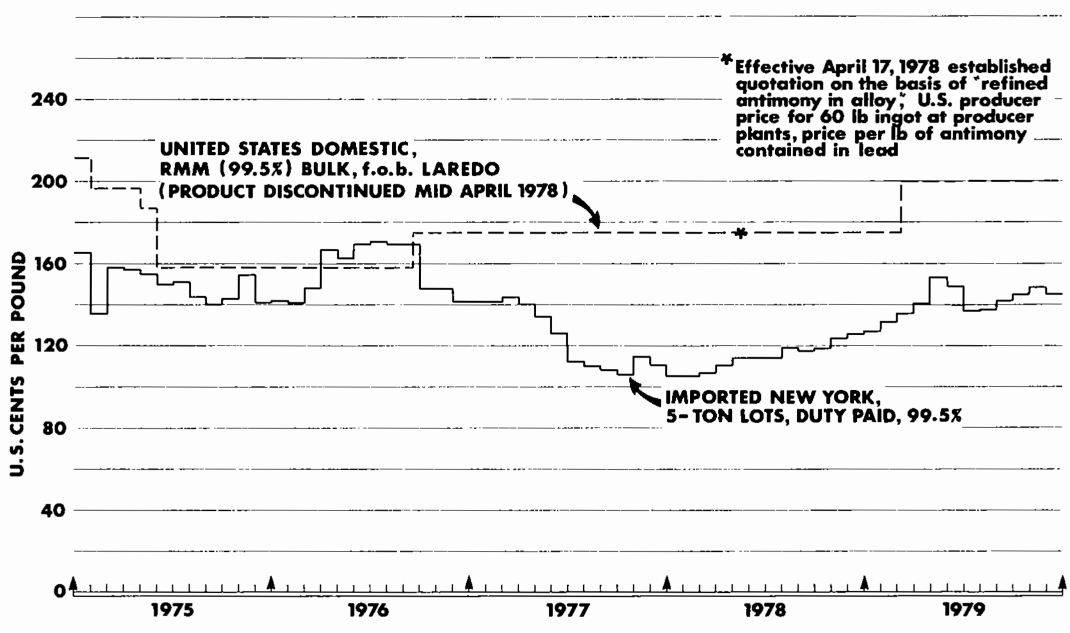
In the short- to medium-term the supply of antimony will be more than adequate to meet demand. China is the largest supplier of antimony metal and oxides to the world's market and because of large reserves, production could be increased to meet market demands. The price of antimony increased moderately during 1979 but no large price increases are anticipated in the near future. China, by regulating the amount of antimony and antimony oxide made available to the world market, can influence the price pattern. No problems of supply are envisaged in the long-term.

PRICES

The producer price for antimony contained in antimony lead alloy, in 60 pound ingots fob producer plants, as quoted in **Metals Week,** was \$U.S. 1.75 per pound from the beginning of the year until March 6, 1979. On March 7 the price was increased to \$U.S. 2.00 per pound and it remained at this level for the balance of the year.

The New York dealer price for foreign antimony metal increased steadily during

ANTIMONY METAL PRICES



1979. The average dealer price for the month of January 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. 1.27 per pound of antimony. The price increased gradually to an average price of $U.S. 1.41 per pound for April on increased demand and reportedly because China regulated the amount of metal released to the market. The price increased sharply in May to a monthly average high of $U.S. 1.53 per pound because China was withholding metal from the market for higher prices. In July the average monthly price of antimony dropped to $U.S. 1.37 per pound and remained near this level for August. Prices began an upward trend in September and the average price for December was $U.S. 1.46 per pound of antimony. An increased demand for antimony by antimonial lead producers, purchases by eastern European countries and the withholding of metal by China, were largely responsible for the price improvement.

The European free market metal price, 99.6 per cent antimony, cif Europe as quoted in **Metal Bulletin** opened for the year 1978 at $U.S. 2652 to 2703 per t of antimony. With minor fluctuations the antimony price increased during the year and closed for the year 1979 at $U.S. 3200 to 3260 per t. The peak antimony price for the year 1979 of $U.S. 3240 to 3300 was recorded on May 9.

Antimony ore prices in the United States market, as quoted in **Metals Week**, varied slightly during 1979. The price at the beginning of 1979 was quoted at $U.S. 19.00 to 19.75 per short ton unit (stu) for 60 per cent lump ore. The price increased to $U.S. 22.00 to 23.25 on August 24. At this time **Metals Week** discontinued quoting an ore price.

The price for antimony trioxide for 1979 was quoted at $U.S. 1.64 to 1.80 per pound until February 2 when the price was lowered to $U.S. 1.50 per pound. At the end of August **Metals Week** discontinued quoting an antimony trioxide price. The price at that time was $U.S. 1.50 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	25
33502-1	Antimony oxides	free	free	12.5	25

MFN Reductions under GATT (effective January 1 of year given)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
33502-1		12.5	10.9	9.4	7.8	6.3	4.7	3.1	1.6	free
	General	Remains at 25								

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
601.03	Antimony ore	Remains free								
632.02	Antimony metal unwrought etc.	1.0	0.9	0.8	0.6	0.5	0.4	0.3	0.1	free

European Economic Community MFN

	1979	Base Rate	Concession Rate
		%	%
26.01	Antimony ore	free	free
81.04	1. Antimony wrought waste and scrap	free	free
	2. Unwrought waste and scrap	8	-
	Other	10	8

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20, No. L289, 1979.

Asbestos

G.O. VAGT

Shipments of asbestos, particularly during the first half of 1979, were moderately higher than in 1978 mainly as a result of firm demand for asbestos-cement grades of fibre. The industry placed considerable emphasis on plant modernization programs and greater environmental control.

Negotiations between the Quebec government and General Dynamics Corporation, of St. Louis, Missouri, for the company's holding in Asbestos Corporation Limited were unsuccessful and court action to resolve constitutional issues will continue into 1980.

CANADIAN PRODUCTION (SHIPMENTS)

Asbestos fibre shipments in 1979 were 1 501 000 tonnes (t) valued at $641,221,000 compared with 1 421 808 tonnes valued at $532,402,870 in 1978. Approximately 89 per cent of total production was from Quebec, 6 per cent from British Columbia and 5 per cent from Newfoundland.

Total production figures since 1977 inclusive include the approximate quantities of fibre contained in concentrate produced in Ungava and shipped for final milling in West Germany; not included are relatively small quantities of serpentine filler produced by Hedman Mines Limited, Timmins, Ontario.

Private negotiations between the Quebec Crown Corporation, la Société nationale de l'amiante (SNA), established by Bill 70 in May 1978, and General Dynamics Corporation (GDC) of St. Louis, failed to establish a purchase price for the Quebec assets of Asbestos Corporation Limited (ACL). GDC owns 54.6 per cent of the 2.8 million outstanding common shares of ACL.

Expropriation legislation (Bill 121) adopted in June 1979 failed to accelerate negotiations because GDC maintained that the legislation was unconstitutional. In September the company refused a formal government offer of $42 a share. ACL, on December 13, 1979 was granted an injunction by the Quebec Court of Appeals against an immediate threat of expropriation by the Quebec government. The constitutionality of Bill 70 and Bill 121 will be tested before the Quebec Superior Court of Appeals in early 1980.

Mine location and mill capacity data are highlighted in the accompanying table. A large portion of nearly $10 million in capital expenditures by Cassiar Asbestos Corporation Limited was devoted to completion of the prior year's projects interrupted by the 1978 strike. A program to improve housing and community facilities was a major factor in reducing turnover at the Cassiar mine from 92 per cent in 1977 to 49 per cent in the current year.

Fibre recovery at Advocate Mines Limited was lower than expected. Costs were higher than normal, new financing was arranged and ore reserves were revised downward by 10.2 million t to 28.9 million t. A plan was designed to continue the removal of about 15.5 million t a year of material resulting in an expected mine life until 1993.

TABLE 1. CANADA, ASBESTOS PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)[1]				
By type				
Crude, groups 1, 2 and other milled	1	2,156	-	-
Group 3, spinning	21 209	21,558,756	24 000	..
Group 4, shingle	456 467	290,676,629	500 000	..
Group 5, paper	196 234	86,462,081	199 000	..
Group 6, stucco	219 520	61,947,710	260 000	..
Group 7, refuse	528 360	71,754,783	518 000	..
Group 8, sand	17	755	-	-
Total	1 421 808	532,402,870	1 501 000	641,221,000
By province				
Quebec	1 263 436	440,006,405	1 329 000	532,932,000
British Columbia	68 267	47,066,170	94 000	67,270,000
Yukon	53 255	26,948,800	-	-
Newfoundland	36 850	18,381,495	78 000	41,019,000
Ontario	-	-	-	-
Total	1 421 808	532,402,870	1 501 000	641,221,000
Exports				
Crude				
United States	1	2,000	20	12,000
Total	1	2,000	20	12,000
Milled fibre (groups 3, 4 and 5)				
West Germany	123 318	62,126,000	121 225	80,026,000
United States	126 355	83,817,000	107 353	76,274,000
United Kingdom	39 494	27,828,000	44 547	35,331,000
Mexico	35 463	23,886,000	40 351	28,780,000
France	26 498	17,513,000	38 458	24,972,000
Japan	32 974	17,429,000	38 347	22,114,000
India	21 556	13,950,000	30 971	22,063,000
Italy	13 519	9,715,000	25 262	18,777,000
Spain	18 526	12,229,000	21 130	14,380,000
Malaysia	14 404	8,626,000	18 624	12,477,000
Australia	24 563	16,179,000	18 187	12,348,000
Belgium-Luxembourg	13 941	9,814,000	10 449	6,861,000
Brazil	17 570	10,856,000	8 150	5,665,000
Other countries	181 509	116,644,000	196 017	136,942,000
Total	689 690	430,612,000	719 071	497,010,000
Shorts (groups 6, 7, 8 and 9)				
United States	413 139	71,604,000	397 561	72,490,000
Japan	84 445	20,185,000	97 164	26,318,000
United Kingdom	48 344	8,944,000	50 749	10,240,000
West Germany	27 084	5,323,000	32 016	6,727,000
France	12 003	2,175,000	20 109	4,370,000
Brazil	12 886	2,528,000	18 504	3,591,000
Netherlands	23 705	4,247,000	18 582	3,507,000
Mexico	8 386	2,209,000	10 315	2,842,000
Belgium-Luxembourg	9 168	2,456,000	10 642	2,804,000
Spain	6 162	1,583,000	8 391	2,461,000

TABLE 1. (cont'd)

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Shorts (cont'd)				
Argentina	4 274	987,000	8 824	2,027,000
Thailand	5 431	1,593,000	6 247	2,012,000
Taiwan	4 583	1,426,000	5 600	1,722,000
Venezuela	5 791	1,612,000	6 905	1,251,000
South Korea	3 965	1,163,000	3 027	922,000
Other countries	39 026	9,737,000	47 309	12,290,000
Total	708 392	137,772,000	741 945	155,574,000
Grand total crude, milled fibres and shorts	1 398 083	568,386,000	1 461 936	652,596,000
Manufactured products				
Asbestos cloth, dryer felts, sheets				
United States		3,195,000		5,355,000
United Kingdom		215,000		564,000
Thailand		46,000		93,000
Singapore		-		77,000
Taiwan		-		65,000
Netherlands		-		37,000
Other countries		370,000		187,000
Total		3,826,000		6,378,000
Brake linings and clutch facings				
United States		2,994,000		2,491,000
Australia		124,000		255,000
Ecuador		90,000		158,000
France		80,000		152,000
Hong Kong		93,000		145,000
South Korea		-		42,000
Syria		-		35,000
Uruguay		10,000		29,000
Lebanon		5,000		17,000
Other countries		95,000		64,000
Total		3,491,000		3,388,000
Asbestos and asbestos cement building materials				
United States		12,188,000		13,884,000
United Kingdom		107,000		899,000
Jamaica		-		682,000
Singapore		179,000		349,000
Emirates, U.A.		-		177,000
Nigeria		-		175,000
Thailand		25,000		98,000
Australia		203,000		95,000
Iran		11,000		76,000
Other countries		1,437,000		369,000
Total		14,150,000		16,804,000

TABLE 1. (concl'd)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Asbestos basic products, nes				
United States		5,121,000		9,618,000
Switzerland		85,000		152,000
Australia		6,000		68,000
France		22,000		41,000
Singapore		-		32,000
Other countries		117,000		195,000
Total		5,351,000		10,106,000
Total exports, asbestos manufactured		26,818,000		36,676,000
Imports				
Asbestos, unmanufactured	757	556,000	1 953	1,008,000
Asbestos, manufactured				
Cloth, dryer felts, sheets, woven or felted		4,504,000		2,813,000
Packing		2,258,000		2,921,000
Brake linings		6,758,000		7,843,000
Clutch facings		1,258,000		1,702,000
Asbestos-cement shingles and siding		78,000		26,000
Asbestos-cement board and sheets		567,000		639,000
Asbestos building materials, nes		6,770,000		4,472,000
Asbestos basic products, nes		4,327,000		6,101,000
Total asbestos, manufactured		26,520,000		26,517,000
Total asbestos, unmanufactured and manufactured		27,076,000		27,525,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value of containers not included.
P Preliminary; - Nil; nes Not elsewhere specified; .. Not available.

United Asbestos Inc. arranged a $35 million refinancing loan that will remove it from control of a trustee. In March 1977, the company was declared in default on loans from its main creditor. Cost estimates will be made of outlays necessary for the possible reopening of the company's Midlothian mine near Matachewan, Ontario.

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 have not been updated but are estimated to be well over $400 million based on an annual output of approximately 200 000 t of fibre. Ore reserves in the "A" deposit are estimated at 100 million t 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 aproximately 32 km east of Chibougamau, Quebec.

TABLE 2. CANADIAN ASBESTOS PRODUCERS AND PROSPECTIVE PRODUCERS, 1979

	Mine Location	Mill Capacity (tonnes)		Remarks
Producers		ore/day	fibre/year	
1. Advocate Mines Limited	Baie Verte, Nfld.	6 800	80 000	Open pit. Produces groups 4 and 6.
2. Carey Canada Inc.	East Broughton, Que.	5 000	210 000	Open pit. Mainly produces groups 6 and 7.
3. 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.
Normandie mine	Black Lake, Que.	6 800		Reserves exhausted. Mill processes K-B open pit ore.
4. Bell Asbestos Mines Ltd.	Thetford Mines, Que.	2 700	55 000	Underground.
5. Lake Asbestos of Quebec Ltd.	Black Lake, Que.	8 200	235 000	Open pit.
National Mines Division	Thetford Mines, Que.	3 200		Open pit.
6. Johns-Manville Canada Inc.				
Jeffrey mine	Asbestos, Que.	30 000	645 000	Open pit (western world's largest known asbestos deposit).
7. United Asbestos Inc.	Matachewan, Ont.	3 600	100 000	Inactive.
8. Cassiar Asbestos Corporation Limited				
Cassiar mine	Cassiar, B.C.	3 000	100 000+	Open pit.
Prospective Producers				
9. Abitibi Asbestos Mining Company Limited	Amos, Que.	11 800		Feasibility study has been undertaken.
10. McAdam Mining Corporation Limited	Chibougamau, Que.	4 500		Feasibility study has been undertaken.
11. Cassiar Asbestos Corporation Ltd.	Dease Lake, B.C.			Possible future development.

Sources: Energy, Mines and Resources Canada; Quebec Asbestos Mining Association, Quebec.

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

WORLD PRODUCTION AND DEVELOPMENTS IN MAJOR MARKETS

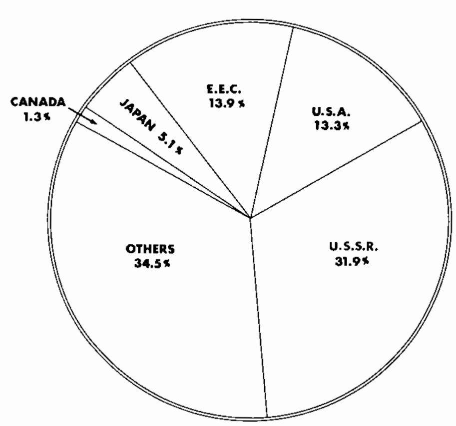
Total world production of asbestos in 1979 was an estimated 5.20 million t based on the inclusion of Russian grades approximately equivalent to Canadian grades. Chrysotile accounted for about 90 per cent of world production and the remaining production consisted of about 6 per cent crocidolite (blue 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 diagrams show a breakdown of 1978 world production and world consumption by country. Discrepancies occur in the data available from the U.S.S.R. and also in the interpretation of this 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 t are exported mainly to eastern European countries, Japan, France, West Germany and India.

The three major producers in the U.S.S.R. are: the Uralasbest Combine in the Central Urals, near Sverdlovsk; the Kustanaiasbest Combine in the Dzhetygara district of Northwest Kazakhstan, along the eastern flanks of the southern Urals; and the Tuvaasbest Combine in the Tuva district west of Lake Baikal. At the new Kiembay development in the southern Urals, several Council for Mutual Economic Assistance (COMECON) countries are assisting in the completion of a project designed to produce 550 000 t a 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 and is also a major producer of crocidolite and chrysotile. Normally, about 30 per cent of

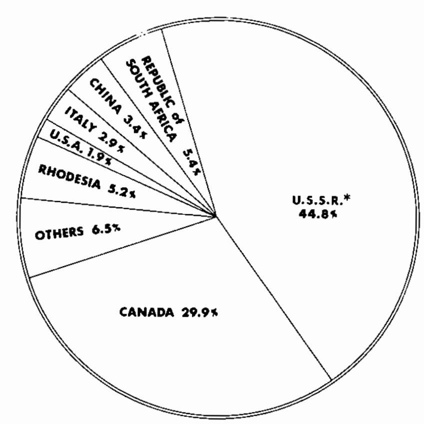
ASBESTOS
APPARENT WORLD CONSUMPTION
1978



APPARENT CONSUMPTION 4 596 000 m.t.

Source: EMR estimates from numerous sources.

ASBESTOS
WORLD PRODUCTION
1978



PRODUCTION 4 760 000 m.t.

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

this country's annual production of about 360 000 t is chrysotile. Cutbacks in production of amosite and crocidolite resulted in total production of only 249 000 t in 1979.

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 U.N. 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 about 250 000 t a year.

United States production of approximately 90 000 t a year is from California, Vermont and Arizona. Significant changes in levels of production are not expected. The United States produces approximately 16 per cent of its asbestos needs and imports the remainder, practically all of which is chrysotile from Canada.

Woodsreef Mines Limited, N.S.W., Australia, received short term government assistance and is seeking long term aid in an attempt to attain its production goal of 100 000 t of fibre a year.

In Greece, construction of a proposed new mine-mill complex was delayed pending a complete financing package by the Hellenic Industrial Development Bank. The expected life of the mine is 20 years and about 75 per cent of the production is planned 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. Other asbestos projects in various stages of development are underway in Brazil, Colombia, Mexico, and Yugoslavia.

FIBRE GROUPS, USES AND TECHNOLOGY

The particular properties that give asbestos commercial value are fibrous structure, high tensile strength that imparts reinforcing characteristics to numerous products and resistance to high temperature and to certain types of chemical attack.

Asbestos is classified and priced by groups from the longest fibre, corresponding to No. 1, to the shortest, No. 7. Groups 8 and 9 are sold on the basis of bulk measure. There are more than 3,000 uses for asbestos and 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.

TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1965, 1970, 1975-79

	Crude	Milled	Shorts	Total
	(tonnes)			
Production[1]				
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	1	673 910	747 897	1 421 808
1979p	-	723 000	778 000	1 501 000
Exports				
1965	112	572 231	624 600	1 196 943
1970	91	747 814	669 509	1 417 414
1975	183	570 418	514 997	1 085 598
1976	83	725 197r	777 154r	1 502 434r
1977	1	705 832r	709 649r	1 415 482r
1978	1	689 690	708 392	1 398 083
1979p	20	719 071	741 945	1 461 036

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Producers' shipments.
p Preliminary; r Revised; - Nil.

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, paper and pipe coverings.

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

In the United States, by far Canada's major market, about 60 per cent of asbestos is used in the construction industry for 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, 25 per cent; flooring products, 21 per cent; friction products, 14 per cent; roofing products, 10 per cent; asbestos-cement sheet, 5 per cent; coatings and compounds, 5 per cent; paper, 5 per cent; packing and gaskets, 4 per cent; insulation, 3 per cent; textiles and plastics, 1 per cent each; and other uses 6 per cent.

Federal emission regulations, pursuant to the Clean Air Act and as recommended by the Department of the Environment (DOE) 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 (cc). Fibres are defined as those greater than five micrometres in length with an aspect ratio of at least three to one. Quebec in-plant regulations, based on recommendations made in 1976 by the Beaudry Study Committee, are determined by the level of total respirable dust, asbestos content of the total respirable dust and the number of fibres greater than five microns in length. The average concentration of fibre is restricted to two fibres/cc or lower in order to satisfy the maximum, never-to-exceed limit, of five fibres/cc. A maximum of five milligrams (mg)/cubic metre (m^3) of total respirable dust is allowed in the workplace and a maximum of 0.20 mg/m^3 of total respirable dust is allowed in the return air flow. British Columbia in-plant regulations, effective in January 1980, will restrict the level of airborne asbestos in the working environment to two fibres/cc.

In June 1979 l'Institut de recherche et de développement de l'amiante (IRDA) was created, when an agreement was signed by the Quebec Minister of Natural Resources and the president of the Association des mines d'amiante du Québec (AMAQ). AMAQ will incorporate and organize IRDA in its first year by means of a $500,000 starting fund underwritten by AMAQ. During the following five years Quebec will contribute up to $5 million, with a yearly average of $1 million, and AMAQ members will contribute up to one-half of one per cent of the total value of their annual net sales of fibre. The objectives of the centre are: the measurement of the amount of fibre emission in the environment caused by existing and future asbestos-based products, and research on methods aimed at its elimination; and the development of new asbestos-based products leading to the establishing of new industries using asbestos fibre. Headquarters will be established in Sherbrooke and work will be coordinated with asbestos-related research programs already established at Sherbrooke and at the Quebec Industrial Research Centre.

Asbestos involves no risk for the general public, based on preliminary results of an epidemiological study carried out under rigourously scientific methodology by the Quebec Department of Social Affairs. Results suggested that mortality rates due to respiratory deficiencies, lung diseases or other ailments, which asbestos could possibly be associated with, are no higher in asbestos mining communities where people have been living for generations.

SNA started its first venture in asbestos processing with the running-in of an asbestos-felt flooring plant situated at Cap-de-la-Madeleine. The plant, which was formerly a newsprint mill owned by Consolidated-Bathurst Inc. was renovated with Quebec financing of $4.7 million and is managed by Papiers Cascade Ltée.

In the United States asbestos health hazards continued to be a high profile issue. The Consumer Product Safety Commission (CPSC) and Environmental Protection Agency (EPA) published advanced notices of Proposed Rulemakings (ANPRM's) in the Federal Register on October 17. CPSC proposes initially to seek elimination of all non-essential uses of asbestos in consumer products from which asbestos fibres are released during foreseeable conditions of use, or misuse. EPA's ANPRM covers commercial and industrial use of asbestos and under the Toxic Substances Control Act, EPA's regulatory approach will involve assessment of risks from mining and milling, processing, product manufacturing, use and disposal. Responses to the ANPRM's by industry are due in February 1980. Hearings on a proposal in 1975 by the Occupational Safety and Health Administration to limit worker exposure to 1.0 fibre/cc of air have never been scheduled.

Personal injury actions against numerous producers of asbestos and asbestos-based products continue in the United States. Suits typically allege that companies failed in their duty to warn of the hazards of inhalation of asbestos fibre in dust originating from certain asbestos-containing products or to warn of hazards associated with the use of fibre in certain product manufacturing plants.

Three delegations from France, as part of a Quebec-France technical exchange program, toured asbestos mining installations and laboratories in Quebec and participated in scientific and technical sessions. Representatives from the government, scientific and industrial sectors left with a much better understanding of the importance that university, government and industrial circles in Quebec ascribe to questions of health and safety. The first-hand knowledge gained about certain achievements and facts left a positive impression contrasting with assumptions or prejudices that have tended to be influential in some circles around the world.

A Soviet delegation, at the invitation of AMAQ, made an official tour of the Quebec asbestos region. The Deputy Minister of Building Materials of the U.S.S.R. stressed the importance of technical exchanges for the Soviets. In particular, certain asbestos milling problems have persisted in the Russian industry and have led the Russians to attempt to purchase licenses and equipment from some western producers.

OUTLOOK

Economic conditions and the possible effects of asbestos on health may contribute to weaker demand for some asbestos materials particularly in the United States. Slow growth or lack of growth in some industrialized countries is expected to be offset by increased demand for asbestos in developing countries and western world growth in asbestos demand is estimated to be in the range of 1.5 to 2 per cent over the medium term.

Expansion 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 current Canadian asbestos exports are to these markets. Environmental-health studies are ongoing in the industrialized countries and 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.

A U.K. government advisory committee published its final report (Simpson Report) after a three-year investigation of the health hazards of asbestos. It rejected calls for a complete ban, but recommended stricter environmental controls. This action may influence regulatory decision making authorities in other countries.

The international asbestos industry is continuously striving to improve the quality of its products, and is actively investigating the development and application of alternative materials. In this connection, however, it is emphasized that such materials must meet three basic requirements: they must present less hazard to health than the asbestos product; they must offer equivalent technical properties, notably in the way of fire protection and in terms of thermal and chemical resistance and mechanical strength; and, they must be economically satisfactory.

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

Quebec asbestos producer prices were increased about 8.5 per cent for all grades on January 1, 1979 and about eight per cent for certain grades on July 1, 1979. A further increase of about eight per cent became effective January 1, 1980. Cassiar Asbestos Corporation Limited increased prices about 17 per cent on January 1, 1980.

PRICES

Canadian asbestos prices quoted in **Asbestos**, September, 1979[1].

	July 1, 1979 ($ per short ton)
Quebec, fob mines	
Crude No. 2	2,295
Group	
No. 3 (spinning fibre)	1,023 - 1,606
No. 4 (asbestos-cement fibre)	687 - 1,011
No. 5 (paper fibre)	388 - 580
No. 6 (waste, stucco, plaster)	330 - 352
No. 7 (refuse, shorts)	113 - 218

	January 1, 1979 ($ per short ton)
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. 4 AX grade	670
No. 5 CY grade	470
No. 5 AY grade	470
No. 6 AZ grade	340
No. 6 CZ grade	340

1 **Asbestos** is a magazine 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 of asbestos, for use in manufacture of clutch facings and brake linings	7 1/2	7 1/2	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, n.o.p.	15	22 1/2	25	8
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, n.o.p.	free	12 1/2	25	free
31220-1	Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	12 1/2	12 1/2	30	8

MFN reductions under GATT, effective January 1 of year given

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
31200-1	15.0	11.9	11.4	10.8	10.3	9.7	9.1	8.6	8.0
31205-1	22.5	11.9	11.4	10.8	10.3	9.7	9.1	8.6	8.0
31215-1	7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
31220-1	12.5	11.9	11.4	10.8	10.3	9.7	9.1	8.6	8.0

		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)

United States

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
518.11	Asbestos, not manufactured, crudes, fibres, etc.	free			

Item No.		1979	1980	1981	1982	1983 (%)	1984	1985	1986	1987
518.21	Asbestos, yarn, slivers, cloth, etc.	3.5	3.5	3.0	2.5	2.0	1.5	1.0	0.5	free
518.51	Asbestos articles nop	3.9	3.9	3.4	2.8	2.3	1.7	1.1	0.6	free
518.41	Pipes, tubes, fittings (¢/lb)	0.15	-	-	-	-	-	-	-	-
518.44	Other asbestos cement articles			Remain free						

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

Shipments of barite in 1979 were 67 035 tonnes (t) valued at $1.98 million. The successively decreasing level of shipments during the past two years resulted from closure of the Walton, Nova Scotia mine in 1977. Imports of barium carbonate, one of the most important barium chemicals derived from barite, amounted to 3 546 t valued at $1,195,000 in 1979.

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 has been found in relatively large quantities only in the north of England. The major western world producers of barite are: United States, India, Ireland, Peru, Thailand, Italy and Mexico.

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 British Columbia and Ontario in 1979.

Mountain Minerals Co. Ltd. mines barite underground from vein deposits near Parson and Brisco in eastern British Columbia, and recovers crude barite from lead-zinc tailings at the Mineral King mine near Invermere. All of 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 t 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; near mile 397 of the Alaska Highway in British Columbia; north of mile 548 of the Alaska Highway in British Columbia and in the Yukon Territory, notably in the Macmillan Pass region and at locations near the Dempster Highway.

TABLE 1. CANADA, BARITE PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production (mine shipments)	99 339	2 656 672	67 035	1 984 000
Imports				
United States	15 635	2 093 000	8 381	1 358 000
United Kingdom	-	-	9	1 000
Total	15 635	2 093 000	8 390	1 359 000
Exports				
United States	43 082	1 188 000	2 038	49 000
Venezuela	13 701	303 000	-	-
Total	56 783	1 491 000	2 038	49 000
	1977		1978	
Consumption[1]				
Well drilling	48 582e		53 068e	
Rubber goods	810		2 977	
Paint and varnish	2 474		1 071	
Glass and glass products[2]	156		13	
Other[3]	1 486		1 062	
Total	53 508		58 191	

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[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 Estimate.

Considerable effort has been directed toward assessing the feasibility of recovering barite from the zinc-lead-copper tailings at Buchans. Production plans are expected to 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 t of ore grading 33 per cent barite and 17 per cent fluorspar. International Mogul Mines Limited recently carried out limited metallurgical tests on samples from the prospect.

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.

In 1978, consumption of barite in Canada was an estimated 58 191 t, with over 90 per cent of this utilized in drilling muds.

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 $BaSO_4$, particle size 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 increase the brilliance or lustre of the product. Specifications call for a minimum of 98 per cent $BaSO_4$, a particle size range of 40 to 140 mesh and usually a magnetically separated ore is used with iron often reduced to 0.1 per cent. However, producers of fine glassware use precipitated barium carbonate to circumvent impurity problems often associated with natural barite.

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 consumption in 1979 was 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 barium chemicals inlcude the nitrate, acetate, oxide, hydroxide and stearate compounds, 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 vehicle 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 1979 was an estimated 6.1 million t 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 inter-related with the drilling companies. Most of these companies are controlled or associated with one of the following major United States organizations: Baroid Division of N L Industries, Inc.; Dresser Industries, Inc.; Milchem, Inc.; and Imco Drilling 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 mines produced an estimated 1.81 million t in 1979, derived mostly from Nevada, Arkansas and Missouri. More than 90 per cent of production was used as a weighting agent in drilling muds. Annual imports of barite to the United States during 1978 and 1979 were 1.17 and 1.27 million t, respectively. Following the United States, which accounted for 32.8 per cent of the total world production were India, 6.2; Ireland, 6.1; Peru, 5.1; Thailand, 4.1; Italy, 3.8; Mexico, 3.6; France, 3.0; Morocco, 2.6; West Germany, 2.6; Yugoslavia, 1.3; Canada, 1.0; other market economy countries, 18.0; and other central economy countries, except Yugoslavia, 9.8.

The United States, the principal consumer of barite, used an estimated 2.8 million t in 1979. Imports into the United States for the years 1975 to 1978, inclusive, came from: Peru, 30 per cent; Ireland, 19 per cent; Mexico, 12 per cent; Morocco, 9 per cent and other, 30 per cent.

TABLE 2. CANADA, BARITE PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970 AND 1975-79

	Production[1]	Imports	Exports	Consumption[2]
	(tonnes)			
1965	184 181	3 344	167 858	19 667
1970	133 584	6 827	90 305	50 106
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	99 339	15 635	56 783	58 191
1979P	67 035	8 390	2 038	73 387

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Mine shipments. [2] Apparent consumption.
P Preliminary.

TABLE 3. WORLD MINE PRODUCTION OF BARITE 1977-79 AND RESERVES, 1979

	Mine production			Reserves
	1977	1978	1979[e]	1979
	(000 tonnes)			
United States	1 355	1 916	1 815	50 000
India	315	289	345	27 000
Ireland	373	290	336	8 000
Peru	435	263	281	6 000
Thailand	118	204	227	9 000
Italy	150	195	209	5 000
Mexico	271	191	200	9 000
France	220	154	163	5 000
West Germany	266	139	145	5 000
Morocco	150	132	145	3 000
Yugoslavia	52	64	73	3 000
Canada	141	99	67	15 000
Other free world countries	1 011	980	997	20 000
Communist countries	909	672	544	20 000
World totals	5 766	5 588	5 547	185 000

Sources: United States Bureau of Mines, Mineral Commodity Summaries, January, 1980 and United States Bureau of Mines, Mineral Trade Notes, August, 1979, and Energy, Mines and Resources, Ottawa.

[e] Estimated.

In the United States, several major barite producers constructed or expanded grinding facilities and continued development progrmas to assure a continuing supply of barite. Elsewhere, grinding facilities were installed in Nigeria, Abu Dhabi and Trinidad. In Ireland, the largest producer in western Europe, Milchem, Inc. brought into production its Lady's Well mine in County Cork.

Listed prices of domestic U.S. drilling mud and grade barite increased about 10 per cent and the listed average price, foreign ports, of imported ore increased nearly 30 per cent in 1979.

Increased oil and gas exploration success in western Canada and offshore in the Canadian Arctic and along the east coast almost assures increased demand during the next several years. A trend is expected to continue toward deeper wells which will result in more barite being consumed per foot of well.

There is good potential for discovery and development of barite deposits near most regions where there is drilling activity. Restrictions on exports of crude barite in favour of ground barite, or other possible disruptions to world trade, could place more emphasis on exploration activity in North America.

In the future, larger quantities of barite may be recovered from mine dumps and tailings ponds in Canada and abroad. In particular, tailings at the Buchans mine, Newfoundland, owned by Abitibi-Price inc. and ASARCO Incorporated have been the subject of renewed evaluation. Also, an increasingly important source of barite may be as a coproduct from the mining of iron, base-metal, fluorspar and rare-earth ores.

The relatively low cost and technical advantages of barite for the drilling-mud market indicate that other materials will not likely be substituted on a large scale in this major application.

PRICES

United States prices of barite as reported in **Engineering and Mining Journal**[1], of January 1980.

	($ per short ton)
Unground	
Chemical and glass grade:	
Hand picked, 95% $BaSO_4$, not over 1% Fe	66.00
Magnetic or flotation, 96-98% $BaSO_4$, not over 0.5% Fe	60.00-70.00
Imported drilling mud grade, specific gravity 4.20 - 4.30, cif	
Gulf ports	24.00-47.00
Canada	19.00
Ground	
Water ground, 95% $BaSO_4$ 325 mesh, 50-lb bags	80.00-133.00
Dry ground, drilling mud grade, 83%-93% $BaSO_4$ 3-12% Fe, specific gravity 4.20-4.30	70.00-90.00
Imported	
Specific gravity 4.20-4.30	35.00-46.00

[1] Published by McGraw-Hill

TARIFFS

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			%		
49205-1	Drilling mud and additives	free	free	free	free
68300-1	Barites	free	10	25	free
92842-1	Barium carbonate	10	15	25	10
92818-1	Barium oxide, hydroxide peroxide	10	15	25	10
93207-5	Lithopone	free	12 1/2	25	free

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					%				
92818-1	15.0	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free
92842-1	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
93207-5	12.5	12.2	11.9	11.6	11.3	10.9	10.6	10.3	10.0

United States

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
472.02	Barium carbonate - Crude	Remain free								
472.04	- Ground	6.0%	5.8%	5.6%	5.3.%	5.1%	4.9%	4.7%	4.4%	4.2%
		($ per long ton)								
472.10	Barium sulphate - Crude	1.27	1.27							
472.12	- Ground	3.25	3.29							

United States (cont'd)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(¢ per lb)				
472.14	Barium sulphate - Precipitated	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
473.72	Pigment etc.	0.43	0.43							
473.74	Pigment etc.	0.43 ¢/lb +3.5%	0.43 ¢/lb +3.5%							

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa, Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

CELESTITE

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

There has been no Canadian production of celestite since Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, closed its mining operation at Loch Lomond, Cape Breton Island, Nova Scotia and its strontium products plant at Point Edward, Nova Scotia, in 1976.

North American consumers continue to depend totally on imports of strontium minerals. The strontium-mining industry in the United States has been dormant since 1959 and Mexico and the Federal Republic of Germany are the major suppliers of celestite and strontium compounds to the U.S. market.

PRICES

United States prices, according to **Chemical Marketing Reporter,** December 31, 1979.

	($ per short ton)
Strontium carbonate glass grade, bags carlot, truckload, works	560.00-570.00
	($ per 100 pounds)
Strontium nitrate, bags, carlot, works	24.00

TARIFFS

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92839-5	Strontium nitrate	free	free	free	free

United States, Customs Tariffs (MFN)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
					%				
Strontium metal									
632.46	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.68	7.5	6.9	6.4	5.8	5.3	4.7	4.1	3.6	3.0
473.17	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
Strontium compounds									
421.70	Remain free								
421.72	6.0	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
421.74	6.0	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
421.76	6.0	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
421.82	Remain free								
421.84	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
421.86	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

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 in Canada, none of these has been identified as bentonite.

Bentonite is a clay of varied chemical composition consisting of the mineral montmorillonite, a member of the smectite group of clay minerals. "Smectite", as a group name, replaces confusing terminology that includes "montmorillonite" as both mineral species and group names.

Bentonite 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.

Montmorillonite is a hydrated aluminum silicate with weakly-attached cations of sodium and calcium which impart different properties to bentonite depending on amounts of 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 dry-bonding strength, especially at high temperatures, a feature important in the pelletizing of iron ores and 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 non-swelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally-occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, "fuller's earth", also contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. These clays are non-plastic, usually high in magnesia and have natural bleaching and absorbent properties allowing their use for decolourizing and purifying. The terminology is confusing, and bentonite and fuller's earth may or may not be separated in world trade and production figures by country.

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. operate a 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 tpy plant. Major uses of the final product are as a binder in foundry moulds, for reservoir sealing, oilwell drilling mud, and for iron ore pelletizing.

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 material before trucking it to the plant for drying, pulverizing and bagging. Bentonite, of intermediate swelling quality, from

TABLE 1. CANADA, BENTONITE IMPORTS AND CONSUMPTION, 1978 and 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Imports				
Bentonite				
United States	218 271	6 256 000	423 909	15 703 000
Greece	77 437	1 555 000	188 775	5 130 000
Other countries	-	-	73	32 000
Total	295 708	7 811 000	612 757	20 865 000
Activated clays and earths				
United States	12 208	3 747 000	14 031	6 281 000
France	1 038	844 000	801	626 000
West Germany	66	51 000	169	156 000
Other countries	7	1 000	-	-
Total	13 319	4 643 000	15 001	7 063 000
Fuller's earth				
United States	226	14 000	1 483	156 000

Consumption[1] (available data)	1976	1977	1978P
		(tonnes)	
Pelletizing iron ore	241 604	256 066	183 290
Foundries	61 209	58 297	54 691
Well drilling	22 820	22 685	19 820
Fertilizer stock and poultry feed	1 389	1 578	1 059
Paint and varnish	183	166	142
Chemicals	65	180	146
Other products[2]	1 612	1 419	1 953
Total	328 882	340 391	261 101

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Does not include activated clays and earths or fuller's earth. Breakdown by Mineral Policy Sector, Energy, Mines and Resources Canada. [2] Refractory brick and mixes, rubber products, paper and paper products, ceramic products and other miscellaneous minor uses.

P Preliminary; - Nil; e Estimated.

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 non-swelling bentonite from the Upper Cretaceous Vermillion 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 activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows. Highly sorptive properties also make this bentonite suitable for pet litter and floor seeping compounds. Control of Pembina was acquired by Filtrol Corporation, controlled in turn by United States Filter Corporation of New York. Plant expansions were started to increase output and to develop a more complete range of products for the domestic and export markets.

USES, CONSUMPTION AND TRADE

Bentonite has many uses, and is used in the manufacture of many products, but generally constitutes only a small part of the final product.

Select swelling bentonite has found widespread and rapidly growing uses as a binder in the pelletizing of iron ore concentrates. Approximately 70 per cent of the reported total consumption of bentonite in Canada in 1978 was used for this purpose according to Statistics Canada. About 18 pounds is used in every long ton of concentrate to provide pellet with sufficient "green" strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate. 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 serves as a binder in moulding sands used by iron and steel foundries. For blending purposes the use of non-swelling bentonite is also important.

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

Some non-swelling bentonite is used in pelletizing stock 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 hydrocarbons. Quantities of activated clays and fuller's earth are imported mainly from the United States. Some activated bentonite from Manitoba is exported to the United States.

The average level of bentonite consumption in Canada increased substantially during the last decade, largely because of increased consumption as a binder in iron 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 that vary from region to region are also important determinants.

Bentonite production in the United States is 4.0 million t with approximately 75 per cent 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 iron ore pelletizing in eastern Canada to Creek bentonite producers. The cost spread between rail and ocean transportation is the principal reason for this change. Canada is by far the main importer from the United States, which also ships some bentonite to numerous countries throughout the world. Major swelling and non-swelling bentonite producers in the United States either announced planned expansion or had expansions under way.

A variety of fuller's earth, mainly comprising attapulgite, a lath-shaped amphibole clay mineral, was produced primarily in Florida and Georgia. Additional types of fuller's earth, mainly comprising montmorillonite, were produced in seven other states.

OUTLOOK

Demand for pelletizing grade bentonite will remain stable because the iron ore industry is expected to remain in a surplus capacity situation until about 1985. However, transportation costs to often very 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, more attention will be directed toward finding closer or otherwise less expensive 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 the direct reduction (DR) process, the tonnage processed by DR methods will remain a small proportion of the total for many years. Countering expansions to Canadian 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 oilwell drilling industry there is a trend toward the use of low-solids mud systems, utilizing organic polymers. Also, in land-based regions characterized by deep, high temperature drilling, there is an increasing use of oil-based muds.

TABLE 2. CANADA, BENTONITE IMPORTS[1] AND CONSUMPTION[2], 1965, 1970, and 1975-1979

	Imports		Consumption
	(tonnes)	($)	(tonnes)
1965	174 334	2 310 566	157 539
1970	351 066	5 590 000	285 671
1975	287 886	9 388 000	286 109
1976	367 162	10 244 000	335 553
1977	481 213	13 757 000	346 698
1978	309 253	12 468 000	253 049
1979P	629 241	28 084 000	..

Sources: Energy, Mines and Resources Canada; 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.

PRICES

United States bentonite prices according to **Chemical Marketing Reporter**, December 31, 1979

	$
Bentonite, domestic, 200 mesh bags, carlots, fob mines Western, per short ton	28.00-30.00
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	

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
				(%)					
93803-2	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
					(cents per long ton)					
521.61	Bentonite	40)								
521.51	Fuller's earth - not beneficiated	25) Remains the same								
521.54	Fuller's earth, bulk	50)								
					(cents per lb + % ad valorem)					
521.87	Clays, artificially activated etc.	0.05¢ +6.0%	0.04¢ 5.6%	0.04¢ 5.1%	0.03¢ 4.7%	0.02¢ 4.3%	0.02¢ 3.8%	0.01¢ 3.4%	0.01¢ 2.9%	- 2.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

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 1979, based on bismuth recovered from domestic ores and concentrates plus the recoverable bismuth content of bullion and concentrates exported, was estimated to be 112 000 kilograms (kg) valued at $875,000, compared with 145 104 kg in 1978 valued at $1,159,717. Bismuth output declined by 22.8 per cent and value of production by 24.6 per cent. Inventory of metallic bismuth held by Canadian consumers as of December 31, 1979 totalled 2 945 kg compared with 3 663 kg in stock as of December 31, 1978.

World mine production of bismuth in 1979, as estimated by the United States Bureau of Mines, excluding United States production, was 4 058 250 kg, 3.6 per cent lower than the 4 209 871 kg produced in 1978. Australia maintained its position as the world's largest producer, accounting for 907 180 kg or over 22 per cent of the world's total. Other large producers were Mexico, Japan, Peru and Bolivia. The above five countries accounted for over 80 per cent of the bismuth produced in 1979.

DOMESTIC SOURCES

The Smelting Division of Brunswick Mining and Smelting Corporation Limited has facilities to produce bismuth metal and alloys at its plant at Belledune, about 40 kilometres (km) northwest of Bathurst, New Brunswick. The bismuth content of lead-bismuth alloy produced in 1979 was 68 000 kg compared with 116 932 kg in 1978.

Primary bismuth metal is produced by 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. The metal is recovered as 99.99+ per cent metal from the treatment of residues resulting from the electrolytic refining of lead bullion. Production in 1979 totalled 91 375 kg compared with 77 184 kg in 1978. Cominco's production includes bismuth recovered from its own ores plus a significant amount from imported materials. Bismuth for use in research and in the electronic industry is further processed at Cominco's nearby high purity plant to give it a purity of up to 99.9999 per cent.

In August 1979 Brunswick Tin Mines Limited, a subsidiary of Sullivan Mining

Group Ltd. and Billiton Canada Ltd., a Canadian subsidiary of Billiton International Metals B.V., reached an agreement whereby Billiton would bring Brunswick Tin's property located about 64 km north of St. Andrews in Charlotte County, New Brunswick, into production. The property will be operated under a joint venture arrangement - Mount Pleasant Joint Venture. Billiton will arrange financing for construction, estimated to be $80,000,000 and will manage the operations. It is expected the property will come on-stream toward the end of 1981. Bismuth is one of the many metals occurring in the ore deposit but reports indicate that initially the metals recovered will be tungsten and molybdenum.

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

The bismuth market was comparatively stable in 1979 except for a short period beginning in May in which a substantial price increase occurred. Adequate supply of the metal enabled consumers to maintain stocks at a low level, avoiding the high cost of carrying inventory.

Peko-Wallsend Ltd., a major producer of bismuth in Australia, operated the Warrengo gold mine which contains appreciable amounts of bismuth. It is located in the Tennant Creek area, Northern Territory. Assessment of the ore deposit at deeper levels continued throughout the year. Underground development work is being carried out on the nearby Gecko mine with the objective of bringing the mine into full production in 1980. Consideration is being given to reopening the Tennant Creek copper smelter which closed in 1975. Extensive modifications to the smelter are planned. A modification in the metallurgical process has made it posssible to lower the bismuth content in the concentrate feed to the smelter. The smelter is expected to be in operation by late 1980. The first stage of a bismuth plant is being built to recover copper and gold from bismuth dusts and concentrates. Bismuth production by Peko-Wallsend can be regulated to meet market demand; when prices are low bismuth concentrates and bismuth-containing dust from the furnaces can be stockpiled to be treated at a later date.

TABLE 1. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1978 and 1979

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Production, all forms[1]				
New Brunswick	116 932	993 265	68 000	531 000
British Columbia	28 172	166 452	44 000	344 000
Total	145 104	1 159 717	112 000	875 000

	1978r	1979
	(kilograms)	(kilograms)
Consumption, refined metal (available data)		
Fusible alloys	7 818	6 787
Other uses	17 847	18 390
Total	25 665	25 177

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.
P Preliminary; r Revised.

TABLE 2. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1970, 1975-79

	Production all forms[1]	Consumption[2]
	(kilograms)	
1970	267 774	11 135
1975	156 605	29 267
1976	129 578	21 105
1977	164 685	25 016
1978	145 104	25 665
1979p	112 000	25 177

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.

A new plant to remove bismuth from lead, being built at Port Pirie, South Australia by The Broken Hill Associated Smelters Pty Ltd., is expected to be completed by mid-1980. The bismuth content has recently been rising in the lead-zinc ores of The Consolidated Zinc Corporation Ltd. and The Zinc Corporation Ltd. at Broken Hill, New South Wales, which are treated at the Port Pirie smelter.

Bolivia is one of the few countries where the bismuth content of some ores is high enough to be mined primarily for bismuth. Bolivia can therefore adjust its output to meet market demand. Most of Bolivia's bismuth output comes from four main mines in the Quechisla group, which are operated by the state-owned Corporacion Minera de Bolivia (COMIBOL). The mines are located in southern Bolivia. COMIBOL operates the country's sole bismuth smelter at Telemaya, about 100 km north of Quechisla. The smelter can treat about 4 800 tonnes (t) of concentrate per year, equivalent to about 800 t 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 t of 99.99 per cent bismuth. Bolivia

TABLE 3. WORLD MINE PRODUCTION OF BISMUTH, 1977-79

	1977	1978p	1979e
		(kilograms)	
Australia	912 000	1 000 000	907 180
Mexico[1]	729 000	730 000	680 390
Japan	697 719	623 841	635 030
Peru[1]	585 467	590 000	589 670
Bolivia[2]	679 579	482 226	498 950
People's Republic of China	250 000	250 000	..
Canada	164 685	145 104	112 000
Republic of Korea	134 000	140 000	136 080
Romania	80 000	80 000	..
Yugoslavia	74 236	12 500	..
France	52 000	60 000	..
U.S.S.R.	65 000	70 000	..
Other countries	28 300	26 200	498 950
Total[3]	4 451 986	4 209 871	4 058 250

Sources: For Canada, Statistics Canada and Energy, Mines and Resources Canada. For other countries for 1977 and 1978 U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 3. For other countries for 1979, U.S. Bureau of Mines, Mineral Commodity Summaries, 1980.
[1] Bismuth content of refined metal, bullion and alloys produced indigenously, plus recoverable bismuth content of ores and concentrates exported for processing. [2] Production by Corporacion Minera de Bolivia (COMIBOL) plus exports by medium and small mines. [3] Total for listed figures only; it excludes United States production, which is not available for publication, as well as that of some other smaller producing countries.
e Estimated; p Preliminary; .. Data not available, but estimate included in figure for "Other Countries".

also exports some bismuth contained in ores and concentrates. In 1979, Bolivia's facilities for producing bismuth were operating well below capacity. Bismuth production in 1979 was estimated at 500 t.

Refined bismuth metal in Peru was produced, as a byproduct of lead ores, at the La Oroya smelting and refining complex of Empresa Minera del Peru (Centromin).

In the United States, consumption of bismuth in 1979 was 1 237 016 kg, up 8.6 per cent from 1 139 368 kg in 1978. The pharmaceutical industry was the largest consumer, accounting for 566 381 kg in 1979, an increase of 8.6 per cent over the 521 487 kg consumed in 1978. In both years this industry consumed 45.8 per cent of the total. Fusible alloys consumption was 327 060 kg, a decrease of 13.8 per cent. The usage of bismuth as a metallurgical additive, especially in malleable iron castings, increased to 45 per cent to 319 225 kg in 1979 from 220 121 kg in 1978 because of strong demand for the cast iron applications. No sales of bismuth were made from the nation's strategic and critical materials stockpile in 1979. The goal established by the U.S. Federal Preparedness Agency for bismuth is 349 720 kg. At the end of 1979 the stockpile contained 943 920 kg, leaving a surplus of 599 200 kg. This surplus cannot be disposed of without Congressional approval. The U.S. Congress has not reached a consensus on discussions held to establish a disposal policy for strategic materials.

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.

TABLE 4. UNITED STATES CONSUMPTION OF BISMUTH BY PRINCIPAL USES, 1978 AND 1979

	1978	1979
	(kilograms, bismuth content)	
Pharmaceuticals[1]	521 487	566 381
Metallurgical additives	220 121	319 225
Fusible alloys	379 213	327 060
Other alloys	9 877	9 992
Experimental uses	253	1 430
Other uses	8 417	12 928
Total	1 139 368	1 237 016

Source: U.S. Bureau of Mines, Mineral Industry Surveys, "Bismuth in the Fourth Quarter 1979, and First Quarter 1980".
[1] Includes industrial and laboratory chemicals.

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 appplications, 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 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.

An important use of bismuth is as an additive to aluminum alloys, malleable irons and steel alloys to improve machinability. With indium the metal forms a low-melting alloy used in ophthalmic industry for holding lenses. The United States Atomic Energy Commission uses 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, mainly in France, has been largely responsible for the depressed state of the world bismuth market. No significant improvement is expected in the short to medium term. The price on the New York dealer market improved in 1979 over that in 1978 but it was comparatively stable over the last six months and this stability has carried over into 1980. Research for new uses for bismuth is being done but to date no significant new uses have been developed. In the short term consumption is expected to remain near the present level or decline slightly because the slackening demand for iron and steel could lower the demand for metallurgical additive and alloy applications. In the longer term 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 partly offset the oversupply situation, producers in Bolivia have reduced output. Bolivia is the only major producer that recovers bismuth from ores mined primarily for their bismuth content and is therefore better able to regulate output than are byproduct producers, whose output is determined by demand for lead and copper. No developments are underway or planned that could add significantly to the world's bismuth supply. Adequate bismuth supply exists for the short to medium term and no problems are envisaged in meeting long term requirements.

PRICES

The Canadian price for bismuth metal 99.994 per cent pure in 1979, as quoted by Cominco Ltd., was $2.50 per pound for the period January to April; $3.00 per pound for May to July and $4.00 per pound from August to December. The average bismuth price for 1979 was $3.24.

The United States domestic producer price for 99.99 per cent pure bismuth in 1979, as quoted in **Metals Week** was $2.50 per pound for the period January to April. On reports of certain major producers withholding metal from the market and of pending purchases by eastern European countries, and rumours on the development of a new use for bismuth, the producer price increased sharply to $4.00 per pound early in May and remained at that price until mid-June. The new use for bismuth did not develop and the price fell back to $3.50 per pound on June 20. On July 24 the price dropped to $3.00 per pound where it remained until the remainder of the year.

The dealer price for bismuth on the New York Market opened the year at $1.72 to $1.84 per pound. The price moved up gradually to near the producer price by the end of April, then rose sharply in the first part of May in line with the producer price to a high of $4.25 to $4.50 on May 4. The dealer price then declined steadily to close at $2.50 to $2.60 per pound at year end.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
		(%)	(%)	(%)	(%)
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	free	25

TARIFFS (concluded)

UNITED STATES (MFN)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
601.66	Bismuth ores and concentrates					free				
632.10	Bismuth metal unwrought, etc.					free				
632.64	Alloys of bismuth etc.					free				
632.66	Other alloys of bismuth	9	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Bismuth metal wrought	9	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa (1979); Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44.

Cadmium

M.J. GAUVIN

Cadmium is a relatively rare element in the earth's crust, occurring most commonly as the sulphide, greenockite (CdS) which is found associated with zinc sulphide ores, particularly sphalerite ((Zn, Fe)S). There are no known commercial orebodies of cadmium; reserves at any time are a function of zinc reserves and specifically the cadmium content of those reserves.

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 a function of zinc metal production. Canadian production in the past five years has ranged from 2.5 to 2.9 kilograms of cadmium for each tonne (t) of zinc metal produced.

PRODUCTION AND CONSUMPTION

Canadian production of refined cadmium in 1979 was 1 455 t compared with 1 265 t in 1978. Production of cadmium in the western world as reported by the World Bureau of Metal Statistics is estimated to have increased to 14 425 t in 1979 compared with 13 195 t in 1978.

Consumption of refined cadmium in Canada as reported by consumers to Statistics Canada was 48.7 t in 1979 compared with 47.5 t in 1978. Western world consumption as reported by the World Bureau of Metal Statistics was 14 448 t in 1979 compared with 12 855 t in 1978.

TABLE 1. CANADIAN PRIMARY CADMIUM STATISTICS, 1977-79

	1977	1978	1979P
		(tonnes)	
Metal production	1 369	1 265	1 455
Metal capacity	1 705	1 705	1 705
Metal shipments:			
Domestic	85	142	121
Exports	870	1 259	1 293

Sources: Statistics Canada; Energy, Mines and Resources Canada.

P Preliminary.

USES

Cadmium is a soft, ductile, silver-white electropositive metal with a valence of two. It is used 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, and this is 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 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. A 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.

TABLE 2. CANADA, CADMIUM METAL CAPACITY, 1979

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

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

TABLE 3. CANADA, CADMIUM PRODUCTION AND EXPORTS 1978 AND 1979 AND CONSUMPTION 1977-79

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Production				
All forms[1]				
Ontario	517 958	3,191,616	765 000	5,488,000
British Columbia	255 807	1,576,265	217 000	1,553,000
Quebec	243 448	1,500,104	138 000	989,000
Newfoundland	66 858	411,972	67 000	479,000
Manitoba	56 740	349,627	61 000	434,000
Saskatchewan	10 429	64,265	8 000	57,000
Yukon	58	355	-	-
Total	1 151 298	7,094,204	1 256 000	9,000,000
Refined[2]	1 264 804	..	1 454 954	..
Exports				
Cadmium metal				
United States	724 076	3,954,000	720 955	4,082,000
United Kingdom	378 511	1,916,000	561 363	3,230,000
Netherlands	125 638	651,000	9 997	42,000
Greece	200	1,000	200	1,000
Hong Kong	20 726	12,000	-	-
Other countries	10 139	58,000	-	-
Total	1 259 290	6,592,000	1 292 515	7,355,000

TABLE 3 (cont'd)

	1977	1978	1979
		(kilograms)	
Consumption			
Cadmium metal[3]			
Plating	24 003	19 319	24 558
Solders	3 394	4 368	6 568
Other uses[4]	22 972	23 836	17 620
Total	50 369	47 523	48 746

Sources: Statistics Canada; Energy, Mines and Resources 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; .. Not available.

TABLE 4. CANADA, CADMIUM PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975-79

	Production		Exports Cadmium Metal	Producers' Domestic Shipments
	All Forms[1]	Refined[2]		
		(kilograms)		
1970	1 954 055	836 745	702 630	157 307
1975	1 191 674	1 142 508	637 797	98 820
1976	1 313 723	1 387 805	1 555 772	135 354
1977	1 185 446	1 369 447	869 883	84 944
1978	1 151 298	1 264 804	1 259 290	141 579
1979P	1 256 000	1 454 954	1 292 515	120 926

Sources: Statistics Canada; Energy, Mines and Resources 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 5. CADMIUM METAL PRICES, 1979

	Northern Miner	Metals Week		Metal Bulletin	
Month	Cominco	U.S. Producer	New York Dealer	Commonwealth Producer	European free market, sticks
	($ Cdn/lb)	($ US/lb)		($ US/lb)	
January	2.25	2.450	2.150-2.400	3.00	2.083-2.159
February	2.75	2.693	2.400-3.000	3.00	2.598-2.723
March	2.75	2.950	3.050-3.300	3.00	2.956-3.089
April	2.75	3.108	3.000-3.300	3.00	2.964-3.029
May	3.15	3.091	2.950-3.200	3.00	2.950-3.000
June	3.25	3.108	2.400-3.150	3.00	2.744-2.894
July	3.25	2.898	2.300-2.800	3.00	2.217-2.344
August	2.75	2.520	2.250-2.400	3.00	2.074-2.193

TABLE 5. (cont'd)

Month	Northern Miner Cominco	Metals Week U.S. Producer	Metals Week New York Dealer	Metal Bulletin Commonwealth Producer	Metal Bulletin European free market, sticks
	($ Cdn/lb)	($ US/lb)		($ US/lb)	
September	2.75	2.500	2.200-2.450	3.00	2.125-2.263
October	2.75	2.500	2.350-2.500	3.00	2.244-2.361
November	2.75	2.509	2.250-2.800	3.00	2.211-2.378
December	3.00	2.791	2.650-2.950	3.00	2.608-2.750
Average 1979	2.85	2.760	2.496-2.854	3.00	2.481-2.599

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

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
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	25	free

UNITED STATES

Item No.		
601.66	Cadmium in ores and concentrates	free
632.14	Cadmium metal, unwrought, waste and scrap	free

		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
632.84	Cadmium alloys unwrought	9.0	-	-	-	-	-	-	-	-
632.86	Cadmium alloys, unwrought containing by weight 96% or more but less than 99% of silicon	8.6	5.6	5.1	4.7	4.2	3.8	3.3	2.9	2.4
632.88	Cadmium alloys, unwrought, other	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Cadmium metal, wrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

TARIFFS (cont'd)

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1979	Base Rate	Concession Rate
			(%)	
26.01	Cadmium in ores and concentrates	free	free	free
81.04	Cadmium metal, unwrought, waste and scrap	4	4	4
	Cadmium metal, other	6	6	6

JAPAN (MFN)

Item No.				
26.01	Cadmium in ores and concentrates	free	free	free
81.04	Cadmium metal:			
	Unwrought	8	10	5.1
	Waste and scrap	8	10	4.8
	Powders and flakes	8	10	5.8
	Cadmium metal, other	12	15	6.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20, No. L289, 1977; Customs Tariff Schedules of Japan, 1978; GATT Documents, 1979.

Calcium

D. PEARSON

Calcium occurs both in the earth and in the sea in great quantities, and is the fifth most abundant element in the earth's crust. It occurs abundantly in limestones, gypsum, fluorite and apatite. This element is an essential constituent to all plant and animal life. Calcium metal is highly reactive and, for this reason, is never found in the pure state in nature. The metal is soft, ductile and easily shaped. The main uses of metallic calcium are as a reducing agent and an alloying element with other metals.

There are two methods of producing metallic calcium; by electrolysis and by the aluminothermic reduction of lime. The latter method is used exclusively by the three producers in the non-communist world. These producers are: 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.

Canada produced 477 000 kilograms (kg) of calcium in 1979 and exported 377 000 kg or almost 79 per cent of the metal produced. Production declined by about 17 per cent compared to that in 1978 and total exports rose by nearly 35 per cent. Exports to the United States, which has been Canada's traditional customer, declined. United States consumption of calcium has increased over the past three years (from 229 000 kg to 359 000 kg), but Canada's share of total United States imports, as

TABLE 1. CANADA, CALCIUM PRODUCTION AND EXPORTS, 1978 AND 1979

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Production (metal)[1]	574 764	2,688,932	477 000	2,335,000
Exports (metal)				
United States	199 263	906,000	166 000	898,000
Mexico	32 795	128,000	145 000	559,000
South Africa	35 108	319,000	23 000	216,000
West Germany	499	4,000	15 000	99,000
Australia	-	-	11 000	46,000
Other countries	12 474	61,000	17 000	116,000
Total	280 139	1,418,000	377 000	1,934,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of calcium metal and calcium used in production of calcium alloys.
- Nil; P Preliminary.

reported by U.S. agencies, decreased from 95 to 41 per cent during that period. The difference has been supplied by the U.S.S.R. However, Canadian exports to Mexico rose sharply in 1979 and significant quantities of Canadian calcium continued to be sold in South Africa, West Germany and, for the first time, Australia. In these countries it is believed that most of the calcium was used in the treatment of lead to eliminate bismuth, whereas in the United States much is used for deoxidation of steel and addition to lead for battery grids.

TABLE 2. CANADA, CALCIUM PRODUCTION AND EXPORTS, 1970 AND 1975-79

	Production[1]	Exports
	(kilograms)	
1970	201 194	79 000
1975	428 288	309 800
1976	513 964	298 000
1977	490 856	268 700
1978	574 764	280 139
1979P	477 000	377 000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of calcium metal and calcium metal used in production of calcium alloys.
P Preliminary.

CANADIAN INDUSTRY

Chromasco Limited is the only producer in Canada. This company produces a number of metals and alloys at its metallurgical plant at Haley, near Renfrew, Ontario. To make calcium, high-purity quicklime (CaO) and commercially pure aluminum are briquetted, and the briquettes are charged into horizontal electric retorts. Under vacuum, the aluminum reduces the quicklime so that calcium is liberated as a vapour which crystallizes in a water-cooled condenser section of the retort at about 700°C. The crystallized product is known as "crowns" and is about 98 per cent pure. 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 at 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 and 0.45 per cent aluminum and 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 3. IMPORTS OF CALCIUM METAL BY THE UNITED STATES

Year	Per Cent from Canada	Per Cent from U.S.S.R.	Total Imports
			(tonnes)
1977	95	5	227
1978	73	27	249
1979	41	59	326

Source: Mineral Industry Survey, U.S. Bureau of Mines.

USES

Calcium's powerful reducing properties makes it ideal in the manufacture of many of the less common metals such as columbium, tantalum, titanium, thorium, uranium, vanadium and zirconium. In nonferrous metallurgy, its uses are in debismuthizing lead, as an alloying additive in storage battery grids in the "maintenance free" battery, and as an alloying element to magnesium and aluminum. Calcium metal, calcium compounds and ferrosilicon alloys containing calcium are widely used in ferrous metallurgy to control grain size, inhibit carbide formation, improve ductility and to reduce internal flaws in castings.

OUTLOOK

It is anticipated that demand for Canadian calcium metal in 1980 will be at the same level as in 1979 barring a severe economic recession. There is optimism for increased consumption of calcium in the deoxidizing of steel and as an addition to lead grids of "maintenance-free" batteries in the United States and Canada.

PRICES

The price of calcium metal increased from $U.S. 1.80 per pound in 1978 to $U.S. 1.89 per pound in 1979, according to **Metals Week.** The price of calcium-silicon was increased three times during 1979, rising from $U.S. 0.57 at the beginning of January to $U.S. 0.71 per pound effective October 1, 1979.

TARIFFS

Canada: Customs Tariffs, 1979

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

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					%				
92805-1	15.0	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2

United States, Customs Tariffs (MFN)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						%				
632-16	Calcium	7.5	6.9	6.4	5.8	5.3	4.7	4.1	3.6	3.0
633-00	Other base metals, wrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Cement

D.H. STONEHOUSE

THE CANADIAN INDUSTRY

Strong markets for Portland cement in western Canada, particularly in Alberta, continued through 1979 to the extent that shipments of both cement and clinker from eastern production plants were necessary to supplement output from regional plants. In view of soft markets in eastern Canada this phenomenon permitted companies to rationalize transportation costs, effect economies in plant operations and to make interplant shipments which, under other circumstances, would be considered too costly. Overall cement shipments from Canadian plants together with amounts used by producers were up 12 per cent in 1979 to over 11.8 million tonnes (t) representing a 74 per cent utilization of theoretical capacity.

Exports of both portland cement and clinker to the United States established new records and with exported clinker added to total cement production, capacity utilization escalates to 84 per cent. While cement shipments to the United States were to established markets and to markets which United States producers were unable to supply because of capacity inadequacy, clinker shipments were principally to company-owned grinding facilities in the United States or to honour firm contracts with existing cement producers. Clinker exports were up 42 per cent to 1.53 million t, cement exports were up by 30 per cent to 1.86 million t. The trend will continue as long as the demand remains high and the United States producers remain stalled by environmental and monetary restrictions. The Canadian-United States dollar relation is attractive to Canadian exporters and the United States should be happy to import energy in the form of cement clinker.

Plant expansions at Exshaw, Alberta (Canada Cement Lafarge Ltd.) and at Edmonton (Inland Cement Industries Limited) continued throughout the year. Both projects are on schedule and startup of the additional facilities is still planned for 1980. At its St. Basile, Quebec plant, Ciment Quebec Inc. is installing a Fuller suspension preheater with precalciner flash furnace system, the first in Canada. The 2 000 tpd line will replace an existing wet process plant of approximately half that capacity. Completion is scheduled for 1981. No new expansions were announced during 1979.

St. Lawrence Cement Company purchased coal reserves in New Brunswick from a joint venture group (consisting of Camflo Mines Limited, Canadian Reynolds Metals Company, Limited, Lynx-Canada Explorations Limited) for $3 million and in turn sold about 50 per cent of the proven reserves to a New Brunswick government-owned corporation, Provincial Holdings Ltd. St. Lawrence is proceeding with plans to strip mine the Leakestream section of the deposit at a rate of 100 000 tpd to supply fuel for its Quebec-based Portland cement operations.

TABLE 1. CANADA, CEMENT PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
By province				
Ontario	3 952 730	183 110 158	4 257 000	216 971 000
Alberta	1 167 313	113 537 250	1 324 000	155 783 000
Quebec	2 809 119	130 146 752	3 012 000	153 488 000
British Columbia	1 019 488	56 106 764	1 357 000	90 365 000
Manitoba	681 260	34 544 160	694 000	38 712 000
Saskatchewan	352 997	24 689 373	410 000	34 715 000
Nova Scotia	..	12 127 508	..	22 854 000
New Brunswick	..	12 643 491	..	15 794 000
Newfoundland	..	5 685 020	..	8 180 000
Total	10 558 279	572 590 476	11 835 000	736 862 000
By type				
Portland	10 191 261	..	11 444 000	..
Masonry[2]	367 018	..	391 000	..
Total	10 558 279	572 590 476	11 835 000	736 862 000
Exports				
Portland cement				
United States	1 622 699	62 346 000	2 288 694	94 991 000
France	-	-	55	7 000
St. Pierre-Miquelon	172	13 000	66	6 000
Other countries	11 714	525 000	47	3 000
Total	1 634 585	62 884 000	2 288 862	95 007 000
Cement and concrete basic products				
United States	..	32 373 000	..	61 501 000
Other countries	..	317 000	..	753 000
Total	..	32 690 000	..	62 254 000
Imports				
Portland cement, standard				
United States	97 849	4 583 000	110 521	6 852 000
Japan	1 251	91 000	-	
Other countries	276	24 000	120	12 000
Total	99 376	4 698 000	110 641	6 864 000
White cement				
United States	12 818	913 000	15 345	1 921 000
Japan	1 171	83 000	625	71 000
Belgium and Luxembourg	727	59 000	432	43 000
Total	14 716	1 055 000	16 402	2 035 000
Aluminous cement				
United States	8 544	1 551 000	9 980	2 224 000
Yugoslavia	35	6 000	124	17 000
United Kingdom	-	-	1	...
Total	8 579	1 557 000	10 105	2 241 000

TABLE 1. (cont'd)

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Cement, nes				
United States	95 918	6 603 000	56 688	4 041 000
Italy	53	4 000	405	37 000
United Kingdom	254	36 000	154	32 000
West Germany	63	4 000	38	3 000
Japan	879	37 000	-	-
Other countries	88	11 000	-	-
Total	97 255	6 695 000	57 285	4 113 000
Total cement imports	219 926	14 005 000	194 433	15 253 000
Refractory cement and mortars				
United States		7 481 000		9 276 000
United Kingdom		1 103 000		1 065 000
Ireland		359 000		537 000
West Germany		12 000		71 000
Sweden		-		33 000
Other countries		162 000		14 000
Total	..	9 117 000	..	10 996 000
Cement and concrete basic products, nes				
United States		1 408 000		2 194 000
West Germany		216 000		36 000
France		40 000		19 000
Italy		5 000		18 000
United Kingdom		94 000		13 000
Other countries		28 000		4 000
Total	..	1 791 000	..	2 284 000
Cement clinker				
Japan	29 692	867 000	34 690	1 240 000
United States	6 997	220 000	19 119	587 000
United Kingdom	108	23 000	180	46 000
Total	36 797	1 110 000	53 989	1 873 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Includes small amounts of other cement. p Preliminary; .. Not available; - Nil; nes Not elsewhere specified; ... Amount too small to be expressed.

Genstar Limited concluded the sale of the cement and building materials operations of Miron Inc. to Saudi Arabian-controlled Interedec of Vancouver. The takeover was approved by the Foreign Investment Review Agency (FIRA) in February 1979.

Energy conservation programs adopted by the Canadian cement industry resulted in reaching the goal of a 9 to 12 per cent reduction in energy consumption per unit of production based on 1974 calculations. In 1979 the average plant consumption of energy of all types was 5,429 mega joules a t, a 12.7 per cent fuel saving over 1974.

A change in the fuel mix from 1974 to 1979 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 1979 natural gas usage was 36.7 per cent of the total energy requirements while petroleum products were 33.7 per cent and coal and coke rose to 29.6 per cent.

TABLE 2. CANADA, CEMENT PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1975-79

	Production	Shipments[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
			(tonnes)		
1975	9 740 502	9 719 959	934 981	420 430	9 205 408
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	10 472 724	10 558 279	1 634 585	217 925	9 141 619
1979P	11 459 393	11 835 000	2 288 862	194 433	9 740 571

Sources: Statistics Canada; Energy, Mines and Resources 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.
P Preliminary.

The Canadian cement industry is strongly regionalized on the basis of market availability. Capacity concentration is closely aligned to population density, reflecting the importance of transportation costs to the consumer. The availability and cost of energy could weigh just as heavily as product transportation costs on decisions regarding new plant locations in future, and perhaps even on the viability of existing plants.

Atlantic region. The Atlantic region is supplied mainly from three plants - North Star Cement Limited at Corner Brook, Newfoundland and Canada Cement Lafarge Ltd. at Brookfield, Nova Scotia and at Havelock, New Brunswick. Limestone and shale for North Star's dry process are quarried near the plant site and gypsum is purchased from Flintkote Holdings Limited, which quarries gypsum at Flat Bay, about 95 kilometres (km) south of Corner Brook.

Canada Cement Lafarge's Brookfield, Nova Scotia plant began production in 1965. 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. The company's Havelock, New Brunswick plant is a two-kiln, dry-process operation with recently installed electrostatic precipitators. Raw materials, including gypsum, are obtained 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, was part of the assemblage of cement plants that formed Canada Cement Company, Limited in 1909. Plans to rehabilitate the plant beginning in 1976 were delayed repeatedly because of poor marketing conditions in the Quebec region, and currently the facilities are utilized for grinding only.

Canada Cement Lafarge's plant at St. Constant, south of Montreal, is modern, technically efficient and, with a capacity of over 950 000 tpy, 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 tpy of cement. Limestone and shale are available at the site; iron oxide and gypsum are

TABLE 3. CEMENT PLANTS, APPROXIMATE ANNUAL CAPACITIES, END OF 1979

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: Energy, Mines and Resources Canada.

[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	Portland Cement Production	Cement Clinker Exports[1]	Total (1) & (2)	Approximate Capacity Utilization
			(tpy)	(tonnes)(1)	(tonnes)(2)		(%)
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]
1979	24	51	15 985 000	11 459 393	1 530 537	12 989 930	81

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.

available at the site; iron oxide and gypsum brought in. 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. Marketing conditions in northeastern United States have not warranted the intended expansion.

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 tpy. The company is installing what will be the first Fuller suspension preheater with a precalciner flash furnace system in Canada. The 2 000 tpd output will replace production from the existing wet plants.

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 to augment production in that region of high demand.

Lake Ontario Cement Limited enjoyed record shipments again in 1979 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 Lafarge Ltd. brought its 1 million tpy Bath, Ontario plant on stream late in 1973 at a cost of $50 million and subsequently phased out its Belleville plant. Limestone 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's Woodstock plant is capable of producing about 540 000 tpy from a two-kiln, wet process. This plant has experimented with the use of selected, processed garbage as fuel.

St. Lawrence Cement Company built its Clarkson, Ontario plant in 1957 and, with the expansion to 1.58 million tpy in 1968, it became Canada's largest producing plant. The plant now combines a wet and a dry process. The company has developed a cooperative and innovative approach to on-site experiments such as burning chlorinated hydrocarbons in the cement-kiln and utilizing waste oil as fuel.

Limestone for the plant is brought by boat from Ogden Point, 160 km east of Toronto on the north shore of Lake Ontario. Gypsum is trucked from producers in southwestern Ontario. The market area

TABLE 5. CANADA, DISTRIBUTION OF DOMESTIC CEMENT SALES[1] FROM PRODUCERS' PLANTS, 1975-79

	1975	1976	1977	1978	1979
			(tonnes)		
Quebec					
Portland	2 509 057	2 006 578	1 991 607	1 818 456	1 817 792
Masonry	81 191	87 379	89 899	80 672	78 617
Total	2 590 248	2 093 957	2 081 506	1 899 128	1 896 409
Ontario					
Portland	3 089 953	3 051 287	2 920 972	2 819 248	2 734 519
Masonry	186 296	194 355	182 809	171 622	173 507
Total	3 276 249	3 245 642	3 103 781	2 990 870	2 908 026
Other provinces					
Portland	2 966 838	3 383 503	3 369 219	3 720 725	3 875 740
Masonry	60 318	65 495	70 709	63 273	66 698
Total	3 027 156	3 448 998	3 439 928	3 783 998	3 942 438
Canada					
Portland	8 565 849	8 441 368	8 281 798	8 358 429	8 428 051
Masonry	327 805	347 229	343 417	315 567	318 822
Total	8 893 654	8 788 597	8 625 215	8 673 996	8 746 873
Exports					
Portland	660 864	734 421	1 071 889	1 390 243	1 817 243
Masonry	19 610	24 053	24 887	38 595	43 158
Total	680 474	758 474	1 096 776	1 428 838	1 860 401
Clinker[2]	658 954	645 377	775 195	1 077 274	1 530 537
Total Sales					
Portland	9 226 714	9 175 789	9 353 687	9 748 672	10 245 294
Masonry	347 415	371 282	368 304	354 162	361 980
Total cement	9 574 129	9 547 071	9 721 991	10 102 834	10 607 274
Total clinker[3]	658 954	645 377	775 195	1 077 274	1 530 537

Source: Statistics Canada.

[1] Does not include amounts used at producers' plant sites. [2] United States Bureau of Mines, Division of Non-Metallic Minerals for years 1975 to 1977 inclusive. Statistics Canada for 1978 and 1979. [3] Interplant shipments are not reported by Statistics Canada.

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 tpy 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.

TABLE 6. CANADA, MINERAL RAW MATERIALS[1] USED BY THE CEMENT INDUSTRY, 1978 AND 1979

Commodity	1978	1979p
	(tonnes)	
Limestone	11 861 135	12 284 058
Shale	588 260	700 458
Clay	869 580	655 977
Gypsum	482 370	481 772
Sand	197 021	349 255
Iron oxide	111 135	116 404
Sandstone	164 277	66 336

Source: Statistics Canada.

[1] Includes purchased materials and material produced from own operations.
p Preliminary.

Federal White Cement completed the construction of a new plant at Woodstock, under the guidance of Lafarge Consultants Ltd. The plant can produce up to 100 000 tpy of white cement. Limestone is purchased from Canada Cement Lafarge's Woodstock quarry.

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. Continued high demand for cement in Alberta necessitated the import of both clinker and cement from outside the region. Production of finished cement, with the help of imported clinker, was actually above the region's rated capacity to produce in 1979. Plant expansions at Exshaw (Canada Cement Lafarge Ltd.) and at Edmonton (Inland Cement Industries Limited) will increase capacity by about 1.3 million tpy.

Canada Cement Lafarge Ltd. operates a cement-manufacturing plant at Fort Whyte, near Winnipeg, Manitoba, capable of producing about 570 000 tpy of cement. 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. The company's Exshaw, Alberta plant has undergone recent expansions including installation of a new kiln and development of a new quarry. A current program will nearly double the present capacity of 726 000 tpy 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.

Inland Cement Industries Limited 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 tpy. 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 t 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 tpy.

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

Pacific region. Genstar's decision to construct a 1 million tpy cement-manufacturing plant in the Vancouver region reflected 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.

TABLE 7. PLANNED CAPACITY CHANGES AS OF END OF 1979

Company	Plant Location	Net Capacity Change Compared With Table 3 (tonnes per year)	Expected Date of Completion	Approximate Cost ($ million)	Remarks
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 preheater, 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: Energy, Mines and Resources Canada.

.. Not available.

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

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.

TABLE 8. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1978 AND 1979

	Starts			Completions			Under Construction		
	1978	1979	% Diff.	1978	1979	% Diff.	1978	1979	% Diff.
Newfoundland	2,865	2,999	+5	3,561	2,611	-27	3,483	2,850	-18
Prince Edward Island	1,210	1,068	-12	1,036	1,173	+13	528	403	-24
Nova Scotia	4,853	4,538	-6	5,745	6,132	+7	5,463	3,634	-33
New Brunswick	5,167	5,021	-3	5,896	5,090	-14	1,888	1,951	-3
Total (Atlantic Provinces)	14,095	13,626	-3	16,238	15,006	-8	11,362	8,838	-22
Quebec	43,671	41,730	-4	54,129	44,288	-18	24,053	20,413	-15
Ontario	71,710	56,887	-21	80,429	76,570	-5	66,106	44,851	-32
Manitoba	12,121	5,772	-52	10,550	8,410	-20	8,048	4,992	-38
Saskatchewan	9,527	11,742	+23	11,383	10,865	-5	8,138	8,640	+6
Alberta	47,925	39,947	-17	43,025	44,492	+3	31,323	25,454	-19
Total (Prairie Provinces)	69,573	57,461	-17	64,958	63,767	-2	47,509	39,086	-18
British Columbia	28,618	27,345	-4	30,779	26,858	-13	15,672	15,413	-2
Total Canada	227,667	197,049	-13	246,533	226,489	-8	164,702	128,601	-22

Source: Statistics Canada.

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.

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.

TABLE 9. WORLD PRODUCTION OF CEMENT, 1968, 1978 and 1979

	1968	1978	1979P
		(thousand tonnes)	
U.S.S.R.	87 502	129 280	136 080
Japan	47 162	84 353	81 650
United States (including Puerto Rico)	67 352	72 471	76 200
People's Republic of China	19 600	68 000	45 360
Italy	29 575	38 493	36 290
West Germany	32 832	32 993	36 290
France	25 637	31 175	31 750
Spain	14 864	32 064	27 220
Brazil	17 281	23 203	..
Poland	11 592	21 678	..
India	11 940	19 561	..
United Kingdom	17 977	16 564	18 140
Republic of Korea	3 574	15 467	..
Turkey	4 728	15 409	..
Mexico	6 008	15 285	..
Romania	7 020	14 000e	..
East Germany	7 553	12 520	..
Greece	4 079	11 333	..
Canada	7 408	10 558	11 835
Other countries	102 816	194 593	316 115
Total	516 500	859 000	816 930

Sources: Energy, Mines and Resources, Ottawa; Cembureau, World Statistical Review, No. 35 and 36; U.S. Bureau of Mines, Mineral Commodity Summaries, 1980.

P Preliminary; e Estimated; .. Not available.

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.

Although individual companies continued 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 wide-

TABLE 10. APPARENT CONSUMPTION OF CEMENT BY THE LEADING PRODUCERS, 1978

	Production[p]	Apparent Consumption	Apparent Consumption
	(000 tonnes)		(kg/capita)
U.S.S.R.	129 280	126 324	483
Japan	84 353	79 187	689
United States (including Puerto Rico)	72 471	74 326	341
People's Republic of China	68 000	66 600[e]	71[e]
Italy	38 493	37 200	656
West Germany	32 993	31 882	520
France	31 175	26 947	506
Spain	32 064	22 028	599
Brazil	23 203	23 343	202
Poland	21 678	21 178[e]	604[e]
India	19 561	20 747	32
United Kingdom	16 564	14 900	267
Republic of Korea	15 467	14 762	403
Turkey	15 409	14 187	329
Mexico	15 285	13 785[e]	206
Romania	14 000[e]	11 000[e]	503[e]
East Germany	12 520	11 920[e]	711[e]
Greece	11 333	6 459	690
Canada	10 558	9 142	389
Other countries	194 593		
Total	859 000		

Sources: Statistics Canada; **Cembureau, World Statistical Review,** No. 36, 1978.

[p] Preliminary; [e] Estimated.

TABLE 11. CANADA, VALUE OF CONSTRUCTION BY PROVINCE, 1978 and 1979

	1978[1]			1979[2]	1980[3]
	Building Construction	Engineering Construction	Total	Total	Total
	($ million)				
Newfoundland	359.9	282.9	642.8	807.7	831.9
Nova Scotia	564.2	434.5	998.7	1 122.4	1 240.4
New Brunswick	509.8	417.9	927.7	1 078.1	1 029.4
Prince Edward Island	111.3	54.3	165.6	164.4	179.1
Quebec	4 768.1	3 759.6	8 527.7	9 394.7	9 797.5
Ontario	7 207.4	3 772.1	10 979.5	11 538.5	12 261.3
Manitoba	977.7	524.7	1 502.4	1 451.8	1 510.0
Saskatchewan	944.9	708.3	1 653.2	2 046.9	2 339.7
Alberta	3 831.3	3 579.1	7 410.4	9 051.2	10 656.9
British Columbia, Yukon and Northwest Territories	2 959.3	2 422.9	5 382.2	5 715.0	6 572.2
Canada	22 233.9	15 956.3	38 190.2	42 370.7	46 418.4

Source: Statistics Canada.

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

TABLE 12. CANADA, VALUE OF CONSTRUCTION BY TYPE, 1978-80

	1978	1979p	1980f
		($ million)	
Building construction			
Residential	13 780	14 153	14 540
Industrial	1 563	1 945	2 178
Commercial	3 856	4 825	5 357
Institutional	1 682	1 966	2 137
Other building	1 353	1 549	1 705
Total	22 234	24 438	25 917
Engineering construction			
Marine	223	250	310
Highways, airport runways	3 035	3 428	3 484
Waterworks, sewage systems	1 804	1 956	2 091
Dams, irrigation	148	189	220
Electric power	3 855	4 073	4 358
Railway, telephones	1 442	1 663	1 913
Gas and oil facilities	3 336	4 197	5 606
Other engineering	2 113	2 177	2 519
Total	15 956	17 933	20 501
Total construction	38 190	42 371	46 418

Source: Statistics Canada.

p Preliminary; f Forecast.

spread, 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 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. In current dollars, construction is credited with about 17 per cent of gross national expenditure. In 1979 capital and repair expenditure on construction was $42.4 billion, up 11 per cent over expenditures in 1978.

The most visible area of construction, residential building, was reduced from 227,667 starts in 1978 to 197,049 starts in 1979. The prospects for anything but a moderate 2 or 3 per cent increase in 1980 are remote, in face of current high interest rates, a high inventory of unsold units and uncertainty about the amount of increase to be expected in the overall cost of living.

A slight increase in the amount of non-residential building offset to some degree the negative effects of the depressed housing market. Engineering construction, which normally constitutes about 40 per cent of total construction expenditures, is beginning to indicate an upturn with projects in the energy, environmental control and transportation industries being planned. Analysts predict engineering construction will account for over 50 per cent of total construction during the 1980s. A healthy and predictable economy results in capital investments in industry expansions which in turn permits the construction industry to plan and operate efficiently.

OUTLOOK

Construction expenditures in Canada in 1979 will be in the range of $46 billion, with the greatest percentage increases expected in Alberta, British Columbia and Saskatchewan. Housing starts could be as low as 180,000. 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 concrete needed, but effective advertising and public relations must continue to be used to encourage its use. 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 to four 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 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 is placed on cement and concrete together. 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 t 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 817 million t, down from about 859 million t in 1978 and below estimates made a few years ago. 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 1980 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
		(cents per hundred pounds)			
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

M.F.N. Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
	(cents per hundred pounds)								
29005-1	4.0	4.0	3.9	3.9	3.9	3.8	3.8	3.7	3.7

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

	1979	1980	1981	1982	1983	1984	1985	1986	1987
	(% ad valorem)								
511.25 Other concrete mixed, per cubic yard	7.5	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated 1978, USITC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Cesium

J.J. HOGAN

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. Cesium, 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, ultraviolet 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.

OCCURRENCE AND RECOVERY

Cesium is widely distributed in the earth's crust at low concentrations (1 to 4 parts per million) in granitic type rocks and in sediments. It also occurs in brines and saline deposits. The most important economic source of the metal is the rare mineral pollucite. Pollucite is usually found in complex, generally well-zoned granitic pegmatite dykes that are rich in lithium minerals, especially lepidolite and spodumene.

Pollucite is a hydrated silicate of aluminum and cesium (H_2O $2CsO$ $2Al_2O_3$. $9SiO_2$). Naturally occurring pollucite contains from 6 to 32 per cent cesium oxide (Cs_2O).

The current small demand for cesium does not encourage exploration for pollucite or other cesium containing minerals. They are usually found in conjunction with exploration for associated minerals, such as tantalum and lithium-bearing minerals. Pollucite ore is generally mined to meet market demand.

The largest known reserves of pollucite are: 372 000 tonnes (t)* at the Bernic Lake mine in Manitoba, Canada; some 135 000 t in the Bikita district of Rhodesia; and 45 000 t 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

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

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). Hudson Bay Mining and Smelting Co., Limited and Kawecki Berylco Industries, Inc. of New York each own 37.5 per cent of Tanco. The remaining 25 per cent interest is held by the Manitoba Development Corporation (MDC), the investment agency of the Manitoba government. 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. As of December 31, 1978 the company's cesium ore reserves consisted of 270 000 t of pollucite averaging almost 23.9 per cent Cs_2O in the main zone, 47 000 t averaging almost 23.9 per cent Cs_2O in one westerly zone and 55 000 t 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. 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 t 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 t with an average Cs_2O content of almost 27 per cent. Of this total, almost 86 per cent was exported to Russia, approximately 8 per cent to the United States, and the remainder went to the United Kingdom, West Germany and Japan. 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. Under the terms of this legislation shipments of cesium in all the above-mentioned forms to all communist countries was banned. 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 t, all exported to the United States. In 1979, a small shipment of pollucite was made to western Europe.

Research and development projects are the major consumers of cesium and cesium compounds. Until 1968, world consumption of cesium metal and cesium compounds was small, probably under 10 t per year. Since then, there has been a major increase in consumption, mainly because of 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 t of pollucite ore from Canada between late 1969 and the end of 1975, which suggests an annual consumption in the range of 52 000 kilograms (kg) of cesium metal equivalent, unless some of the imports were stockpiled. The U.S.S.R. has for several years been doing extensive research in cesium-based MHD generation of electricity, recently in co-operation with the United States.

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 elements 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.

The cesium chapter of the Canadian Minerals Yearbook, 1978, provides greater detail on the above uses for cesium.

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 non-ferrous 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

To date, 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.

The successful development of the MHD power generation appears to have the best potential for significantly increasing the consumption of cesium. The U.S.S.R. has been a leader in MHD power generation research and plans to have the first commercial MHD power plant unit, of 500 megawatts capacity, in operation in the early part of the 1980's. The United States has also been involved in MHD research directly and in cooperation with the U.S.S.R. The 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. 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 abundantly available world's 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 oxides, 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.

Recent European price for pollucite concentrates containing a minimum of 24 per cent Cs_2O fob, as quoted in Metals Bulletin, varied from about $U.S. 1.24 to $U.S. 1.30 per kilogram (kg) of contained Cs_2O. Because of the limited number of pollucite producers and the relatively small demand for pollucite ore the price for pollucite ore would probably be negotiated between buyer and seller. Cesium metal of 99+ per cent purity was quoted in the American Metal Market at $U.S. 225.00 per pound ($U.S. 496.00 per kg) at year end. Cesium compound prices range from about $U.S. 64.00 to $U.S. 82.00 per kg depending on the type of the compounds, purity and quantity purchased. In the United States two firms in California and two in Pennsylvania accounted for all of the cesium products in that country.

TARIFFS

Canada

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
92805-1	Cesium	10	10	15	25
93819-1	Compounds of Cesium	10	10	15	25

MFN reductions under GATT, effective January 1 of year given

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					%				
92805-1	15	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2
93819-1	15	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

United States: (MFN)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						%				
601.66	Pollucite	Remains free								
415.10	Cesium	8.5	8.1	7.7	7.3	6.9	6.5	6.1	5.7	5.3
418.50	Cesium chloride	6.0	5.8	5.5	5.3	5.0	4.8	4.5	4.3	4.0
418.52	Other compounds	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

TARIFFS (concluded)

European Economic Community: (MFN)

		Base Rate %	Concession Rate %
28.05	Cesium & rubidium	5	3.9
28.30	Chlorides, other	15	11.4

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Volume 44, No. 241; Official Journal of the European Communities, Volume 20, No. L289, 1977; Customs Tariff Schedules of Japan, 1977; GATT Documents, 1979.

Chromium

D.G. LAW-WEST

Canada imports all of its chromium requirements, which are largely in the form of ore and ferrochromium. Virtually all imported chromite ores are consumed by the refractory brick industry. The stainless and specialty steel producers have imported all of their ferrochromium since 1975, the last year that ferrochromium was produced domestically. Imports of chromium-bearing materials in 1979 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, the Bird River 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.

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, as a secure source of supply in the event of a dislocation of imports. Although these small deposits are generally satisfactory in grade and composition, further exploration is required to delineate and quantify the resource base. The region has not been systematically explored largely because the mineral rights are held by a large number of small land owners.

WORLD DEVELOPMENTS

The most notable event in the world chromite industry in 1979 was the lifting of trade sanctions against Zimbabwe (Rhodesia). Trade sanctions were initially invoked by the United Kingdom in 1965 and many other countries took similar action by 1968.

Zimbabwe is believed to have vast reserves of high-grade metallurgical chromite. The major Zimbabwe producers are Union Carbide Rhomet (Private) Limited, Rhodesia Chrome Mines Ltd., and Rio Tinto (Rhodesia) Ltd. No production data has been released but the country's current production is estimated to be around 600 000 tonnes (t) of chromite ore per year.

The South African chromite industry remained the largest in the world with a total production in 1979 of 3.3 million t of chromite ore. The country's ferrochromium producers were near capacity production throughout the year, a large improvement over recent years when production was about 80 per cent of capacity. Ferrochromium production in 1979 was approximately 775 000 t, of which about 525 000 t was shipped for export.

The Soviet Union, the number two chromite producer in the world, increased

TABLE 1. CANADA, CHROMIUM IMPORTS, 1978 and 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Imports				
Chromium in ores and concentrates				
United States	6 116	1,488,000	11 122	2,326,000
Mozambique	331	86,000	9 166	1,404,000
Philippines	14 044	2,591,000	3 865	1,296,000
South Africa	1 972	289,000	2 788	540,000
Other countries[1]	11 383	1,547,000	433	346,000
Total	33 846	6,001,000	27 374	5,912,000
Ferrochromium				
United States	11 779	7,836,000	12 704	9,663,000
South Africa	13 500	6,210,000	15 925	7,121,000
Brazil	4 300	1,605,000	4 350	1,786,000
Other countries[2]	853	934,000	1 739	1,941,000
Total	30 432	16,585,000	34 718	20,511,000
Chromium sulphates, including basic				
United States	1 391	793,000	1 379	932,000
United Kingdom	469	305,000	3 383	237,000
West Germany	56	36,000	39	33,000
Poland	-	-	36	24,000
Total	1 916	1,134,000	4 837	1,226,000
Chromium oxides and hydroxides				
United States	1 271	2,402,000	1 780	3,917,000
United Kingdom	265	624,000	75	181,000
West Germany	61	123,000	53	159,000
Other countries[3]	41	95,000	-	-
Total	1 638	3,244,000	1 908	4,257,000
Chrome dyestuffs				
West Germany	7	61,000	7	162,000
United States	9	44,000	9	76,000
Netherlands	2	17,000	9	45,000
Other countries[4]	7	42,000	15	60,000
Total	25	164,000	40	343,000

Source: Statistics Canada.

[1] Includes West Germany, Netherlands, Greece, Sweden, Finland, Turkey. [2] Includes Norway, Sweden, Yugoslavia, Japan. [3] Includes Netherlands and Poland. [4] Includes Italy, People's Republic of China, Poland, Switzerland and United Kingdom.
P Preliminary; - Nil.

ore output to 2.4 million t in 1979. The country's ore exports declined to about 750 000 t due mainly to increased internal consumption for ferrochromium production.

With an annual output estimated at 750 000 t, Turkey has overtaken Zimbabwe as the world's third largest chromite producer. Turkey is currently expanding its ferrochromium production capacity to more than double the present 60 000 tpy.

USES AND TECHNOLOGY

The three commercial grades of chromite, the only ore mineral of chromium are 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 and some is used for the production of 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 improves the resistance to oxidation and corrosion, and increases 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 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. & Supply Co. together developed 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 also used for refractory purposes in mortars, ramming gun mixes, or directly for furnace repair.

Refractories composed of both chromite and magnesite are used in furnaces wherever

TABLE 2. CANADA, CHROMIUM TRADE AND CONSUMPTION, 1965, 1970, 1975-79

	Imports		Consumption[2]	
	Chromite[1]	Ferro-chromium[2]	Chromite	Ferro-chromium
	(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	33 846	30 432	27 472	36 572
1979P	27 374	34 718	27 205	24 037

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Chromium content. [2] Gross weight.
P Preliminary.

basic slags and dust are encountered, 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 has 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 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 the separation of various types of bricks by a chemically neutral substance is desirable. Castables and ramming mixes are used mainly in open-hearth furnaces.

TABLE 3. WORLD CHROMITE MINE PRODUCTION AND RESERVES, 1978 and 1979

Country	Mine Production 1978	Mine Production 1979[e]	Reserves[e]
	(000 tonnes, gross weight)		
Republic of South Africa	3 145	3 175	2 300 000
Turkey	680	680	5 000
Zimbabwe[e]	599	599	1 000 000
Philippines	532	544	3 000
Other market economy countries	2 314	2 268	48 000
Centrally planned economies	2 310	2 359	100 000
World total	9 580	9 625	3 450 000

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, January, 1980.

[e] Estimated.

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 saccharin; 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.

OUTLOOK

The outlook for chromium is closely linked to that of stainless steels. While stainless steel production is presently at a high level it is questionable whether it can be maintained. Should there be a slowdown in this steel production, there would be a marked softening of the chromium market. The fact that various countries are creating stockpiles of strategic materials such as chromium tends to further cloud the short and medium term outlook for chromium. A large build-up of stocks could create a false increase in demand followed by an oversupply situation.

Overshadowing the entire chromium market is the uncertainty of continuous supply of chromium from South Africa, due to its fragile political stability. An interruption in supply from this source would have serious economic consequences in Canada and the rest of the western world. The more serious problem would be physical availability rather than increased prices as other producing countries could not quickly increase chromium production to fill the gap left by the loss of the South African supply.

PRICES

Chrome prices published by **Metals Week**

	December 31, 1978	December 31, 1979
	($U.S.)	
Chrome ore, dry basis, fob cars Atlantic ports		
Transvaal 44% Cr_2O_3, no ratio (per tonne)	54.00-58.00	54.00-58.00
Turkish 48% Cr_2O_3, 3:1 ratio (per tonne)	105.00	110.00
Chromium metal		
Electrolytic 99.8% fob shipping point (per kg)	1.36	1.59
	(¢U.S.)	
Ferrochrome, fob shipping point (per kg Cr content)		
High carbon 66-70% Cr, 5-6.5% C	90.39-99.21	99.21-116.84
Imported 60-65% charge chrome	80.47-87.08	105.82-114.64
Low carbon 67-73% Cr, 0.025% C	176.37	209.44

fob - Free on board.

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

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
37506-1	5.0	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
92821-1	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

UNITED STATES

Item No.		
473.10-20	Chrome colours	5%
606.24	Ferrochromium, containing over 3% by weight of carbon, on chromium content	0.625 cents per pound
632.86	Chromium alloys, unwrought, 96-99% silicon	9%

		1979	1980	1981	1982	1983	1984	1985	1986	1987
		(per cent)								
420.98	Chromate and dichromate	2.9	2.8	2.8	2.7	2.7	2.6	2.5	2.5	2.4
531.21	Chrome refractories	12.5	11.8	11.0	10.3	9.6	8.8	8.1	7.3	6.6
601.15	Chrome ore	Remains free								
606.22	Ferrochromium, not containing over 3% by weight of carbon	4.0	4.0	4.0	3.9	3.7	3.6	3.4	3.3	3.1

TARIFFS (Cont'd.)

		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(per cent)				
632.18	Chromium metal, unwrought (duty on waste and scrap suspended)	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.88	Chromium alloys, unwrought, not otherwise specified	9.7	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

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 proximity to growth centres in which clay products will be consumed.

USES, TYPES AND LOCATION OF CANADIAN DEPOSITS

Common clays and shale. Common clays and shales are the principle 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^{0}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

TABLE 1. CANADA, PRODUCTION OF CLAY AND CLAY PRODUCTS FROM DOMESTIC SOURCES, 1977-79

	1977r	1978	1979p
		($000)	
Production from domestic sources, by provinces			
Newfoundland	550	592	450
Nova Scotia	4 547	4 700	5 000
New Brunswick	1 894	2 300	2 500
Quebec	16 989	17 220	22 747
Ontario	56 252	59 667	68 260
Manitoba	2 673	2 000	2 800
Saskatchewan	3 065	3 146	3 100
Alberta	10 518	11 200	11 500
British Columbia	6 873	8 810	9 000
Total Canada	103 361	109 635	125 357
Production[1] from domestic sources, by products			
Clay, fireclay and other clay	...	...	...
Brick - soft and stiff mud process and dry press	70 751	80 508	88 377
- fancy and ornamental, sewer brick and paving brick	898	...	...
Structural hollow blocks	...	...	...
Drain tile	3 554	3 205	3 760
Sewer pipe	(2)	(2)	(2)
Flue linings	2 875	2 510	3 134
Pottery glazed or unglazed (including coarse earthenware, stoneware and all pottery)	(2)	(2)	(2)
Other products	20 814	15 782	21 311
Small establishments not reporting detail	4 469	7 630	8 775
Total	103 361	109 635	125 357

Source: Statistics Canada.

[1] Producers' shipments. Distribution for 1979 estimated by Statistics Section, Mineral Policy Sector.
[2] Included in "Other products".

p Preliminary; r Revised; ... Figures not appropriate or not applicable.

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. 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 granite. 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 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 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 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 some encouraging results were obtained. 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

TABLE 2. CANADA, IMPORTS AND EXPORTS OF CLAY, CLAY PRODUCTS AND REFRACTORIES, 1978 and 1979

	1978		1979p	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
Clays				
Bentonite	295 708	7 811	612 757	20 865
Drilling mud	77 355	13 301	44 214	12 534
China clay, ground or unground	181 887	12 935	273 427	19 652
Fire clay, ground or unground	34 876	1 971	52 245	2 810
Clays, ground or unground nes	164 723	7 294	119 567	6 674
Clays and earth, activated	13 319	4 643	15 001	7 063
Subtotal, clays	767 868	47 955	1 117 211	69 598
Clay Products	(M)		(M)	
Brick-building, glazed	3 275	413	2 045	336
Brick-building, nes	128 406	2 269	76 882	4 224
Building blocks	..	2 048	..	2 458
Clay bricks, blocks and tiles, nes	..	3 585	..	5 431
Ceramic tiles	(m^2)		(m^2)	
under 2 1/2" x 2 1/2"	1 611 186	7 700	1 372 577	6 896
over 2 1/2" x 2 1/2"	5 935 802	21 931	5 737 519	31 646
Subtotal, brick, blocks, tile	..	37 946	..	50 991
Tableware, ceramics	..	80 504	..	89 729
Porcelain, insulating, fitting	..	13 747	..	12 903
Pottery settings and firing supplies	..	747	..	872
Subtotal, porcelain pottery	..	94 998	..	103 504
Refractories	(tonnes)		(tonnes)	
Firebrick				
Alumina	26 848	12 642	27 832	17 314
Chrome	574	563	1 511	1 226
Magnesite	15 468	9 162	15 876	11 071
Silica	6 948	1 897	4 896	1 510
nes	107 069	28 360	177 022	46 553
Refractory cements and mortars	..	9 117	..	10 996
Acid-proof brick	..	251	..	159
Crude refractory materials, nes	10 662	2 250	9 568	2 586
Grog (refractory scrap)	12 844	1 409	12 544	1 212
Refractories, nes	..	5 475	..	6 389
Subtotal refractories	..	71 126	..	99 016
Total clay, clay products and refractories	..	252 025	..	323 109
Imports				
By main countries				
United States	..	127 374	..	174 366
United Kingdom	..	53 300	..	63 900
Italy	..	15 389	..	23 619
Japan	..	22 476	..	19 761
West Germany	..	7 735	..	10 558
Spain	..	3 888	..	5 181
Greece	..	1 562	..	5 134
France	..	4 234	..	3 242
South Korea	..	2 439	..	3 183
Philippines	..	2 586	..	1 534
Other countries	..	11 042	..	12 631
Total	..	252 025	..	323 109

TABLE 2. (cont'd.)

	1978		1979P	
	(tonnes)	($000)	(tonnes)	($000)
Exports				
Clays, ground and unground	2 893	240	1 311	134
Clay products	(M)		(M)	
Building brick, clay	15 656	2 946	9 537	1 865
Clay bricks, blocks, tiles, nes	..	1 393	..	1 546
Subtotal, bricks, blocks, tiles	..	4 339	..	3 411
High-tension insulators and fittings	..	3 523	..	3 599
Tableware, nes	..	5 817	..	6 841
Subtotal porcelain tableware	..	9 340	..	10 440
	(tonnes)		(tonnes)	
Refractories				
Firebrick and similar shapes	53 200	19 425	73 900	32 736
Crude refractory materials	1 081 685	2 548	1 023 750	2 310
Refractory, nes	..	7 062	..	12 077
Subtotal refractories	..	29 035	..	47 123
Total clays, clay products and refractories	..	42 954	..	61 108
Exports				
By main countries				
United States	..	28 251	..	31 663
Venezuela	..	2 090	..	8 949
Mexico	..	505	..	3 581
Saudi Arabia	..	271	..	1 913
Dominican Republic	..	771	..	1 653
Indonesia	..	526	..	1 580
Zambia	..	1 444	..	809
United Kingdom	..	1 099	..	753
Australia	..	533	..	628
Ecuador	..	427	..	617
Colombia	..	427	..	538
South Africa	..	886	..	328
Other countries	..	5 724	..	8 096
Total	..	42 954	..	61 108

Source: Statistics Canada

P Preliminary; .. Not available; nes: Not elsewhere specified; (M) = thousands; (m^2) = square metres; - Nil.

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, non-plastic 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° 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 some very 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 long firing range a and a fired colour from buff to grey. They range from commercially inferior material through semirefractory to firebrick clays. They should have low fire shrinkage, enough plasticity and toughness for shaping, no lime- or iron-bearing concretions and very little coarse sand.

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

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

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

CANADIAN INDUSTRY AND DEVELOPMENTS

Clay products manufacturers using domestic sources include establishments primarily engaged in the manufacture of clay brick, drain tile, structural tile and sewer pipe from Canadian clays. The value of clay products produced from domestic sources in 1979 was approximately $125 million, up from the final 1978 figure of $109.6 million. The brick and tile manufacturing industry accounts for nearly 75 per cent of the total value of this group of clay products.

Clay products manufacturers using imported clays include operations primarily involved in the manufacture of products such as electrical porcelains, glazed floor and wall tiles, pottery, chinaware and sanitary ware. The estimated value of shipments of this group of products during 1979 is $68 million.

TABLE 3. CANADA, SHIPMENTS OF CLAY PRODUCTS PRODUCED FROM IMPORTED CLAY[1], 1976-78

	1976	1977	1978P
		($000)	
Electrical porcelains	24 874	20 705	(2)
Glazed floor and wall tile	7 950	8 966	(2)
Sanitaryware	18 079	..	(2)
Pottery, art and decorative ware	-	..	(2)
All other products	8 104	31 478	64 767
Total	59 007	62 306	64 767

Source: Statistics Canada.
[1] Does not include refractories. (2) Included with "All other products".
P Preliminary; .. Not applicable or not available; - Nil.

TABLE 4. CANADA, SHIPMENTS OF REFRACTORIES, 1976-78

	1976		1977		1978P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Castables	17 826	5 374	21 530	6 495	29 835	10 170
Firebrick and similar shapes	94 019	30 615	(1)	(1)	94 651	43 976
Cement, mortars, castables, plastics etc.	39 961	9 864	32 465	7 789	45 918	12 869
All other products	..	19 183	..	55 886	..	30 330
Total	..	65 036	..	70 170	..	97 345

Source: Statistics Canada.
(1) Confidential included with "All other products".
P Preliminary; .. Not applicable or not available.

TABLE 5. CANADA, CLAY AND CLAY PRODUCTS, PRODUCTION AND TRADE 1965, 1970, 1975-79

	Production					
Year	Domestic Clays	Imported Clays	Total	Refractory Shipments[1]	Imports	Exports
			($ million)			
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	25.1
1976	98.5	59.0	157.5	65.0	178.8	25.2
1977	103.4	62.3	165.7	70.2	220.0	30.6
1978	109.6	64.8	174.4	97.3	252.0	43.0
1979P	125.4	..	..	..	323.1	61.1

Source: Statistics Canada.
[1] Includes fire brick and similar shapes, refractory cements, mortars, castables, plastics, etc., plus all other products shipped.
P Preliminary; .. Not available.

TABLE 6. CANADA, CONSUMPTION (AVAILABLE DATA) OF CHINA CLAY, BY INDUSTRIES, 1977 and 1978

	1977	1978p
	(tonnes)	
Paper and paper products[1]	109 236	145 658
Ceramic products	10 452	9 351
Paint and varnish	4 199	4 248
Rubber and linoleum	3 708	4 322
Other products[2]	47 457	52 588
Total	175 052	216 167

Source: Energy, Mines and Resources Canada.

[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.

The value of imported clay products comprising brick, blocks, tile, tableware, porcelain and pottery was approximately $154 million in 1979. The value of imported refractory products was approximately $99 million during the same period.

IXL Industries Ltd. of Medicine Hat, Alberta announced a plant expansion that will more than double present output by its Redcliff Pressed Brick Division. Clayburn Industries Ltd. of Abbotsford, British Columbia expanded its brick manufacturing capacity to produce an additional 10 000 tonnes (t) of brick products a year.

A symposium addressing research and development needs of the Canadian glass, ceramics and allied industries was sponsored by the Canada Centre for Mineral and Energy Technology and the Ontario Research Foundation.

WORLD REVIEW

United States mine production of clays in 1979 increased to approximately 54 million t valued at about $870 million.

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.

In Brazil, a second kaolin project is being developed in the Capim River area of Para by Caulim do Para Ltd., a joint venture of the Brazilian Constructura Mendes Junior Group and J.M. Huber Corporation. The mine and processing facilities are to have an estimated annual capacity of about 270 000 t.

In Western Australia a preliminary agreement to develop a 220 000 tpy kaolin deposit about 50 kilometres northeast of Perth was signed by Engelhard Minerals & Chemicals Corporation. Current reserves are estimated to last about 10 years.

Emphasis continued to be placed on improved energy efficiency by using lower cost or alternative fuel sources and on improved heat 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

The clay and clay products industry will continue to place increasing emphasis on improving energy efficiencies. The brick and tile industry made its commitment to reduce energy consumption 23 per cent between 1973-74 and 1985. This goal will be easily met based on trends to date. Research and development is expected to 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 1979. Steel processes such as the basic oxygen furnace, pressure pouring and continuous casting, represent relatively new refractory requirements. New products and designs have also been dictated by changes in reducing atmospheres in the chemical and petrochemical industry, by increased 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, 1979.**

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.

PRICES

United States clay prices, according to **Chemical Marketing Reporter,** December 31, 1979.

	($ 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 (koalin)	
Water washed, fully calcined, bags, carlots, fob Georgia	175.00-208.00
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 than $100 per 1,000, rectangular shaped, not to exceed 100 x 25 in.^{3} for use in kiln repair or other equipment of a manufacturing establishment	free	free	free	free

CANADA

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
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	22 1/2	5
28200-1	Building brick and paving brick	10	10	22 1/2	6 1/2
28205-1	Manufactures of clay or cement, nop	12 1/2	12 1/2	22 1/2	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	17 1/2	20	free
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	32 1/2	35	free
	General Agreement on Tariffs and Trade		17 1/2		
28415-1	Earthenware tiles, nop	12 1/2	20	35	12 1/2
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	27 1/2	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, semi-porcelain or white granite, excluding earthenware articles	free	20	35	free
28705-1	Articles of chinaware, for mounting by silverware manufacturers	12 1/2	17 1/2	22 1/2	11 1/2
28710-1	Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware	free	10	35	free
28800-1	Stoneware and Rockinghamware and earthenware, nop	17 1/2	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	12 1/2	20	35	12 1/2

TARIFFS (cont'd.)

MFN Reductions under GATT (effective January 1 of year given)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
28110-1	Firebrick, nop	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
28200-1	Building brick and paving brick	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
28205-1	Manufactures of clay or cement, nop	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
28300-1	Drain tiles, not glazed	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
28400-1	Drain pipes, sewer pipes and earthenware fittings therefor; chimney linings or vents, chimney tops and inverted blocks glazed or unglazed, nop	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28405-1	Earthenware tiles, for roofing purposes	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28415-1	Earthenware tiles, nop	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
28600-1	Earthenware and stoneware, viz: demijohns, churns or crocks, nop	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28700-1	All tableware of china, porcelain, semi-porcelain or white granite, excluding earthenware articles	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28705-1	Articles of chinaware, for mounting by silverware manufacturers	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
28710-1	Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28800-1	Stoneware and Rockinghamware and earthenware, nop	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
28805-1	Chemical stoneware	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0

TARIFFS (cont'd.)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
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	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
					(¢ per long ton)					
521.71	Common blue clay and other ball clays, not beneficiated	42.0	41.5	41.0	40.5	40.0	39.5	39.0	38.5	38.0
521.74	Common blue clay and other ball clays wholly or partly beneficiated	85.0	84.0	83.0	82.0	81.0	80.0	79.0	78.0	77.0
					¢ per lb. + % ad valorem					
521.87	Clays artifically activated with acid or other material	0.05¢ +6.0%	0.04¢ +5.6%	0.04¢ +5.1%	0.03¢ +4.7%	0.02¢ +4.3%	0.02¢ +3.8%	0.01¢ +3.4%	0.01¢ +2.9%	- +2.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc.

Coal and Coke

J.A. AYLSWORTH and H.J. WEYLAND

The year 1979 was another one of growth for the Canadian coal industry. Production, consumption and imports were up, while exports declined slightly. The domestic thermal electric industry was the most active in terms of new projects, while the export sector continued to give promise of major developments in the 1980s. Several new coal-fired electricity generating facilities were in the construction or planning stage. Over 2 million tonnes (t) of western Canadian thermal coal was transported to markets in Ontario during the first full year of operation of the new delivery system developed to serve Ontario Hydro, while nearly 500 000 t of coking coal moved from Nova Scotia to Hamilton.

STATISTICAL REVIEW

The volume and value of coal production rose to record levels in Canada in 1979. Production of clean coal increased to 33.0 million t in 1979, up 2.5 million t or 8 per cent from 30.5 million t in 1978. Production of bituminous and sub-bituminous coal increased to 18.4 and 9.6 million t, up from 17.1 t and 8.3 million t, respectively. Lignite production remained virtually unchanged at 5.0 million t. The average fob minesite value of bituminous coal produced in 1979 was $41.79 per t while the value of sub-bituminous coal was $4.55 per t and lignite $4.34 per t.

In terms of overall output, Alberta produced 14.9 million t of bituminous and sub-bituminous coal, British Columbia 10.6 million t of bituminous coal, Saskatchewan 5.0 million t of lignite coal, Nova Scotia 2.2 million t and New Brunswick 301 000 t of bituminous coal. Ontario was once again the leading coal consumer, utilizing 17.6 million t of coal. Alberta consumed 9.3 million t, Saskatchewan 5.1 million t, Nova Scotia 1.5 million t, New Brunswick 244 000 t, Quebec 450 000 t, Manitoba 295 000 t, and British Columbia 114 000 t. In 1979 8.1 million t of coking or metallurgical coal was consumed in Canada. Of this amount 7.1 million t was consumed in Ontario, 636 000 t in Nova Scotia and the rest in British Columbia and Saskatchewan. Another 2.1 million t of coal was utilized by the general industry and space heating sector.

TRADE

Canadian imports and exports, which had almost been in balance in 1978, were weighted in favour of imports again in 1979. Imports reached a record level of 17.5 million t in 1979, the highest level since 1970. Exports totalled 13.7 million t, down slightly from 1978. The value of coal imports rose to $1 billion, up 30 per cent from $790 million in 1980. Exports were valued at $785 million, down slightly from $790 million in 1978.

The volume of both coking and thermal imports was up in 1979 over 1978 as central Canadian consumers replaced coal run down during the coal strikes in the United States

TABLE 1. CANADA, COAL PRODUCTION[1] BY TYPES, PROVINCES AND TERRITORIES, 1978 AND 1979

	1978		1979	
	(000 t)	($ 000)	(000 t)	($ 000)
Bituminous				
Nova Scotia	2 650	116,322	2 157	103,279
New Brunswick	315	10,042	310	10,260
Alberta	5 115	212,616	5 349	190,059
British Columbia	9 061	379,489	10 616	466,801
Total	17 141	718,469	18 432	770,399
Sub-bituminous				
Alberta	8 278	36,135	9 569	43,562
Lignite				
Saskatchewan	5 058	21,520	5 012	21,770
All types, Canada total	30 477	776,124	33 013	835,731

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production represents clean coal output, plus raw coal sales from mines where there is a preparation plant; plus raw coal shipments from mines where there is no preparation plant.

TABLE 2. CANADA, COAL PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, 1969-79

	Production	Imports	Exports	Domestic Consumption
		(tonnes)		
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	30 476 855	14 119 424	14 000 718	31 738 310
1979	33 013 000	17 524 382	13 698 618	34 764 012

Sources: Statistics Canada; Energy, Mines and Resources Canada.

in 1978. Thermal coal imports from the United States to Ontario Hydro grew to 9.8 million t in 1979, up 23 per cent from 8.0 million t in 1978. Coking coal imports grew to 6.8 million t, up 28 per cent from 5.2 million t in 1978, while imports for general industry and other users remained virtually unchanged at 1.3 million t.

Coke production grew by 16 per cent to 5.8 million t from 5.0 million t in 1978. Coke imports fell by 30 per cent to

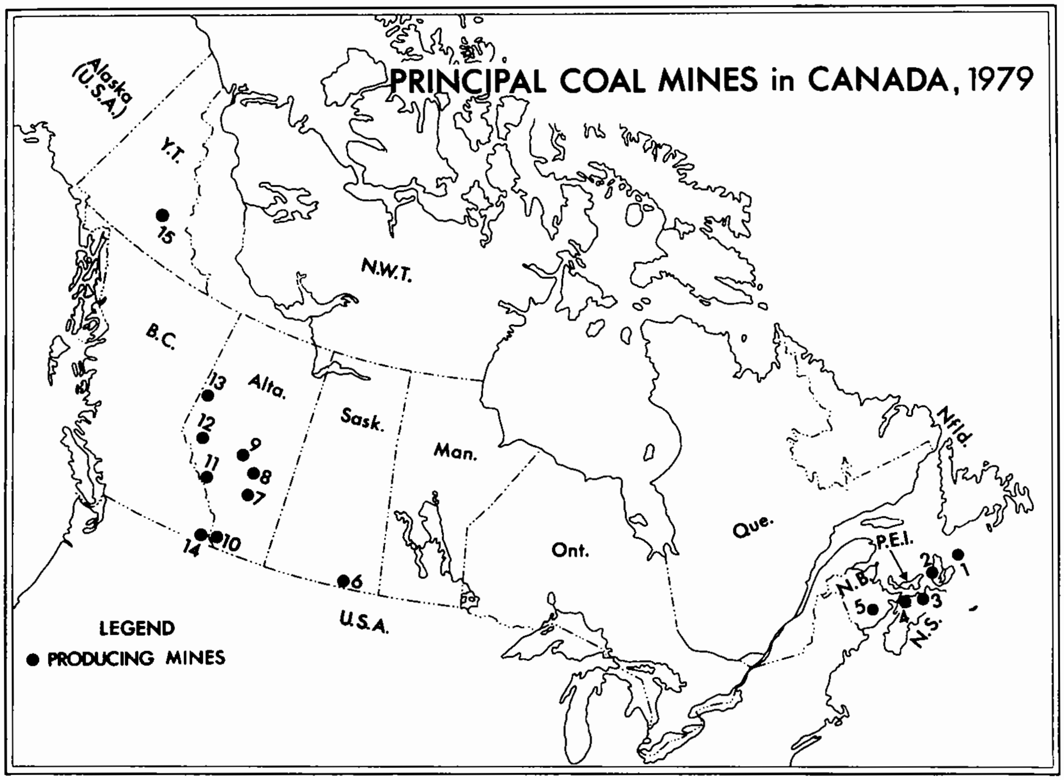


TABLE 3. PRINCIPAL COAL PRODUCERS IN 1979

Company and Mine Location	1979 Raw Coal Production	Coal Rank	Chief Markets	Remarks
(Numbers refer to locations on map above)	(000 tonnes)			
Nova Scotia				
1. Cape Breton Development Corporation (DEVCO)				
Lingan Mine, Lingan	1 492	Hvb A	Power generation	Underground
No. 26, Glace Bay Colliery	731	Hvb A	Metallurgical, Industrial, Domestic	Underground
Prince Mine, Point Aconi	162	Hvb A	Power generation	Underground
1. Thomas Brogan Limited Florence	41		Power generation Residential	Surface
2. Evans Coal Mines Limited St. Rose	31	Hvb B	Power generation Residential	Underground

TABLE 3 (cont'd)

Company and Mine Location	1979 Raw Coal Production (000 tonnes)	Coal Rank	Chief Markets	Remarks
3. Thorburn Mining Limited Stellarton	42		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	310	Hvb A	Power generation Paper mills	Surface
Saskatchewan				
6. Manitoba and Saskatchewan Coal Co. (Limited) M&S Mine, Bienfait	342	Lig A	Power generation Industrial	Surface
Boundary Dam Mine, Estevan	1 678	Lig A	Power generation	Surface
6. Manalta Coal Ltd. Klimax Mine, Estevan	559	Lig A	Power generation Industrial	Surface
6. Manalta Coal Ltd. Utility Mine, Estevan	2 102	Lig A	Power generation	Surface
6. Saskatchewan Power Corp., Souris Valley Coal Mine, Estevan	331	Lig A	Power generation	Surface
Alberta				
Sub-bituminous Mines				
7. Manalta Coal Ltd. Roselyn Mine, Sheeness	167	Sub C	Power generation	Surface
8. Manalta Coal Ltd. Vesta Mine, Halkirk	811	Sub C	Power generation Residential	Surface
8. Forestburg Collieries Limited Diplomat Mine, Forestburg	685	Sub C	Power generation Residential	Surface
9. Manalta Coal Ltd. Whitewood Mine, Wabamun	1 769	Sub A & B	Power generation	Surface
Highvale Mine, Sundance	6 041	Sub C	Power generation	Surface
Bituminous Mines				
10. Coleman Collieries Limited Vicary Creek, Coleman	91	Mvb	Japan for coke-making	Underground
Tent Mountain, Coleman	1 162	Mvb	Japan for coke-making	Surface

TABLE 3 (cont'd)

Company and Mine Location	1979 Raw Coal Production (000 tonnes)	Coal Rank	Chief Markets	Remarks
11. The Canmore Mines, Limited Canmore	56	An	Japan for coke-making	Underground, operations ceased during 1979
12. Cardinal River Coals Ltd. Cardinal River Mine	1 918	Mvb	Japan for coke-making	Surface
12. Luscar Sterco Ltd. Coal Valley Mine	3 227	Mvb	Ontario Hydro and West Germany	Surface mine opened in 1978
13. McIntyre Mines Limited Smoky River Mines, Grande Cache	1 156 750	Lvb	Japan for coke-making	Surface and underground
British Columbia				
14. Kaiser Resources Ltd. Michel Colliery, Natal Harmer Ridge, Sparwood	8 288	Lvb	Japan for coke-making	Surface and underground (hydraulic mining)
14. Fording Coal Limited Fording Mine, Fording Valley	4 758	Lvb	Japan for coke-making	Surface
14. Byron Creek Collieries Limited, Corbin	893	Mvb	Ontario and Europe for steam generating	Surface
Yukon				
15. Cyprus Anvil Mining Corporation, Carmacks Coal Mine, Carmacks	15	Hvb B	Anvil lead-zinc mine for heating and concentrate drying	Underground

Sources: Statistics Canada; Energy, Mines and Resources Canada.

Note: An - Semi-anthracite; Lvb - Low volatile bituminous ; Mvb - Medium volatile bituminous; Sub - Sub-bituminous; Lig - Lignite; Hvb - High volatile bituminous.

382 000 t, while exports grew by 5 per cent to 229 000 t.

PRODUCTION AND MINE DEVELOPMENT

British Columbia

Production of clean coal reached a new record level of 10.6 million t in 1979, up 16 per cent over the 1978 figure of 9.1 million t. Raw coal production totalled 14 million t in 1979. Three coal operations in the southeastern corner of the province accounted for all of B.C.'s production. Kaiser Resources Ltd. produced 8.3 million t of raw coal from its two mines near Sparwood, up 12 per cent from 1978. Exports of clean coal to Japan grew to 4.4

million t, while exports to 12 other countries totalled 1.6 million t.

Fording Coal Limited remained British Columbia's second-largest producer in 1979 with a raw coal output of 4.8 million t - also up nearly 12 per cent from 1978. In addition to spot shipments to Greece, France and Belgium, Fording marketed 2.9 million t of coking coal to the Japanese steel industry. Byron Creek Collieries Limited registered the greatest relative increase in production reaching 893 000 t in 1979, up nearly 67 per cent over the 1978 output of 536 000 t. Byron Creek markets the majority of its coal to Canadian customers, including Ontario Hydro and several small industrial users, while about 10 per cent of its coal is sold to Japan.

Exploration, drilling and other pre-development work continued in a number of areas in British Columbia in 1979 as potential developers prepared for a growth of coking and thermal demand from offshore markets. In the northeastern region of the province a large number of companies are actively involved in various stages of development from very preliminary exploration to detailed feasibility studies. Some of the companies involved in this area include: Amalgamated Brameda-Yukon Limited, BP Canada Inc., Brascan Resources Limited, Cinnabar Peak Mines Ltd., Denison Mines Limited, Gulf Canada Limited, Imperial Oil Limited, Pacific Petroleum Ltd., Pan Ocean Oil Ltd., Petro Canada, Teck Corporation and Utah Mines Ltd.

Work also continued in several other regions of British Columbia including the southeastern, central and Vancouver Island areas. In the southeast, both existing and potential producers are working to bring new production on stream in the early 1980s. Crows Nest Industries Limited, Fording Coal Limited, Kaiser Resources Ltd., Pan Ocean Oil Ltd., Rio Algom Limited and others are involved in a number of potential new coking and thermal mining operations. In central British Columbia and on Vancouver Island several thermal coal prospects are under consideration. British Columbia Hydro and Power Authority, Cyprus Anvil Mining Corporation, Luscar Ltd., and Norco Resources Ltd. are some of the companies involved in central British Columbia and the Vancouver Island region.

TABLE 4. CANADA, RAW COAL PRODUCTION[1] BY RANK, PROVINCE AND TYPE OF MINING, 1979

	Production[1]	
	Underground	Surface
	(000 tonnes)	
Bituminous		
Nova Scotia	2 492	41
New Brunswick	-	335
Alberta	1 303	6 557
British Columbia	846	13 593
Sub-bituminous		
Alberta	16	9 553
Lignite		
Saskatchewan	-	5 012
Canada, 1979	4 657	35 091
1978	5 433	30 788
Total, all mines		
1979	39 748	
1978	36 211	

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Raw coal production only; - Nil.

Yukon and Northwest Territories

The Carmacks coal mine owned by the Cyprus Anvil Mining Corporation remains the only producing coal mine north of the 60th parallel of latitude. Production was 15 000 t in 1979, virtually unchanged from the year before. Preliminary exploration studies are under way on several coal deposits in the Yukon and Northwest Territories.

Alberta

Salable coal production grew to 14.9 million t in 1979, up 11 per cent over the 1978 level of 13.4 million t. Sub-bituminous production accounted for most of this increase, growing from 8.3 to 9.6 million t while bituminous production grew marginally from 5.1 to 5.3 million t. Overall raw coal production in Alberta totalled 17.4 million t.

TABLE 5. DISPOSITION OF DOMESTIC COAL PRODUCTION, 1979

Destination	Originating Province					
	Nova Scotia	New Brunswick	Sask.	Alberta	British Columbia	Canada
	(000 tonnes)					
Railways in Canada	-	-	44	-	-	44
Newfoundland	2	-	-	-	-	2
Prince Edward Island	14	-	-	-	-	14
Nova Scotia	1 398	3	-	77	-	1 478
New Brunswick	57	187	-	-	-	244
Quebec	56	120	-	-	-	176
Ontario	449	-	82	1 542	668	2 741
Manitoba	-	-	219	23	46	288
Saskatchewan	-	-	4 639	162	-	4 801
Alberta	-	-	-	9 372	-	9 372
British Columbia	-	-	-	5	226	231
Total Canada	1 976	310	4 984	11 181	940	19 391
United States	-	-	29	12	-	41
Japan	-	-	-	3 008	7 477	10 485
Other	499	-	-	877	1 796	3 172
Total shipments	2 475	310	5 013	15 078	10 217	33 089

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Salable coal (raw coal, clean and middling sales); - Nil.

Sub-bituminous coal was produced in over a dozen mines, most of which were located in the Plains region. With an output of 6.0 million t, the Highvale Mine, operated by Manalta Coal Ltd., was the largest of the Plains coal mines while the nearby Whitewood Mine produced 1.8 million t. Both mines supply the Wabamun and Sundance power stations of Calgary Power Ltd.

Other major mines producing thermal coal included the Vesta Mine near Halkirk and the Roselyn Mine near Sheerness, producing 811 000 t and 167 000 t of coal, respectively, in 1979, and the Diplomat Mine at Forestburg which produced 685 000 t. The former mines are operated by Manalta Coal Ltd. while the latter mine is owned and operated by Forestburg Collieries Limited.

Five mines produced bituminous coal in Alberta in 1979, four serving export coking coal markets and the fifth producing medium-volatile thermal coal for both domestic and export markets. This latter mine, the Coal Valley Mine of Luscar Sterco Ltd., began production in 1978 and in 1979 its raw coal output reached 3.5 million t. Over 1 million t of coal was shipped from this mine to Ontario Hydro through the newly completed coal terminal at Thunder Bay, while over 400 000 t were exported to West Germany.

The other four mines producing bituminous coal exported their output to Japanese steel mills as coking coal. McIntyre Mines Limited and Cardinal River Coals Ltd. each produced 1.9 million t of raw coal. Spot shipments from these mines were made to South American and Asian markets, and Cardinal River supplied over 300 000 t of contract coal to South Korea. Raw coal output from the two mines of Coleman Collieries Limited was approximately 1.3 million t in 1979, up by 100 000 t over 1978. Alberta's smallest coking coal producer, The Canmore Mines, Limited suspended operations indefinitely in July. The mine had been supplying semi-anthracite coal to Japanese steel industry consumers for a number of years, but risig costs in combination with other factors resulted in its closing. Output for 1979 totalled 56 000 t.

Saskatchewan

Coal production remained static in Saskatchewan in 1979 at just over 5 million t of salable coal. Over 4.5 million t of this coal was marketed to utility and other consumers within the province, while shipments to Manitoba totalled 219 000 t. Just over 80 000 t of lignite coal was shipped from Saskatchewan to industrial markets in northwestern Ontario.

Five mines are currently operating in Saskatchewan. Manalta's Utility Mine near Estevan produced 2.1 million t of raw coal, while the M&S Boundary Dam Mine produced 1.7 million t. Output from the Manitoba and Saskatchewan Coal Company (Limited) and Saskatchewan Power Corporation's Souris Valley Mines reached 342 000 t and 331 000 t, respectively, while the Klimax Mine operated by Manalta Coal Ltd. produced 559 000 t.

New Brunswick

Coal output in New Brunswick remained virtually unchanged in 1979 at 310 000 t. All of this coal is mined by N.B. Coal Limited, a provincial Crown corporation. The major customer for this output is the New Brunswick Electric Power Commission, which consumed 198 000 t of coal in 1979, while other markets included industrial consumers in Quebec. Approximately 120 000 t of New Brunswick coal was shipped to this latter market in 1979.

Nova Scotia

Coal production decreased in Nova Scotia in 1979 to 2.2 million t, down nearly 20 per cent from 2.7 million t in 1978. Consumption of thermal coal for electricity generation decreased by 9 per cent from 711 000 t in 1978 to 645 000 t in 1979, while exports dropped 33 per cent from 710 000 t in 1978

TABLE 6. EXPORTS OF CANADIAN COAL, 1978 AND 1979

Country	1978 (000 t)	1978 ($000)[1]	1979 (000 t)	1979 ($000)[1]
Japan	11 017	643,365	10 485	618,753
United States	12	155	41	761
Denmark	309	10,766	133	4,832
Chile	74	4,106	49	2,886
France	-	-	72	3,317
Korea	535	30,458	852	49,920
Germany	492	15,865	641	22,799
Sweden	154	7,891	164	8,358
Mexico	42	2,453	60	3,419
Romania	227	12,564	-	-
Belgium	174	9,076	56	2,755
Brazil	573	32,669	423	25,343
Argentina	51	2,932	27	1,784
Italy	164	8,421	132	7,679
Taiwan	26	1,477	57	3,356
Spain	150	8,641	154	9,348
Greece	-	-	55	2,669
India	-	-	297	17,136
Total	14 000	790,839	13 698	785,115

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] F.O.B. port of export in Canadian dollars.
- Nil.

TABLE 7. COAL USED BY THERMAL POWER STATIONS IN CANADA BY PROVINCES, 1964-79

	Nova Scotia	New Brunswick	Ontario	Manitoba	Sask.	Alberta	Total Canada
				(000 tonnes)			
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
1979[1]	645	198	9 904	73	4 957	9 184	24 961

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Estimates for map purposes by Statistics Canada and Energy, Mines and Resources Canada.

to 479 000 t in 1979. Shipments of coal to other provinces exceeded 500 000 t with over 75 per cent of this coal destined for steel mills in Hamilton, Ontario. Quebec, New Brunswick, Prince Edward Island and Newfoundland also received coal from Nova Scotia in 1979.

Over 95 per cent of all coal production in Nova Scotia comes from three mines owned by the Cape Breton Development Corporation. Raw coal production from the Lingan, No. 26 and Prince mines was 1 500 000 t, 731 000 t and 162 000 t respectively. Five smaller mines produced 148 000 t of coal for local domestic and commercial markets in 1979.

THERMAL POWER INDUSTRY

For the seventh consecutive year, coal consumption in thermal power stations in Canada increased in 1979. Total consumption reached 24 961 000 t, up 9 per cent or 2 million t over the 22 914 000 t consumed in 1978. The amount of coal consumed increased in four provinces (Alberta, Ontario, Saskatchewan and New Brunswick) and decreased in two provinces (Nova Scotia and Manitoba). Forecasts for 1980 indicate that consumption will increase by 10 per cent Canada-wide and in five of the six provinces currently utilizing coal, the exception being Manitoba.

Ontario remained Canada's largest thermal coal consumer, burning 9.9 million t of coal in 1979. Canadian coal became an important element of Ontario's coal supply system for the first time in 1979, as over 2 million t moved from mines in British Columbia and Alberta over CN and CP lines through the recently completed coal terminal at Thunder Bay to thermal stations in central Ontario. Of this 2 million t brought in from western Canada, just over 1 million t was burned, and the remainder stockpiled. The main source of thermal coal for Ontario remained the United States which supplied 9.8 million t in 1979.

Work on new thermal coal stations continued in Ontario in 1979. Two new coal-fired units are scheduled to begin commercial operation in Thunder Bay in

TABLE 8. CANADA, COKE PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979	
	(tonnes)	($)	(tonnes)	($)
Production				
Ontario	4 530	...	5 212	...
Other Provinces	438	...	563	...
Total	4 968	...	5 775	...
Imports				
United States	495	51,994	382	49,890
West Germany	48	4,975	-	-
France	4	580	-	-
United Kingdom	6	590	-	-
Total	553	58,139	382	49,890
Exports				
United States	153	11,160	164	12,542
West Germany	65	1,954	63	2,148
Netherlands	-	-	2	83
Total	218	13,114	229	14,773

Sources: Statistics Canada; Energy, Mines and Resources Canada.

... Practically all coke production is used by producers in the iron and steel industry and is not given a value; - Nil.

1981, while the Atikokan station is scheduled for commercial operation later in the decade. The Thunder Bay station will use lignite coal from Saskatchewan, which will be received at the new Thunder Bay coal terminal.

The Province of Alberta was the second-largest consumer of thermal coal in Canada in 1979. Consumption grew to 9.2 million t, up 15 per cent over the 1978 figure of 8.0 million t. Five coal-fired thermal stations currently provide over 3 000 megawatts of generating capacity and plans call for the doubling of this figure by the end of the 1980s. Separate 375-megawatt additions to the existing Sundance and Battle River stations are scheduled for 1980 and 1981, while three new 750-megawatt stations are scheduled for later in the 1980s.

The first of two 400-megawatt units at Calgary Power Ltd.'s new Keephills station is now scheduled for commercial operation in 1983, the second unit following in 1984. New 375-megawatt units will come on stream in 1985 and 1986 at the Sheerness plant of Alberta Power Limited, while Edmonton Power is proposing two 375-megawatt units at its Genesee site. Sub-bituminous coal consumption in Alberta is forecast to reach the 20 million t level by 1990.

Thermal coal consumption in Saskatchewan increased by 8 per cent to 5 million t in 1979. This increase occurred despite the fact that overall provincial production remained virtually static between 1978 and 1979. Shipments of Saskatchewan coal to Manitoba declined from 482 000 t in 1978 to 219 000 t in 1979, while imports from Alberta to Saskatchewan also declined from 439 000 t to 162 000 t. Two new 300-megawatt units will be operative in 1980 and 1982 at Poplar River, bringing the coal-fired thermal power station capacity in Saskatchewan to nearly 1 800 megawatts. A new coal mine is being developed at Coronach to fuel these new units.

Utility coal consumption in New Brunswick grew by 31 per cent from 151 000

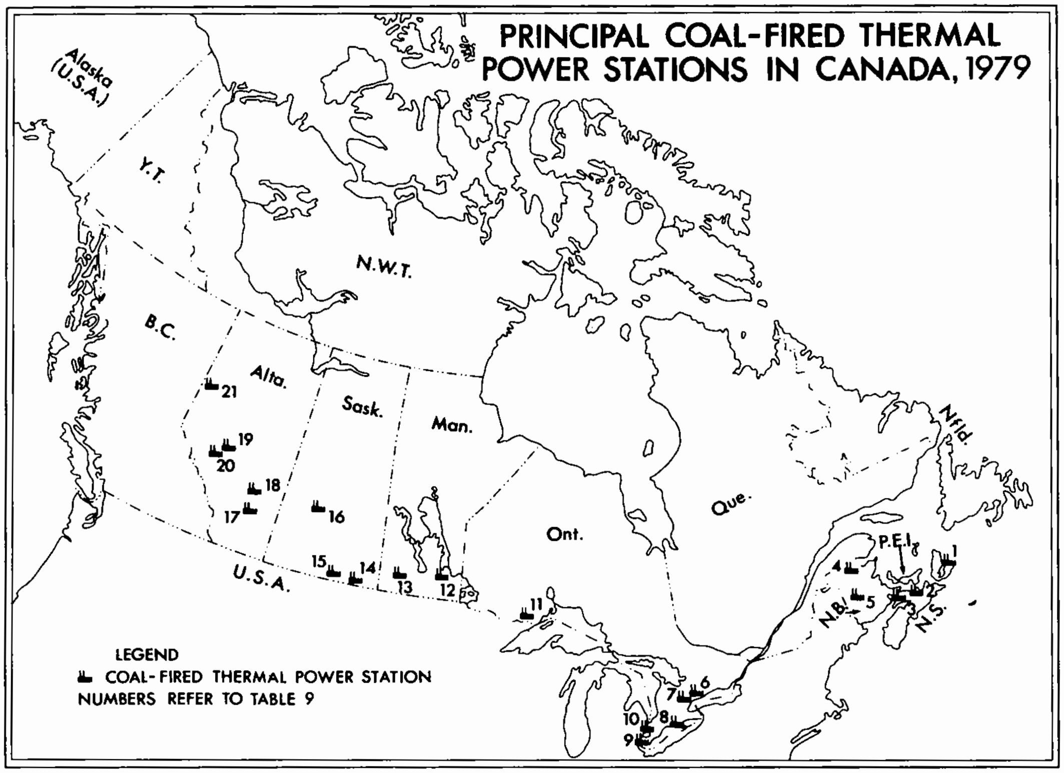


TABLE 9. PRINCIPAL COAL-FIRED THERMAL POWER STATIONS IN CANADA, 1979

Utilities (numbers refer to locations on map above)	Station	Total Station Capacity (kilowatts)	Remarks
Nova Scotia			
1. Nova Scotia Power Corporation	Glace Bay	111 000	
1. Nova Scotia Power Corporation	Lingan	150 000	A second 150-MW unit is to come on stream in 1980.
2. Nova Scotia Power Corporation	Trenton	210 000	
3. Nova Scotia Power Corporation	Harrison Lake	25 000	
New Brunswick			
4. New Brunswick Electric Power Commission	Dalhousie II	200 000	Dual coal-oil fired unit commissioned in 1979.
New Brunswick Electric Power Commission	Chatham	32 500	Plant on stand-by status.
5. New Brunswick Electric Power Commission	Grand Lake No. 1	13 750	
New Brunswick Electric Power Commission	Grand Lake No. 2	85 000	

TABLE 9. **PRINCIPAL COAL-FIRED THERMAL POWER STATIONS IN CANADA, 1979**

Utilities (numbers refer to locations on map above)	Station	Total Station Capacity (kilowatts)	Remarks
Ontario			
6. Ontario Hydro	Richard L. Hearn	1 222 500	
7. Ontario Hydro	Lakeview	2 422 500	
8. Ontario Hydro	Nanticoke	4 022 500	
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 1980-81.
Manitoba			
12. Manitoba Hydro	Selkirk	155 800	
13. Manitoba Hydro	Brandon	237 000	
Saskatchewan			
14. Saskatchewan Power Corporation	Estevan	70 000	New 300-MW units to come on stream in 1980 and 1982 at Poplar River station.
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	
19. Calgary Power Ltd.	Wabamun	582 000	
20. Calgary Power Ltd.	Sundance	1 725 000	One 375-MW unit to be added in 1980.
21. Alberta Power Limited	H.R. Milner	150 000	Burns coal preparation plant by-products.

Sources: Statistics Canada; Energy Policy Sector, Energy, Mines and Resources Canada.

t in 1978 to 198 000 t in 1979. Consumption will increase by greater amounts in 1980 when the new coal-oil Dalhousie II station completes its first full year of operation in 1980. The station became operative in 1979, but will not start using coal until early in 1980. Provincial coal production will increase to meet this expanding demand.

Nova Scotia's thermal coal use declined in 1979 to 645 000 t, down 9 per cent from 1978. However, with the start-up of the first 150-megawatt Lingan unit in 1979, and the second unit scheduled for commercial operation the following year, thermal coal utilization will double by 1981. Further additions to this Lingan station are under consideration for the mid-1980s.

COKE INDUSTRY

In 1979, 8.1 million t of bituminous coking coal was carbonized to produce 5.4 million t of coke, an increase from 1978 of 1.1 and 0.4 million t, respectively. The majority of the coking coal imported into Canada was used by the three Ontario steel companies.

The Algoma Steel Corporation, Limited (Algoma) of Sault Ste. Marie produced 1.4 million t of coke from 2.2 million t of coking coal in 1979, while The Steel Company of Canada, Limited (Stelco), at Hamilton, produced 2.0 million t of coke from 3.1 million t of coking coal. Dominion Foundries and Steel, Limited (Dofasco) of Hamilton, produced 1.3 million t of coke from 1.9 million t of coking coal.

Sydney Steel Corporation (Sysco) of Sydney, Nova Scotia produced 420 000 t of coke from 656 000 t of coking coal. During 1979 Sysco used a coke oven blend of 80 per cent high-volatile eastern coals and 20 per cent western Canadian and U.S. coals.

Two other companies produced coke in Canada in 1979. Kaiser Resources Ltd.'s coke production at Natal, British Columbia amounted to 106 000 t from a coal input of 169 000 t, while the Manitoba and Saskatchewan Coal Company at Bienfait, Saskatchewan produced 52 000 t of coke from 114 000 t of lignitic coal.

RESEARCH AND DEVELOPMENT

Research and development activities cover a wide range of issues in Canada varying with the type of coal activity under way in a region. Studies, research, development and demonstration projects are under way on exploration, mining technology, preparation and beneficiation activities, health and safety aspects, and coal conversion and substitution questions. These activities are funded by federal and provincial government programs and through private industry sponsorship.

Topics of study vary from computer techniques for contour and overburden mapping to evaluations of surface and underground mining techniques and equipment, tests of roof support equipment and mining systems, improved beneficiation and preparation procedures, equipment safety and underground environmental monitoring systems.

The Canadian Coal Conversion Program is an important energy-related activity directed toward reducing the amount of oil Canada must import for utility and industrial needs. This cost-shared program with federal, provincial and industrial participation is designed to consider the options of replacing some of the oil currently used with coal, when and where this is both technically and economically possible. Specific research and development work is proceeding in the

TABLE 10. CANADA, COKE PRODUCTION AND TRADE, 1969-79

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
	(tonnes)					
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	4 967 664	1 014 076	553 349	973 985	217 595	134 762
1979	5 775 141	934 888	381 518	980 657	228 600	125 414

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 11. COKE OVEN AND OTHER CARBONIZATION PLANTS IN CANADA, 1979

Company	Operating Batteries and No. of Ovens	Oven Type	Year Built	Coal Feed	Coke Production	Byproduct
				(000 tonnes/year)		
The Algoma Steel	No. 5 - 86	Koppers-Becker underjet	1943	2 209	1 420	Tars, light oil, gas.
Corporation 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	1978			
The Steel Company of	No. 3 - 61	Wilputte underjet	1947	3 059	2 000	Tars, gas, light oil,
Canada 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	No. 1 - 25	Koppers-Becker gun type comb.	1951	1 885	1 323	Tars, light oil, gas
	No. 2 - 35	Koppers-Becker gun type comb.	1956			sulphur, ammonium
	No. 3 - 45	Koppers-Becker gun type comb.	1958			sulphate.
	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, Sydney, Nova Scotia	No. 5 - 114	Koppers-Becker underjet	1949	656	420	Tars, light oil, gas.
Kaiser Resources Ltd.	16 units	Curran-Knowles	1949	169	106	Crude, tar, gas,
Natal, B.C.	16 units	Curran-Knowles	1952			coke breeze
Manitoba and	2 units	Lurgi carbonizing retort	1925	114	52	Tars
Saskatchewan Coal	1 unit	Lurgi carbonizing retort				
Company (Ltd.)	3 units	Solem rotary hearth calciners	1974			
Char Briquetting Div., Bienfait, Sask.						

Source: Energy Policy Sector, Energy, Mines and Resources Canada.

areas of coal combustion and coal liquefaction. One of the major coal combustion projects involves the designing of a fluidized bed combustion heating plant for use at the Summerside, Prince Edward Island Armed Forces Base. The plant is being designed to burn coal and other fuels in an efficient and environmentally acceptable way. Energy, Mines and Resources Canada is also encouraging demonstration projects utilizing the fluidized bed combustion principle in industrial boiler applications. A western Canadian coal company and the federal government have agreed to demonstrate the application of this combustion principle in utilizing coal washery rejects for coal drying. Other research efforts are directed at reducing SO_x and NO_x emission from pulverized coal burning plants. In this area, the Department of Energy, Mines and Resources is co-operating with domestic as well as international companies and agencies to investigate and demonstrate new burning techniques to reduce air pollutants.

Under the Canadian Coal Conversion Program, federal, provincial and industry groups are supporting projects designed to study the production of coal-derived liquid fuels. One contract between a private company, the Department of Energy and Natural Resources of Alberta, and Energy, Mines and Resources Canada evaluates the technical and economic feasibility of a coal hydrogenation plant. This conceptual study will include coal testing in a German pilot plant, product oil characterization and further upgrading to produce conventional petroleum-type fuels. The study is expected to be complete in 1981 and to provide a techno-economic assessment of coal hydrogenation as a potential Canadian liquid fuel source. In addition, support is provided for many smaller contracts and internal research programs directed toward the economic liquefaction of Canadian coals.

TABLE 12. WORLD COAL PRODUCTION, 1974-78

	1974	1975	1976	1977	1978P
			(000 tonnes)		
North America	571 486	641 291	664 638	627 890	593 690
South America	8 159	8 896	8 598	8 970	9 610
Europe	1 651 315	1 056 211	1 080 683	974 000	1 038 940
Africa	69 550	78 507	74 241	90 260	94 960
Asia	567 489	728 473	628 449	688 940	800 710
Oceania	92 986	76 390	69 633	74 570	76 920
World					
Lignite[1]	834 152	727 725	709 874	909 790	932 745
Bituminous and anthracite[2]	2 126 833	1 862 043	1 816 368	1 554 840	1 682 085
Total, all types	2 960 985	2 589 768	2 526 242	2 464 630	2 614 830

Source: U.S. Bureau of Mines.

[1] Estimated. [2] By subtraction of lignite figures from total.

P Preliminary.

Core drilling offshore north of Cape Perce and Donkin village on Cape Breton Island, Nova Scotia, outlined a huge undersea coal reserve of 1.8 billion tonnes. The Cape Breton Development Corporation (DEVCO) was authorized to tunnel out to a point where mining can begin and work on the twin tunnels as shown here, with the ocean in the background. (Gordon photo, courtesy DEVCO)

Cobalt

D.G. FONG

Canadian production of cobalt in 1979 was 1 381 tonnes (t), up from 1 234 t in 1978. While production increased by less than 12 per cent, the value of cobalt at $82 million was up 150 per cent from the previous year, a reflection of significantly higher world cobalt prices.

World mine supply of cobalt in 1979 was estimated at 27 000 t, while consumption dropped 8 per cent to about 29 000 t. The supply deficit was made up primarily from stocks, scrap and reprocessed tailings.

In 1979, production in Zaire and Zambia was maintained at a high level despite continuing transportation and facility maintenance problems. Zaire and Zambia together account for about 60 per cent of world production. The supply from Zaire was temporarily disrupted in mid-1978 following the occupation of the mining town of Kolwezi by insurgent forces. However, government forces regained control over the region and production of cobalt resumed, with an increase of output in 1979 compared with 1978.

CANADA

Cobalt is recovered in Canada, primarily as a byproduct of nickel-copper mining, by Inco Limited and Falconbridge Nickel Mines Limited while a third company, Sherritt Gordon Mines Limited, obtains cobalt from domestic and some imported nickel refinery feed.

Inco, the largest nickel producer in the world, has nickel-copper mining operations at Sudbury, Ontario and Thompson, Manitoba. Cobalt is currently being produced as commercial grade oxide at its nickel refineries in Port Colborne, Ontario and Thompson. This product is then shipped to its refinery at Clydach, Wales, where refined cobalt oxides and salts are produced.

Inco's 1979 cobalt production was seriously affected by a labour strike from September 16, 1978 to June 5, 1979 at its Ontario operations, and by a strike and extensive flood damage at its Clydach refinery in the latter part of the year. Cobalt recoveries, on the other hand, were improved significantly at its smelter in Thompson and Sudbury. At the Sudbury smelter the company tested a modified process with the objective of doubling annual cobalt production capacity through improved recovery from converter slag and better furnace practice. Inco is also evaluating the feasibility of producing electrolytic cobalt at Port Colborne.

Falconbridge's refinery is located at Kristiansand, Norway, where electrolytic cobalt is recovered from nickel-copper matte produced in Canada. Cobalt output in 1979 at this refinery was substantially increased, largely because of an increased through-put of feed obtained from the company's Canadian smelter and from materials processed under toll-refining arrangements. This refinery has a production capacity of 907 tpy of electrolytic cobalt.

TABLE 1. CANADA, COBALT PRODUCTION TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Production[1] (all forms)				
Ontario	907 016	24,026,091	1 112 000	67,320,000
Manitoba	326 761	8,723,972	269 000	14,814,000
Total	1 233 777	32,750,063	1 381 000	82,134,000
Exports				
Cobalt metal				
United States	629 539	13,892,000	259 913	18,252,000
South Africa	16 546	515,000	10 565	1,801,000
France	12 530	302,000	6 164	541,000
West Germany	4 082	347,000	9 546	331,000
South Korea	3 140	101,000	2 201	221,000
United Kingdom	22 043	290,000	3 416	164,000
Other countries	28 084	959,000	4 340	347,000
Total	715 964	16,406,000	296 145	21,657,000
Cobalt oxides and hydroxides[2]				
United Kingdom	748 300	6,955 000	428 000	7,553,000
United States	-	-	17 000	801,000
Total	748 300	6,955 000	445 000	8,354,000
Consumption[3]				
Cobalt contained in:				
Cobalt metal	103 617	..	86 422	..
Cobalt oxide	32 452	..	19 053	..
Cobalt salts	8 541	..	9 131	..
Total	144 610	..	114 606	..

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, 1970, 1975-79

		Exports		Imports		
	Production[1]	Cobalt metal	Cobalt oxides and hydroxides	Cobalt ores[2]	Cobalt oxides and hydroxides[3]	Consumption[4]
	(tonnes)					
1970	2 069	381	837	..	..	148
1975	1 354	431	561	..	..	123
1976	1 356	523	471	-	96	160
1977	1 485	684	605	519r	68r	147
1978	1 233	716	748	85	83	145
1979P	1 381	296	445	104	46	115

Source: Statistics Canada.
[1] Production from domestic ores, cobalt content. From 1967, production includes cobalt content of Inco Limited and Falconbridge Nickel Mines Limited shipments to overseas refineries, but prior years exclude Inco shipments to United Kingdom. [2] Cobalt content. [3] Gross weight. [4] Consumption of cobalt in metal, oxides and salts.
P Preliminary; - Nil; r Revised; .. Not available.

Sherritt continued to expand its cobalt refining capacity and to set new production records at its Fort Saskatchewan, Alberta facility. During 1979 the plant operated at about 90 per cent of rated capacity and produced 604 t of cobalt powder, some 16 per cent higher than in 1978. Sherritt entered into a long-term supply contract with Inco Metals Company in 1978. The contract ensures a steady flow of feed to Sherritt's integrated nickel and cobalt plant, which has been relying on imported sources of supply since the closure of the company's Lynn Lake, Manitoba mine in 1976.

Three mining companies, Agnico-Eagle Mines Limited, Teck Corporation and Canadaka Mines Limited, produce cobalt-bearing silver concentrates in the Cobalt area of Ontario. Concentrates from the three mines are treated at the nearby silver refinery of Canadian Smelting & Refining (1974) Limited where cobalt-bearing precipitates and residues grading from 2 to 9 per cent cobalt are being stockpiled pending the installation of a cobalt recovery circuit, or until a market can be found for their sale.

Noranda Mines Limited and Agnico-Eagle were negotiating an arrangement for the joint exploration and development of cobalt properties held by Agnico-Eagle in the Cobalt area. The terms would require Noranda to make an initial investment of $500,000 on exploration work and, if the exploration effort is successful, the company could earn a 49 per cent interest in the operation by providing up to $8 million to develop the properties and construct a refining facility.

WORLD REVIEW

World mine production in 1979, estimated at 27 000 t, was inadequate for consumer needs and the supply deficit was made up primarily from recycled scrap, stocks and reprocessed tailings. During the first half of 1979 the demand for cobalt-bearing superalloys was particularly strong in the aerospace industry. However, supply uncertainty, high prices, and increased substitution, especially in the magnet and hard-facing industries, brought demand into line with supply by year-end.

Market developments took some of the pressure off supply by the autumn of 1979 and cobalt became readily available. Nevertheless, African Metals Corp., exclusive dealer for Zairean and Belgian cobalt in the United States, maintained its allocation practice through year-end 1979, restricting its customers to 70 per cent of their 1977 average monthly purchases.

Cobalt production in Zaire, the world's leading cobalt producer, returned to high levels as both political and economic conditions in the country stabilized. In 1979 a large share of Zairean cobalt production was recovered from tailings and stockpiled ores. La Générale des Carrières et des Mines (Gécamines), the state-owned mining company, obtained a total loan of $U.S.460 million in 1979 from the World Bank and the Libyan Arab Bank to expand its mining operations. With this assistance, and a continuation of political stability, Gécamines should be in a good position to boost output to 16 000 tpy from its 1979 production of 14 500 t.

In Zambia, the production of cobalt almost doubled to 3 800 t in 1979 after the opening of the Chambishi Refinery of Roan Consolidated Mines Ltd. Cobalt production at the new plant, which commenced operations in December, 1978 reached design capacity by mid-1979. Nchanga Consolidated Copper Mines Ltd. (NCCM), another major state-controlled company, was expanding its Rhokana plant by adding a cobalt recovery circuit. The company is also planning to build a new cobalt plant. These new developments will increase Zambia's annual cobalt output capacity to 5 000 by the mid-1980s.

Due to continuing problems in shipping across neighbouring countries to coastal ports, both Zambia and Zaire have been airlifting cobalt to major world markets. However, as the result of normalization of political and economic conditions in both these countries and outside financial assistance, cobalt shipments will likely revert to the surface route by way of the Benguela railway.

In the United States, Noranda Mines Limited is evaluating the Blackbird mine near Salmon, Idaho, which has not been in production since 1960. Diamond drilling in 1979 indicated ore reserves of 3.6 million t grading 0.6 per cent cobalt and 1.2 per cent copper. The company is planning to build a 270 tpd pilot plant and, depending on trial results, will determine whether to proceed with production. Noranda has indicated that the mine could be producing 3 600 t of cobalt annually by 1984.

TABLE 3. DELIVERIES OF COBALT BY MAJOR CANADIAN PRODUCERS, 1977-79

	1977	1978	1979
		(tonnes)	
Inco	753	771	562
Falconbridge	678	569	681
Sherritt Gordon	316	626	264
Total	1 747	1 966	1 507

The reopening of the Blackbird mine would reduce United States dependence on cobalt from outside sources. A high proportion of the U.S. cobalt supply has originated for many years in central African states, a region periodically subject to political upheaval. To ensure an adequate supply in case of emergency, the Federal Emergency Management Agency of the General Services Administration (GSA) has been stockpiling cobalt as a strategic mineral. Currently the GSA stockpile of cobalt is 18 500 t, while a new national stockpile goal has been set at 38 700 t. Indications are that the GSA will acquire more cobalt in the near future to fulfill the stockpile goal.

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 oxides. 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 oxides in copper deposits. 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 arsenides or sulpharsenides. The cobalt content of all these ores is generally low. Deposits in Zambia and Zaire can grade as high as 3 or 4 per cent cobalt, but more frequently they grade below 0.5 per cent. In the Sudbury area, the ores can grade as high as 3.5 per cent, but more commonly they contain less than 0.1 per cent cobalt.

A large potential source of cobalt is in manganese-nickel nodules which occur on the ocean floor. These nodules typically contain 0.2 per cent cobalt.

CONSUMPTION AND USES

With the rapid increase in cobalt prices in 1978 and early in 1979, and the continuing uncertainty over security of supply, cobalt consumers have begun to seriously examine their requirements and the prospects for substitution. In 1979 cobalt usage was divided approximately as shown in the following listing:

PATTERN OF COBALT CONSUMPTION[e]

Permanent magnets	20%
High-temperature superalloys	30%
Wear- and abrasion-resistant parts	15%
Pigments and colouring agents	15%
Chemical uses	15%
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 is a wide range of permanent magnet materials, extending from iron-cobalt alloys through the Alnicos (aluminum-nickel-cobalt alloys) to rare earth-cobalt alloys.

In the case of permanent magnets, two usage trends are now under way. One is the switch from permanent magnets made from Alnicos to the stronger rare earth-cobalt magnets. The rare earth magnets use less cobalt and are becoming more important in the field of miniaturization where weight and size limitations are critical. The second trend is the switch from Alnicos to ceramic ferrites in applications such as loudspeakers.

Cobalt is used in high-speed tool steels to increase the red hardness of the steel; that is, its ability to be used at higher rates of speed and for deeper cuts than would be possible if cobalt was not present. The cobalt content in this application 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 reducing the use of cobalt as a steel alloy.

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 grams (g) per t of glass will impart a blue colour to the finished product. Smaller additions of up to 45 g per t neutralize the yellow tint of iron in plate and window glass. Similarly, cobalt is used in the ceramics industry 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 the steel.

Cobalt-base high temperature alloys or superalloys find their principal application in the manufacture of 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 demand for military aircraft and increasing requirements for land-based and marine turbines, the demand for cobalt-bearing superalloys was especially strong in the first half of 1979. Opportunities for substitution for cobalt in the production of superalloys are limited in the short term. Material specifications are exacting for several applications, such as jet engine components, which 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. The cobalt content of dies ranges from 3 to 35 per cent. While nickel is a potential substitute, considerable research will be required to develop a carbide of comparable quality. Since nickel usually sells for about one-eighth the price of cobalt, a substantial reduction in material costs may be possible if this research is successful.

Cobalt-base alloys are also used in applications where difficult cutting is required. The most important group of cobalt-base alloys is the stellite group, containing cobalt, tungsten and chromium as principal constituents. The hardness and strength of the stellites are mainly exploited for cutting tools and hard-wearing parts of machinery, such as those in agricultural implements and excavating equipment. Coating a part with a particular cobalt alloy can provide greater resistance to abrasion, heat, impact and corrosion. Demand for these alloys declined by about 20 per cent in 1979 as consumers switched to iron- and nickel-based alloys.

TABLE 4. WORLD PRODUCTION OF RECOVERABLE COBALT, 1977-79

	1977	1978	1979
	(tonnes)		
Zaire[1]	10 720	12 300	13 500
Zambia[1]	1 850	1 750	3 250
Canada[2]	1 485	1 233	1 381[p]
Finland[1]	997	935	1 180
Morocco[3]	1 015	1 133	907[e]
Philippines[3]	1 084	1 191	1 297[e]
Australia[e]	997	1 360	1 542
Other Western[e]	270	420	480
Subtotal	18 418	20 322	23 537
U.S.S.R.[e]	1 900	1 950	1 800
Cuba[e]	1 600	1 600	1 700
Total	21 918	23 872	27 037

Sources: [1] **Engineering and Mining Journal.** [2] Statistics Canada; Energy, Mines and Resources Canada. [3] U.S. Bureau of Mines.
[p] Preliminary; [e] Estimated.

PRICES

Price escalation continued in early 1979 as a result of heavy demand and tight supply.

In February, cobalt producers raised their price from \$U.S.20 to \$U.S.25 per pound while the dealer price peaked at about \$U.S.50. By mid-year, however, the dealer price weakened as the near-panic atmosphere of 1978 and early 1979 abated. While the producer price was maintained at the \$U.S.25 level, the dealer price for spot sales by year-end dropped to \$U.S.23 per pound as supplies increased and consumers delayed purchases in anticipation of further price reductions. To reduce uncertainty concerning future prices, Zaire announced on December 19, 1979 that the producer price for 1980 would remain at \$U.S.25 per pound.

Prices

	Dec. 1978	Dec. 1979
	(\$U.S.)	
Cobalt metal, per lb. fob New York		
Shot, 99.5%, 250-kg drum	20.00	25.00
Powder, 99%+		
300 and 400 mesh, 50-kg drums	26.32	31.09
extra fine, 125-kg drums	26.22	31.00
S-grade, 10-ton lots	20.00	..

Source: **Engineering and Mining Journal,** January 1979 and 1980.
fob - free on board; .. Not available.

OUTLOOK

The production of cobalt from Canadian ores should increase in 1980 as a result of the introduction of improved recovery techniques. Canada should have adequate cobalt available to meet domestic requirements, since the nation consumes only about one-tenth of its recoverable mine production. However, prices, which are set internationally, will remain a constant source of concern to the consumer.

World mine production is forecast to expand during the next few years with the price expected to hold at about \$25 in 1980 before showing signs of weakening. While the 1979 outlook on availability is favourable, cobalt supply in the final analysis will depend on the well-being of the copper industry, particularly in Zaire and Zambia where cobalt is produced as a byproduct of copper mining. Nickel producers, including those which treat laterite deposits, were expected to maximize cobalt output while high prices prevailed. A sustained growth in cobalt supply from this source, however, will depend upon recovery in the nickel industry.

The situation in central Africa appears to be much more settled than in the past few years. A return to stability and an increase in mining activity will probably result in the restoration of ground route transportation. Although cobalt prices are forecast to stabilize or drop in the short- to medium-term with the expected increases in world supply, two-thirds of mine production is centred in a region that recently has been subject to supply disruption and, accordingly, cobalt prices could become volatile again at some time in the future.

In the near-term, demand for cobalt for high-performance applications such as superalloys and anticorrosives is expected to increase. However, resistance to the current high price of cobalt will bring about increased substitution and improved material management in the lower-performance applications.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
			(%)		
33200-1	Ore of cobalt	free	free	free	free
35103-1	Cobalt metal, excluding alloys, in lumps, powders, ingots or blocks	free	free	free	25

TARIFFS (cont'd)

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
			(%)		
CANADA (cont'd)					
35110-1	Cobalt metal, in bars	free	free	10	25
92824-1	Cobalt hydroxides	10	10	15	25
	(from July 15, 1971 to January 1, 1980)	free	free	15	25
92824-2	Cobalt oxides	free	free	10	20

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
35110-1	10	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8
92824-1	15	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free
92824-2	10	10	10	10	10	10	10	9.9	8.2

UNITED STATES

Item No.		
601.18	Cobalt ore	free
632.20	Cobalt metal, unwrought waste and scrap	free

		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
632.84	Cobalt metal alloys, unwrought (to 632.88 in 1980)	9	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Cobalt metal, wrought	9	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
418.60	Cobalt oxide	1.2¢/lb	-	-	-	-	-	-	-	-
418.62	Cobalt sulfate	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
418.68	Cobalt compounds other than cobalt oxide and cobalt sulfate	6	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
426.24	Cobalt salts, resinate	6	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
426.26	Cobalt salts, other	6	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register, Vol. 44, No. 241.

Columbium (Niobium) and Tantalum

D.G. FONG

OVERVIEW

The world demand for columbium was strong in 1979, especially in the United States where the consumption of ferrocolumbium reached an all-time high. Stable supplies of pyrochlore (columbium bearing oxide) exceeded market requirements although prices remained stable. On the other hand, columbite (columbium and tantalum oxide) which is a source for producing high-purity columbium products, was in short supply and the price more than tripled. Major expansion programs were announced by the two major mine producers: the sole Canadian producer, Niobec Inc., planned to increase its operating capacity by 30 per cent while the Brazilian company, Companhia Brasileira Metalurgia e Mineracao SA, expected to raise its production capacity by 70 per cent. The Brazilian companies also planned to reduce their exports of pyrochlore concentrates, since an increasing portion of these concentrates was being committed for conversion into ferrocolumbium.

In 1979, world tantalum demand strengthened considerably, and because of a continuing shortfall in supply, inventories were reduced. The supply imbalance resulted in tantalum prices soaring by about 120 per cent during the year. Western world mine production increased slightly compared with 1978. The major source of supply was Southeast Asia where tantalum is a byproduct of tin mining. In recent years, an increasing portion of the western world's output has come from secondary materials, tin slags and mine dumps. Canadian mine production in 1979 remained unchanged, as was the case in 1978, and represented about 14 per cent of the western world's total.

Consumer demand for tantalum during the year continued strong for both major end-uses; cemented carbides and capacitors. The substitution for tantalum carbides was slight, whereas tantalum capacitors were virtually phased out in the consumer electronics sector. However, this loss in demand for tantalum has been more than compensated for by a rapid growth in computer and automotive applications.

Columbium

CANADIAN PRODUCTION AND DEVELOPMENTS

Niobec Inc., Canada's only columbium producer, is located near Chicoutimi, Quebec. The company, a 50-50 joint venture between Quebec Mining Exploration Company (SOQUEM) and Teck Corporation, has capacity to produce annually 4 173 tonnes (t) of pyrochlore concentrates grading about 62 per cent columbium pentoxide (Cb_2O_5). In 1979, Niobec produced 2 513 t Cb_2O_5 valued at \$15.3 million, which compares with 2 473 t and \$14.2 million in the previous year. The pyrochlore concentrates are sold under long-term contracts to customers in Europe (60 per cent), Japan (20 per cent) and the United States (20 per cent).

Niobec announced plans to expand production by about 30 per cent through new shaft-sinking, further underground development and mill expansion. This work is to be completed in 1981 at a cost of $10 million.

St. Lawrence Columbium and Metals Corporation at Oka, Quebec had been a significant Canadian columbium producer until 1976. Early in that year operations ceased and subsequently the firm was placed under receivership and much of its property sold. While existing reserves are in the order of 25 million t averaging about 0.44 per cent columbium pentoxide, attempts to find new financing to re-establish the operation have been unsuccessful.

Masterloy Products Limited of Ottawa has the capability of producing ferrocolumbium, but none was produced in 1979. This was attributable to the lack of access to raw material supplies and to environmental problems associated with disposal of the radioactive contaminants present in most columbium concentrates.

WORLD PRODUCTION

Brazil, with two major producers, accounted for about three-quarters of world columbium production capacity. Companhia Brasileira Metalurgia e Mineracao (CBMM), with a mine capacity of 14 500 t of pyrochlore concentrate a year, is the world's leading producer of columbium pentoxide and ferrocolumbium. CBMM announced plans in 1979 to construct a new concentration plant at Araxa to treat 25 000 tpy of pyrochlore. Upon completion of the new plant in mid-1981, the present plant will be closed pending increased demand for columbium.

CBMM also finished building a high-purity columbium pentoxide plant at the Araxa minesite; production at the 1 360 tpy plant was expected to start in 1980. The company also planned to expand its metallurgical facilities for conversion of the increased concentrate production to ferrocolumbium. The 1980 goal for ferrocolumbium output was 13 600 t, up from 10 700 t in 1979.

The other important Brazilian columbium producer, Mineracao Catalao de Goias, had a production capacity in 1979 of about 3 800 tpy of pyrochlore concentrate. The company produced about 3 900 t of Cb_2O_5 in concentrates and also operated a ferrocolumbium plant near Catalao, Brazil which in 1979 produced 1 862 t of ferrocolumbium.

Pyrochlore production in Brazil and Canada together accounted for about 95 per cent of the western world's columbium production during the year. The remainder was 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, which is used in the form of ferrocolumbium as an additive element in high strength, low alloy (HSLA) steels, carbon steels, low-alloy steels, stainless steels and superalloys. The HSLA steels require the largest amount of columbium. Although the quantity of the metal added to HSLA steel may be as low as 0.02 per cent, the mechanical properties and tensile strength of the steel are significantly improved. These characteristics are particularly important in applications such as 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.

The use of columbium for superconductors in 1979 was very small, but substantially greater demand is expected to develop over the next five years. For example, cable and wire manufactured from metal containing columbium alloys could be used directly for electrical power transmission lines or formed into coils for use in the high-intensity magnets required in electrical generators and fusion reactors.

Columbium's breakthrough in superalloys is already apparent because of its growing use in commercial production, particularly in the aerospace industry. Columbium is being used increasingly in aerospace production, in nickel- and chromium-based alloys, and in columbium alloys in engines.

TABLE 1. CANADA, COLUMBIUM (NIOBIUM) AND TANTALUM PRODUCTION, TRADE AND CONSUMPTION, 1970 AND 1975-79

	Production[1]		Imports					Consumption, Ferrocolumbium and ferro-tantalum-Columbium,
			Primary forms and fabricated metals				Exports[2] Columbium Ores and	
	Cb_2O_5 Content	Ta_2O_5 Content	Colum-bium	Columbium Alloys	Tantalum	Tantalum Alloys	Concentrates to U.S.	Cb and Ta-Cb Content
	(kilograms)							
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	2 473 045	158 776	1 705	-	7 655	1 535	552 657	163 293
1979P	2 406 000	159 000	..	..	..	..	509 953	..

Sources: Statistics Canada; Energy, Mines and Resources 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.

PRICES

Although the steady flow of pyrochlore shipments from Canada and Brazil exceeded market requirements in 1979 prices remained stable. Contract prices for Brazilian pyrochlore remained at $U.S. 2.55 per pound of contained pentoxide, a price that had been in effect since May 1977. On the other hand, the price of columbite, the other ore of columbium, soared in 1979 from about $U.S. 3.50 to $U.S. 12.00 per pound, reflecting the higher value of its tantalum content.

OUTLOOK

Pyrochlore prices will remain relatively stable in the early 1980s as production capacity in Canada and Brazil expands, ensuring long-term availability. However, there will continue to be a considerable price differential between pyrochlore and columbite, reflecting shortfalls in columbite-tantalite supplies. In the short term, columbium consumption should at least maintain its 1979 level despite slow economic conditions as any temporary decline in consumption for traditional uses will likely be offset by an increase in consumption by the petroleum industry, which will require HSLA columbium steels for major oil and gas pipeline projects. Also, automobile manufacturers are depending increasingly upon HSLA steels as part of the general weight reduction program in the industry.

Tantalum

PRODUCTION IN CANADA

Tantalum is produced in Canada by the Tantalum Mining Corporation of Canada Limited (Tanco). Tanco, the world's single largest producer of tantalum ore, produces a tantalum concentrate from a complex pegmatite orebody at Bernic Lake, Manitoba. Production in 1979 was 159 t of tantalum pentoxide (Ta_2O_5) in concentrate, little changed from 1978. The bulk of the concentrate, assaying about 40 per cent Ta_2O_5, was sold under long-term contracts, mainly in the United States. Additional exploration at the minesite and the inclusion of lower-grade ore due to rising tantalum prices increased Tanco's ore reserves, thereby extending its operational life until 1986 at the 1979 mining rate.

During the year, Tanco announced a $1 million expansion program to increase mill capacity from 680 t to about 910 tpd. This expansion, scheduled for completion in June, 1980, will enable the company to reprocess about 68 000 t of mill tailings per year in addition to 159 000 t of mined ore. Due to the overall lower grade of ore being processed, the actual quantity of tantalum produced at the enlarged facility will remain unchanged.

WORLD DEVELOPMENTS

Mine production of tantalum pentoxide in the western world in 1979 was about 1 150 t, a 3 per cent increase over 1978. Tantalum is extracted directly from tantalite-columbite ores, recovered from tin mining operations or from tin slags. The flexibility of tantalum production is limited, since almost two-thirds of world production is as a byproduct or coproduct of other operations.

Thailand and Malaysia continued to be major producers of tantalum and in 1979 together accounted for about 55 per cent of the western world's supply. Tantalite is produced from tin slag in both countries, with tantalite being the main product in Thailand, and columbite being the dominant product in Malaysia. Since a large part of the tantalum is inseparable from tin during concentration, it remains in the slag when the tin concentrate is smelted. The tin slags from Thailand contain 11 to 14 per cent Ta_2O_5 and 7 to 9 per cent Cb_2O_5, whereas the tin slags from Malaysia only average 2 to 3 per cent Ta_2O_5.

In recent years the steady increase in the price of tantalum has made it economical to recover tantalum from mine dumps. The concentrates produced, known as struverite, contain up to 30 per cent combined Ta_2O_5 and Cb_2O_5, together with some titanium. Recovery from this source has become more widespread and in 1979 accounted for 5 to 7 per cent of tantalum values shipped from Southeast Asia.

Other important tantalum suppliers in the western world are Australia, Brazil, Zaire, Nigeria and Mozambique. Output declines in Nigeria and Mozambique during 1979 were more than offset by production increases in Australia, Zaire and Brazil. For the first time in many years, The People's Republic of China was reported to have produced some tantalite concentrates and offered them for sale in the United States. In addition, large quantities of synthetic tantalite were processed from tantalum-bearing tin slags in West Germany.

In 1979, despite a very slow fourth quarter, western world consumption of tantalum was about 1 360 t, a 4 per cent increase over 1978. The increase was partly due to higher consumption in carbides and partly to growth in the world economy. About 56 per cent of tantalum supplies was used in capacitor manufacturing. Another 35 per cent was consumed by the carbide industry, and the balance was used mainly for chemical-processing equipment.

Demand for tantalum in the capacitor industry remained strong in 1979. Tantalum oxide's high capacitance value and excellent reliability make it a preferred dielectric. However, as tantalum prices have increased, designers have reduced the size of capacitors; higher-charge tantalum powders have been developed to provide the same performance with less tantalum. Also, ceramic and aluminum capacitors are beginning to make inroads in the capacitor industry, especially in low-performance applications.

The superior physical characteristics of tantalum carbide make it the preferred carbide for use in high-performance, high-speed machining applications. In 1979 tantalum consumption in this industry rose despite the rapid price increase of the metal and the development of substitutes. Hafnium-niobium carbides are now available as substitutes for certain grades of machining steels, which could eventually reduce the annual tantalum requirements of carbide-makers.

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 alloyed with tungsten and/or columbium.

PRICES

Strong consumer demand for tantalum and a relatively tight supply triggered a price increase spiral in 1979. Tanco tantalite, which was selling at \$U.S. 34 per pound at the end of 1978, advanced by 120 per cent to \$U.S. 75 per pound in 1979. Merchant spot market sales, which accounted for about 10 per cent of total tantalum sales, were reported at prices as high as \$U.S. 100 per pound.

Prices

The prices below are in U.S. currency and were quoted in **Metals Week** and **American Metal Market** on December 31, 1979 and January 4, 1980, respectively.

	1978	1979
	($)	
Columbium ore		
Columbite, per pound of pentoxide, cif U.S. ports	3.25-3.75	10.00-12.00
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	5.42-5.73
High purity alloy	16.95-17.64	30.15-35.75
Columbium metal, per kilogram 99.5-99.8%, fas shipping point		
Reactor ingot	29.00-35.00	53.00-60.00
Reactor powder	31.50-39.50	55.50-63.50

Prices (continued)

	1978	1979
	($)	
Tantalum ore		
Tantalite, per pound of pentoxide, Tanco price	34.00	75.00
Tantalum metal, per pound, fob shipping point depending on size of lot		
U.S. powder	48.75-65.00	149.55
U.S. rod 99.9% Ta	44.95-88.80	187.00-250.00

cif - cost, insurance and freight; fob - free on board; fas - free alongside ship.

OUTLOOK

Continuing strong market demand, together with limited potential for increased mine production in the near future, will tend to keep tantalum prices high in 1980. Because of high prices, substitution in cemented carbides for machine cutting tools will most likely increase. On the other hand, the demand for tantalum for manufacturing capacitors should continue to expand, especially over the long term, because of the metals's superior performance in this application.

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, 1980)	free	free	25%	free
37506-1	Ferrocolumbium ferrotantalum, ferro-tantalum-columbium	free	5%	5%	free

MFN Reductions under GATT (effective January 1 of year given)

TARIFFS (concl'd)

CANADA (continued)

Item No.	1979	1980	1981	1982	1983 (%)	1984	1985	1986	1987
37506-1	5.0	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0

UNITED STATES:

Item No.

601.21 Columbium ore Remains free
601.42 Tantalum ore Remains free

Item No.		1979	1980	1981	1982	1983 (%)	1984	1985	1986	1987
628.15	Columbium metal, unwrought, and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
628.17	Columbium, unwrought alloys	7.5	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
628.20	Columbium metal, wrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
629.05	Tantalum metal, unwrought and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
629.07	Tantalum, unwrought alloys	7.5	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
629.10	Tantalum metal, wrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Amendments, Revenue Canada; Notice of Ways and Means Motion, Customs Tariff, December 1979, Department of Finance, Ottawa; Tariff Schedules of the United States, Annotated 1978, TC Publication 843; U.S. Federal Register, Vol. 44, No. 241.

Copper

D.A. CRANSTONE

CANADIAN MINES

Production of primary copper in Canada in 1979 was 643 754 tonnes (t) compared with 659 380 t in 1978. This fall in production was primarily the result of strikes that were carried over from 1978 at the Sudbury operations of Inco Limited, at the Mines Gaspé Division of Canadian Copper Refiners Limited and at Gibraltar Mines Ltd. All these strikes began in 1978 and total lost production in 1978 and 1979 amounted to some 200 000 t of copper, with an approximate value of $400 million.

Refined copper production totalled about 397 262 t in 1979, compared with 446 278 t in 1978 and 508 767 t in 1977, prior to the major strikes. The 1979 refined copper production was particularly affected by the Gaspé and Inco strikes, as the entire copper production from both of these operations is smelted and refined in Canada.

Atlantic Provinces

Consolidated Rambler Mines Limited drove an exploration cross-cut into a footwall mineralized zone on the 1800-foot level and reported that this initial opening exposed marginal copper values. Additional work is planned on this zone to establish tonnage and grade estimates. Heath Steele Mines Limited, together with its 75 per cent interest in the Little River Joint Venture mine, was purchased from AMAX Inc. by Noranda Mines Limited in October 1979. In a related transaction, the other 25 per cent share of the joint venture mine was purchased from Inco Limited by ASARCO Incorporated.

Quebec

The strike at the Mines Gaspé operation at Murdochville that began in October 1978 was not settled until June 10, 1979. The custom copper concentrates that normally provide about one-quarter of the feed to the Gaspé smelter were diverted to other smelters. The loss of production at Gaspé reduced the output of Noranda Mines Limited's Canadian Copper Refiners Limited refinery at Montreal East.

At Rouyn-Noranda, workers at Noranda's Horne smelter ratified without a strike a new two-year collective agreement effective September 1, 1979.

Madeleine Mines Ltd. reopened its copper mine near St. Anne des Monts in the Gaspé peninsula in July, after a two and one-half year closure owing to low copper prices. Copper concentrates from Madeleine are smelted at Noranda's Gaspé smelter. Although when the mine was reopened it was expected that reserves would last for only 18 months, increased copper and silver prices could now result in existing reserves lasting until mid-1983.

Patino N.V. announced that at present milling rates, the mine of its wholly-owned Lemoine Mines Limited will be exhausted early in 1982. A drilling program under way in an attempt to locate additional ore had not been successful by year-end.

Noranda Mines Limited completed the amalgamation of its Orchan and Mattagami operations to form the new Matagami Division. Ground ore pulp from the Orchan mill is now pumped to the Mattagami Lake concentrator for flotation. The instrumentation and computer control at this concentrator have resulted in significant increases in metal recovery from Orchan and Norita ores.

Selco Mining Corporation Limited (66 2/3 per cent) and Hudson's Bay Oil and Gas Company Limited (33 1/3 per cent) are developing the Detour B zone deposit, about 60 km north of Joutel. Production from a 1 500 tpd mine and concentrator is expected to begin during the second half of 1981. Development of the property for production will cost \$80 million, in addition to the \$15-25 million already spent on exploring and testing the property. Exploration of the nearby - but deeper - A-2 zone, about one km to the east, continues.

In 1979 the Quebec government continued to press for bilateral mineral trade agreements between Canada and copper consuming countries. However, there were no further developments in the dialogue begun in 1977 between Quebec and the French government that was aimed at establishing an agreement on copper supplies from Quebec producers to French consumers at stabilized prices.

Ontario

The 8½ month strike at the Sudbury operations of Inco Limited that began in September 1978 continued until June 3, 1979. Inco copper inventories were low when the strike began, so that customers had to seek other sources of supply. The total 1978-79 loss of copper production resulting from the Inco strike, from pre-strike production cutbacks and from the slow post-strike startup amounted to about 150 000 t. Inco reopened its Shebandowan mine, west of Thunder Bay, in June. The mine had been closed in November 1978 since its output is processed at the company's Copper Cliff smelter.

Falconbridge Nickel Mines Limited reactivated its East, Onaping and Lockerby mines (closed in the 1975-78 period) during the year and stepped up production gradually to 60 per cent of capacity. The second roaster-electric furnace line in the company's Sudbury smelter was ready for production at year-end. This has essentially completed the smelter environmental improvement program and the operation now meets emission standards of the Ontario government. Public consciousness of the problems caused by acid precipitation was heightened with the publication in 1979 of the U.S./Canada Research Consultation Group report on the long-range transport of air pollutants in North America. Fossil-fuelled electrical generating plants and nonferrous smelters were identified as the major sources of this form of environmental pollution in eastern North America. The pressure increased greatly on Inco and other Canadian smelting companies in Ontario and Quebec to drastically reduce atmospheric emissions of sulphur dioxide.

Texasgulf Inc. reported that its new copper smelter, now under construction at Hoyle Township near Timmins, will be outstanding from an environmental protection viewpoint. The smelter and associated copper refinery and acid plant, scheduled for completion in mid-1981, will cost \$300 million and will have a capacity of 59 000 tpy. At the company's Kidd Creek mine, ore production rates will be increased from 3.6 million tpy in 1979 to 4.5 million t by the end of 1981. The No. 2 mine shaft was completed in 1979 and was being used for mine development during the final quarter of the year.

At Sturgeon Lake, Mattabi Mines Limited continued development in preparation for underground production in early 1981, when open-pit ore is expected to be depleted. A \$3.4 million exploration program for the property was approved in October.

Selco Mining Corporation Limited announced that ore at the company's South Bay mine, at Confederation Lake, will probably be exhausted during 1981 unless the continuing underground exploration program results in the discovery of more ore.

Manitoba

Sherritt Gordon Mines Limited continued to experience a shortage of manpower at the

TABLE 1. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1978 and 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
British Columbia	273 694	450,046,117	286 509	674,462,000
Ontario	197 039	323,999,680	184 888	435,240,000
Quebec	90 172	148,274,390	80 663	189,887,000
Manitoba	60 239	99,052,944	59 169	139,288,000
New Brunswick	10 341	17,003,616	10 913	25,691,000
Newfoundland	11 533	18,964,123	7 823	18,415,000
Yukon	10 019	16,474,354	7 669	18,053,000
Saskatchewan	6 027	9,910,529	5 851	13,774,000
Northwest Territories	316	518,993	269	633,000
Total	659 380	1,084,244,746	643 754	1,515,443,000
Refined	446 278	..	397 262	..
Exports				
Copper in ores, concentrates and matte				
Japan	213 761	213,315,000	233 547	364,308,000
U.S.S.R.	20 468	18,912,000	20 773	42,567,000
Norway	13 795	12,264,000	20 592	25,522,000
Spain	3 539	2,994,000	16 311	19,235,000
South Korea	1 490	1,292,000	9 025	13,736,000
West Germany	11 137	9,569,000	7 116	10,293,000
United States	5 766	4,822,000	8 528	7,710,000
Belgium and Luxembourg	1 736	1,827,000	1 607	2,270,000
United Kingdom	751	944,000	708	1,206,000
Italy	138	22,000	140	17,000
Yugoslavia	8 285	11,371,000	-	-
Other countries	1 293	2,578,000	-	-
Total	282 159	279,910,000	318,347	486,864,000
Copper in slag, skimmings and sludge				
United States	54	19,000	243	115,000
United Kingdom	12	7,000	-	-
Total	66	26,000	243	115,000
Copper scrap (gross weight)				
United States	8 966	8,493,000	11 840	21,446,000
South Korea	2 691	3,591,000	1 456	2,756,000
Belgium and Luxembourg	815	1,043,000	929	1,807,000
West Germany	293	372,000	416	804,000
Spain	788	395,000	359	653,000
United Kingdom	351	176,000	399	392,000
Japan	1 492	2,007,000	198	277,000
Taiwan	549	418,000	191	100,000
Other countries	947	1,163,000	87	150,000
Total	16 892	17,658,000	15 875	28,385,000

TABLE 1. (cont'd.)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Brass and bronze scrap (gross weight)				
United States	9 668	9,728,000	8 944	12,853,000
Belgium and Luxembourg	2 081	2,121,000	2 387	3,521,000
West Germany	188	224,000	1 093	1,928,000
India	831	763,000	1 468	1,794,000
Japan	3 219	3,065,000	940	1,189,000
South Korea	1 221	1,232,000	576	719,000
Netherlands	72	96,000	251	438,000
Italy	54	52,000	198	250,000
Spain	327	119,000	247	214,000
Taiwan	381	365,000	86	96,000
Angola	407	451,000	61	69,000
Other countries	247	247,000	108	138,000
Total	18 696	18,463,000	16 359	23,209,000
Copper alloy scrap, nes (gross weight)				
Belgium and Luxembourg	950	921,000	2 993	4,261,000
United States	3 370	2,662,000	3 067	3,429,000
West Germany	-	-	147	254,000
Japan	717	791,000	214	249,000
Taiwan	81	17,000	940	215,000
Spain	103	70,000	274	193,000
Other countries	390	201,000	528	434,000
Total	5 611	4,662,000	8 163	9,035,000
Copper refinery shapes				
United States	64 173	102,601,000	71 043	170,573,000
United Kingdom	69 679	111,227,000	54 950	142,204,000
West Germany	19 384	29,700,000	13 206	33,460,000
Belgium and Luxembourg	18 371	28,861,000	10 406	26,446,000
France	17 711	28,968,000	10 457	26,409,000
Italy	11 997	19,192,000	6 793	17,064,000
Sweden	7 574	12,315,000	5 779	14,406,000
Japan	14 641	22,329,000	5 272	8,598,000
Netherlands	660	1,014,000	2 573	6,980,000
People's Republic of China	6 000	8,155,000	3 000	6,706,000
South Korea	2 803	5,056,000	2 858	5,339,000
Greece	2 698	4,307,000	1 593	4,104,000
Other countries	12 036	20,023,000	3 195	6,978,000
Total	247 727	393,748,000	191 125	469,267,000
Copper bars, rods and shapes, nes				
United States	4 431	9,635,000	5 248	15,561,000
Venezuela	2 503	3,952,000	1 602	3,992,000
Pakistan	999	1,414,000	1 566	3,178,000
Bangladesh	1 671	2,596,000	1 250	2,964,000
Nigeria	780	1,550,000	870	2,521,000
Dominican Republic	182	280,000	541	1,300,000
Colombia	100	171,000	200	560,000
Singapore	-	-	302	531,000
Israel	130	198,000	80	113,000
Other countries	1 857	2,950,000	6	19,000
Total	12 653	22,746,000	11 665	30,739,000

TABLE 1. (cont'd.)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Copper plates, sheet, strip and flat products				
United States	6 519	16,602,000	6 464	20,901,000
Venezuela	80	220,000	233	624,000
Saudi Arabia	-	-	14	44,000
Colombia	-	-	10	39,000
Australia	12	31,000	12	37,000
Ecuador	-	-	6	24,000
Other countries	103	170,000	14	27,000
Total	6 714	17,023,000	6 753	21,696,000
Copper pipe and tubing				
United States	5 951	14,522,000	5 494	17,435,000
West Germany	213	556,000	980	2,779,000
Israel	954	2,166,000	928	2,637,000
Venezuela	451	1,359,000	566	2,104,000
Spain	551	1,335,000	644	1,890,000
United Kingdom	156	439,000	441	1,469,000
Italy	-	-	121	378,000
Netherlands	8	23,000	51	203,000
Netherlands Antilles	54	132,000	57	199,000
Australia	31	70,000	57	185,000
Other countries	317	927,000	392	1,433,000
Total	8 686	21,529,000	9 731	30,712,000
Copper wire and cable (not insulated)				
United States	217	337,000	909	1,927,000
Saudi Arabia	1 109	2,149,000	540	1,068,000
Trinidad and Tobago	-	-	10	50,000
Venezuela	-	-	10	39,000
Other countries	8	28,000	7	30,000
Total	1 334	2,514,000	1 476	3,114,000
Copper alloy refinery shapes				
United States	14 395	31,614,000	12 458	34,419,000
Australia	4	14,000	138	395,000
Venezuela	66	175,000	117	356,000
Belgium and Luxembourg	-	-	49	105,000
Puerto Rico	-	-	21	78,000
Ecuador	17	38,000	23	64,000
South Korea	-	-	13	52,000
Other countries	50	64,000	36	109,000
Total	14 532	31,905,000	12 855	35,578,000
Copper alloy pipe and tubing				
United States	5 940	14,454,000	3 300	12,136,000
Puerto Rico	3	10,000	228	989,000
Venezuela	175	546,000	190	892,000
West Germany	46	154,000	62	219,000
United Kingdom	-	-	50	204,000
Spain	-	-	41	140,000
Portugal	-	-	18	88,000
Israel	-	-	20	78,000
Netherlands Antilles	17	38,000	27	72,000
Other countries	44	139,000	47	146,000
Total	6 225	15,341,000	3 983	14,964,000

TABLE 1. (cont'd.)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Copper alloy wire and cable, not insulated				
United States	268	505,000	127	475,000
New Zealand	24	83,000	16	72,000
South Africa	14	47,000	20	68,000
Venezuela	-	-	2	14,000
Other countries	28	89,000	4	18,000
Total	334	724,000	169	647,000
Copper alloy fabricated materials, nes				
United States	765	2,392,000	1 289	4,570,000
United Kingdom	228	400,000	191	531,000
Indonesia	1	3,000	59	124,000
Taiwan	10	31,000	15	55,000
Puerto Rico	-	-	5	50,000
Singapore	-	-	16	39,000
Other countries	408	1,172,000	59	250,000
Total	1 412	3,998,000	1 634	5,619,000
Wire and cable insulated[2]				
United States	9 194	26,728,000	12 942	46,298,000
Saudi Arabia	5 997	15,452,000	4 040	11,707,000
Pakistan	472	956,000	3 231	5,679,000
Dominican Republic	104	305,000	424	1,437,000
Colombia	12	44,000	895	1,182,000
Trinidad and Tobago	259	695,000	311	983,000
Peru	66	194,000	163	569,000
Jamaica	270	643,000	196	510,000
Indonesia	22	66,000	174	503,000
Malta	-	-	124	420,000
Algeria	7	18,000	192	418,000
U.S.S.R.	-	-	138	395,000
Venezuela	140	383,000	123	387,000
Bermuda	88	202,000	103	387,000
Iran	186	519,000	104	328,000
Ivory Coast	5	19,000	134	304,000
Haiti	77	141,000	76	281,000
Chile	158	662,000	87	227,000
Australia	32	96,000	36	201,000
South Africa	48	254,000	28	201,000
Other countries	2 278	4,961,000	1 214	4,736,000
Total	19 415	52,338,000	24 735	77,153,000
Total exports of copper and products		882,585,000		1,237,097,000
Imports				
Copper in ores and concentrates	18 397	17,659,000	2 640	3,248,000
Copper scrap	19 952	21,336,000	26 527	34,953,000
Copper refinery shapes	21 441	37,687,000	32 541	73,901,000
Copper bars, rods and shapes, nes	1 811	2,573,000	800	1,810,000
Copper plates, sheet strip and flat products	1 016	2,482,000	1 117	3,603,000
Copper pipe and tubing	1 985	5,556,000	2 385	8,099,000

TABLE 1. (concl'd.)

	1978		1979P	
	(tonnes)	($)	(tonnes))	($)
Imports (cont'd.)				
Copper wire and cable, except insulated	1 987	3,670,000	1 710	5,096,000
Copper alloy scrap (gross weight)	7 586	6,212,000	8 916	8,714,000
Copper powder	710	1,775,000	569	1,737,000
Copper alloy refinery shapes, rods and sections	9 941	17,802,000	9 816	22,863,000
Brass plates, sheet and flat products	4 386	8,520,000	4 200	9,951,000
Copper alloy plates, sheets, strip and flat products	1 054	3,792,000	1 081	4,253,000
Copper alloy pipe and tubing	2 490	8,164,000	2 484	9,688,000
Copper alloy wire and cable, except insulated	496	1,879,000	764	2,989,000
Copper and alloy fabricated material, nes	1 734	6,550,000	2 040	9,857,000
Insulated wire and cable	..	39,544,000	..	52,239,000
Copper oxides and hydroxides	302	596,000	303	766,000
Copper sulphate	886	606,000	542	464,000
Copper alloy castings	398	1,501,000	582	2,457,000
Total imports of copper and products	..	187,904,000	..	256,688,000
Consumption[3]				
Refined	228 694	..	210 689	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Includes small quantities of non-copper wire and cable, insulated. [3] Producers' domestic shipments, refined copper.
- Nil; P Preliminary; .. Not available or not applicable; nes Not elsewhere specified.

Ruttan mine. As a result, production and mine development were both behind schedule. The Ruttan open-pit is expected to be phased out in 1980 and production will then come entirely from the new underground mine beneath the pit which became operational in March 1979. Ore grades in the underground mine generally exceed expectations that were based on the exploration drilling. At year-end, the service shaft was being deepened for development of the 1,800- and 2,200-foot levels and deep diamond drill holes were probing the 2,600- to 3,000-foot levels, with preliminary planning under way for a production shaft to this depth.

At Sherritt's Fox Lake mine, production was down from 1978, primarily because of a three-week strike in June. Diamond drilling from the 2,480 level for a down-dip extension of the main ore zone was inconclusive, but an intersection of the ore horizon was made at the 4,000-foot level. Ten drill holes on a claim group near the Fox mine intersected a potentially mineable copper-zinc zone. This work was to be continued in 1980.

Hudson Bay Mining and Smelting Co., Limited completed construction of its new 3 450 tpd Snow Lake concentrator, with first ore being treated on April 26. The concentrator was producing at design performance by year-end. Collaring of the shaft at the new Spruce Point mine was completed early in the year and construction of the surface plant was nearly completed by year-end. Shaft sinking was expected to begin early in 1980. Hudson Bay announced the signing of a letter of intent on a 10-year lease to mine the Rod orebody at Snow Lake, owned equally by Falconbridge Nickel Mines Limited and Stall Lake Mines Limited. Hudson Bay estimated that it would spend $10 million to develop the mine, and that production would begin during the second half of 1982. The deposit had been previously estimated to contain 672 641 t grading 5.38 per cent Cu, 2.28 per cent Zn, and small amounts of silver and gold.

British Columbia

Activity in development of new copper mines and in mine expansion projects in British Columbia was at its highest level for some years in 1979.

Craigmont Mines Limited anticipated that it would be able to extend the life of its mine at Merritt into early 1981. The mine, which entered commercial production in September 1961, had previously been expected to close in 1979. Higher copper prices have allowed mining of lower grade, previously uneconomic, ores. The final exploration program on the ground adjacent to the mine was concluded in the spring of 1979 at a cost of $1,655,000, but no additional ore was discovered. Exploration drilling on Craigmont's Chu Chua prospect near Kamloops has indicated an estimated 2 million t, grading 2 per cent copper, and 0.5 per cent zinc, with values in gold, silver and cobalt. In itself, this quantity is not considered sufficient to be economic, but further exploration will be carried out in the area in 1980. Recovery of iron concentrate from about 900 000 t of stockpiled low grade iron concentrate is expected to continue at the end of the copper mining operations.

The smelter at Afton Mines Ltd. near Kamloops reached full production in March, after many months of tune-up.

Production at Brenda Mines Ltd., near Peachland, was somewhat lower in 1979 owing to a 33-day strike that ended October 17 and to unusually high maintenance requirements near the end of the year. The anticipated life of the mine was extended for at least five years by planned pit expansions.

Newmont Mines Limited continued the development of its Copper Mountain mine at the Similkameen Division. Mining of the present Ingerbelle pit is scheduled for completion in December 1981. Ore deliveries from the new Copper Mountain pit, across the Similkameen River from Ingerbelle, are to begin in September 1980. Construction of a shop and office complex and the suspension bridge to support the conveyor carrying ore across the river were completed by year-end.

The strike at Gibraltar Mines Ltd., which had begun in May 1978, was settled on February 6, 1979. Mining was from the Pollyanna pit in 1979, but preparation of the Gibraltar East pit for Stage II mining continued through 1979, with mining to move from the Pollyanna pit to the Gibraltar East pit in 1980. This pit will have the unusual feature of an in-pit primary crusher and conveyor system. The next period of major capital expenditures will occur in 1980 at the time of development for Stage II mining of the Granite Lake pit.

New developments were announced in 1979 for the Highland Valley area. Teck Corporation and Highmont Mining Corporation commenced development of a 22 000 tpd open-pit mine on the Highmont property, adjacent to the Lornex mine, at a capital cost of $150 million. The new Highmont mine is expected to yield an average annual production of 20 865 t of copper and 2 100 t of molybdenum over the first 10 years. Production in the initial years will be from a higher grade molybdenum area, with the first year's output scheduled to be 17 700 t of copper and 4 080 t of molybdenum. Construction, which began in May 1979, was expected to be completed in the autumn of 1980. Later in 1979, Teck Corporation's subsidiary Tecksub (1979) Limited amalgamated with Highmont Mining Corporation and Iso Mines Limited under the name of Highmont Mining Corporation.

Lornex Mining Corporation Ltd. commenced a $160 million expansion program intended to increase production capacity by about 68 per cent by adding a third, slightly larger semi-autogenous mill line, a new crusher and ore conveyor system, 18 new 154 t trucks, three new 17 cubic metre shovels and an additional tailings line and other facilities, including a $6.6 million molybdenum leach plant. Annual copper production at Lornex will increase to about 90 000 t from the present 60 000 t. The expansion project is scheduled for completion by mid-1981.

Valley Copper Mines Limited reported that preliminary studies suggest the Lake Zone deposit "is well placed to be a competitive producer" and began a more definitive cost estimate and project analysis. This study, based on a production rate of 50 000 to 54 500 tpd, was scheduled for completion by the end of 1979, but no decision was announced. Preliminary capital cost estimates for that scale of operations were some $350 million. In 1979, the company stated that copper prices in the range of 90 cents to $1.00 a pound were needed to make the project viable. The deposit is owned 80 per cent by Valley Copper Mines and 20 per cent by Bethlehem Copper Corporation and contains an estimated 820 million t averaging 0.44 per cent Cu at a cutoff grade of .30 per cent. The tonnage ranges between 725 million t grading .46 per cent copper and 910 million t grading .42 per cent copper, depending on the cutoff grade used.

Bethlehem Copper Corporation indicated in its 1979 annual report that the project is proposed ultimately to operate at a rate of 102 000 t of ore a day, which would rank it as one of the largest developments in the world. Should a production decision be forthcoming, Bethlehem would commence an expansion of its mill capacity immediately.

Bethlehem's Iona mine was exhausted by the end of the year, leaving reserves sufficient for about seven years operation in

TABLE 2. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970 AND 1975-79

	Production		Exports			Imports	Consumption[2]
	All Forms[1]	Refined	Ore and Matte	Refined	Total	Refined	Refined
				(tonnes)			
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	635 223	10 908	185 198
1976	730 930	510 469	294 823r	322 991r	617 814r	9 124	206 198r
1977	759 423	508 767	279 583	294 490r	574 073r	18 821	203 382r
1978	659 380	446 278	282 159	247 727	529 886	21 441	228 694
1979P	643 754	397 262	318 347	191 125	509 472	32 541	210 689

Sources: Energy, Mines and Resources Canada; 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, 1979 AND (1978)

Company and Location	Mill or Mine Capacity (tonnes)	Grade of Ore Milled: Copper (%)	Zinc (%)	Lead (%)	Nickel (%)	Silver (grams/ tonne)	Gold (grams/ tonne)	Ore Milled (tonnes)	Copper Concentrates Produced (tonnes)	Grade of Copper in Concentrate (%)	Contained Copper Produced[1] In All Concentrates (tonnes)	Destination of Copper Concentrate[2]
Newfoundland												
ASARCO Incorporated, Buchans	1 100 (1 100)	1.04 (1.04)	11.64 (10.78)	6.51 (6.07)	- (-)	109.71 (104.91)	0.82 (0.79)	113 398 (183 251)	2 526 (4 436)	26.17 (25.97)	1 104 (1 775)	9 (11)
Consolidated Rambler Mines Limited, Ming mine, Baie Verte	1 100 (1 100)	3.90 (4.70)	- (-)	- (-)	- (-)	23.52 (26.47)	2.67 (2.88)	196 918 (247 874)	28 786 (41 456)	25.43 (26.27)	7 320 (10 890)	1 (1)
New Brunswick												
Brunswick Mining and Smelting Corporation Limited, No. 6 and No. 12 mines, Bathurst	9 100 (9 100)	0.31 (0.29)	8.93 (8.88)	3.61 (3.56)	- (-)	94.97 (93.94)	- (-)	2 971 516 (3 058 300)	16 842 (14 330)	21.69 (22.85)	6 032 (5 484)	1 (1)
Heath Steele Mines Limited, Newcastle	3 650 (3 650)	0.91 (1.03)	4.55 (4.43)	1.53 (1.53)	- (-)	55.20 (77.49)	0.69 (0.89)	1 172 737 (1 137 767)	26 394 (26 437)	23.76 (22.56)	7 805 (7 646)	1,2 (1,2)
Quebec												
Campbell Chibougamau Mines Ltd., Cedar Bay, Henderson and Merrill pit, Chibougamau	3 600 (3 600)	1.17 (1.38)	- (-)	- (-)	- (-)	7.54 (8.67)	2.26 (3.46)	396 822 (230 489)	22 318 (14 457)	20.00 (21.12)	4 464 (3 053)	2 (2)
Falconbridge Copper Limited, Millenbach mine, Noranda	1 400 (1 400)	3.60 (3.36)	4.90 (3.85)	- (-)	- (-)	48.69 (43.54)	0.89 (0.82)	419 827 (372 222)	55 826 (44 936)	25.90 (26.53)	14 672 (12 075)	2 (2)
Falconbridge Copper Limited Perry, Springer, Cooke mines, Chapais	2 900 (2 900)	1.79 (1.99)	- (-)	- (-)	- (-)	12.34 (14.06)	1.34 (1.89)	954 801 (967 823)	66 248 (77 836)	23.79 (23.74)	16 236 (18 478)	2 (2)

Canadian Copper Refiners Limited, Mines Gaspé Division Copper Mountain mine, Needle Mountain mine, Murdochville	30 700 (30 600)	0.51 (0.51)	- (-)	- (-)	- (-)	3.16 (3.19)	0.07 (0.07)	5 635 594 (7 985 273)	107 564 (151 664)	23.10 (23.44)	24 859 (35 561)	1 (1)
Molybdenum grades of ore milled: 1979, 0.019%; 1978, 0.027%												
Lemoine Mines Limited (Patino N.V.) Chibougamau	300 (400)	5.07 (4.97)	11.61 (11.18)	- (-)	- (-)	92.91 (94.63)	5.25 (5.31)	108 267 (105 611)	22 047 (20 044)	23.70 (24.82)	5 330 (5 080)	2 (2)
Madeleine Mines Ltd., Ste. Anne des Monts	2 250 (2 250)	0.98 (-)	- (-)	- (-)	- (-)	6.86 (-)	- (-)	297 853 (-)	8 832 (-)	30.68 (-)	2 710 (-)	1 (-)
Louvem Mining Company Inc., Louvem Division, Val d'Or	910 (900)	0.04 (0.15)	4.51 (5.33)	0.55 (0.29)	- (-)	137.83 (87.77)	0.93 (1.75)	72 261 (248 073)	- (1 029)	- (12.62)	19 (304)	- (2)
Noranda Mines Limited Matagami Division Mattagami, Orchan and Norita and Radiore No. 2 mines Matagami (operations merged in 1979)	4 000	0.73	5.37	-	-	26.85	0.58	1 329 025	32 262	23.54	8 346	2
Mattagami mine	(4 000)	(0.52)	(7.56)	(-)	(-)	(32.57)	(0.51)	(878 484)	(13 556)	(24.33)	(3 809)	(2)
Orchan and Garon Lake mines	(1 900)	(0.61)	(5.89)	(-)	(-)	(34.29)	(0.69)	(368 602)	(6 324)	(25.11)	(1 588)	(2)
Patino Mines (Québec) Limited Copper Rand, Copper Cliff, Portage mines, Chibougamau	2 500 (2 500)	1.64 (1.60)	- (-)	- (-)	- (-)	9.50 (9.70)	3.19 (3.39)	606 995 (616 381)	48 080 (44 917)	19.97 (21.04)	9 602 (9 451)	2 (2)
Ontario												
Falconbridge Nickel Mines Limited Falconbridge, Strathcona, East Onaping and Lockerby mines, Sudbury	10 300 (11 300)	0.85 (0.78)	- (-)	- (-)	1.23 (1.29)	3.4 (..)	.07 (..)	2 130 991 (2 073 500)	.. (..)	.. (..)	20 515 (15 491)	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] In All Concentrates	Destination of Copper Concentrate[2]
	(tonnes)	(%)	(%)	(%)	(%)	(grams/	(grams/	(tonnes)	(tonnes)	(%)	(tonnes)	
Ontario (cont'd)												
Falconbridge Copper Limited Sturgeon Lake Joint Venture Sturgeon Lake	1 100 (1 100)	2.17 (2.73)	8.70 (9.14)	1.23 (1.17)	- (-)	169.71 (171.77)	0.62 (0.72)	373 953 (370 087)	33 861 (42 167)	21.88 (22.77)	7 742 (9 955)	2 (2)
Inco Metals Company, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Levack, Levack West and Little Stobie mines, Sudbury; includes Shebandowan mine Shebandowan	49 400[4] (61 200)	1.39 (1.36)	- (-)	- (-)	1.40 (1.48)	.. (..)	.. (..)	5 339 227 (7 021 029)	.. (..)	.. (..)	69 921 (90 471)	3 (3)
Mattabi Mines Limited Sturgeon Lake	2 700 (2 700)	0.55 (0.83)	6.91 (6.49)	0.77 (0.67)	- (-)	97.71 (93.26)	0.38 (0.41)	945 015 (871 675)	15 364 (25 056)	22.71 (24.68)	4 463 (6 720)	2 (2)
Noranda Mines Limited Geco Division Manitouwadge	4 500 (4 500)	1.82 (1.54)	3.24 (2.19)	0.11 (0.12)	- (-)	58.97 (38.74)	0.10 (0.17)	1 475 841 (1 572 458)	90 776 (79 932)	26.91 (27.55)	25 254 (23 129)	2 (2)
Pamour Porcupine Mines, Limited, Schumacher Division mill Timmins	2 700 (2 700)	0.25 (0.23)	- (-)	- (-)	- (-)	3.43 (3.98)	2.96 (3.05)	728 079 (881 357)	6 857 (7 869)	22.56 (21.64)	1 547 (1 702)	2 (2)
Selco Mining Corporation Limited, South Bay mine, Uchi Lake	450 (450)	1.44 (1.43)	10.75 (12.20)	- (-)	- (-)	63.77 (75.77)	- (-)	132 923 (121 635)	6 893 (5 967)	25.33 (26.21)	1 836 (1 636)	2 (2)
Teck Corporation Silverfields Mining Division, Cobalt	250 (250)	0.60 (0.60)	- (-)	- (-)	0.25 (0.26)	308.57 (342.86)	- (-)	75 392 (77 247)	- (-)	- (-)	35 (33)	- (-)

Texasgulf Inc., Kidd Creek mine Timmins	9 100 (9 100)	1.95 (1.87)	5.47 (6.43)	0.15 (0.20)	- (-)	76.03 (102.71)	- (-)	3 680 858 (3 002 148)	259 404 (200 917)	25.18 (24.81)	68 379 (53 325)	2 (2)
Union Minière Explorations and Mining Corporation Limited, Thierry mine	3 600 (3 600)	1.15 (1.29)	- (-)	- (-)	0.11 (0.13)	8.23 (8.23)	.. (0.14)	956 291 (836 119)	36 672 (35 074)	26.82 (28.07)	9 835 (9 845)	2 (2)
Manitoba-Saskatchewan												
Hudson Bay Mining and Smelting Co., Limited Anderson, Chisel, Flin Flon (including Saskatchewan portion), Ghost, Osborne, Stall, White Lake, Centennial and Westarm mines, Flin Flon and Snow Lake	7 250 (7 700)	2.23 (2.26)	3.55 (3.16)	.14 (..)	- (-)	17.3 (20.57)	1.12 (1.22)	1 701 000 (1 679 000)	185 609 (192 538)	17.12 (18.00)	32 296 (35 234)	6 (6)
Inco Metals Company, Pipe and Thompson mines Thompson district	12 700 (..)	.14 (..)	- (-)	- (-)	1.81 (..)	2.74 (..)	.10 (..)	2 269 680 (2 139 911)	.. (..)	.. (..)	..[5] (..)[5]	3 (3)
Sherritt Gordon Mines Limited, Fox mine Lynn Lake area	2 700 (2 700)	1.19 (1.24)	1.82 (1.73)	- (-)	- (-)	4.69 (4.80)	0.17 (0.15)	772 500 (874 933)	31 793 (40 095)	25.84 (25.28)	8 477 (10 413)	6 (6)
Ruttan mine Leaf Rapids area	9 100 (9 100)	1.39 (1.15)	1.17 (1.53)	- (-)	- (-)	5.60 (5.69)	0.21 (0.22)	2 094 159 (2 307 069)	96 923 (87 612)	26.99 (27.06)	26 614 (24 479)	2,6 (2,6)
British Columbia												
Afton Mines Ltd. Dominion pit, Kamloops	7 800 (7 300)	1.06 (1.01)	- (-)	- (-)	- (-)	4.90 (4.97)	0.79 (0.72)	2 822 528 (2 456 770)	42 862 (..)	61.01 (..)	26 149 (21 805)	8 (8)
Bethlehem Copper Corporation, Iona and Jersey mines, Highland Valley	18 100 (18 100)	0.41 (0.41)	- (-)	- (-)	- (-)	2.13 (2.74)	0.04 (0.03)	6 536 861 (6 490 760)	52 482 (49 257)	40.16 (44.08)	21 077 (21 713)	10,13 (10)

Molybdenum grades of ore milled: 1979, 0.036%; 1978, 0.040%

TABLE 3. (cont'd)

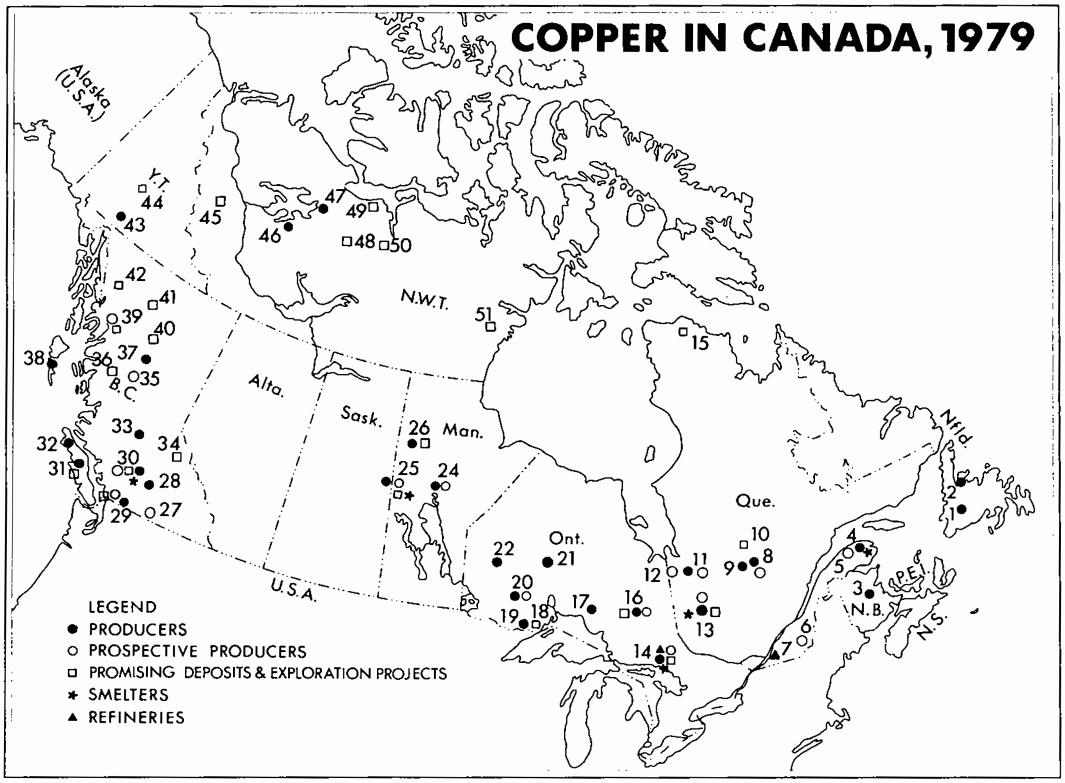
Company and Location	Mill or Mine Capacity (tonnes)	Grade of Ore Milled: Copper (%)	Zinc (%)	Lead (%)	Nickel (%)	Silver (grams/	Gold (grams/	Ore Milled (tonnes)	Copper Concentrates Produced (tonnes)	Grade of Copper in Concentrate (%)	Contained Copper Produced[1] In All Concentrates (tonnes)	Destination of Copper Concentrate[2]
British Columbia (cont'd)												
Brenda Mines Ltd.,	27 000	0.14	-	-	-	1.27	0.02	9 075 720	36 672	29.25	10 727	10,12
Peachland	(21 800)	(0.16)	(-)	(-)	(-)	(1.37)	(0.02)	(9 995 801)	(46 881)	(30.02)	(14 074)	(10,12,13)
Molybdenum grades of ore milled: 1979, 0.036% Mo; 1978, 0.040% Mo.												
Craigmont Mines	5 200	0.86	-	-	-	-	-	1 924 570	49 849	28.32	14 117	10,12,13
Limited	(5 200)	(1.36)	(-)	(-)	(-)	(-)	(-)	(1 899 953)	(82 789)	(28.71)	(23 769)	(10,13)
Merritt												
Gibraltar Mines Ltd.	36 300	0.42	-	-	-	0.96	-	10 446 035	128 455	28.25	36 288	6,10,13
(N.P.L.),	(36 300)	(0.38)	(-)	(-)	(-)	(-)	(-)	(5 135 682)	(60 376)	(26.97)	(16 283)	(6,10,13)
McLeese Lake,												
Caribou District												
Molybdenum grade of ore milled: 1979, 0.011% Mo; 1978, 0.010% Mo												
Phoenix Copper	-	-	-	-	-	-	-	-	-	-	-	-
Division	(2 600)	(0.44)	(-)	(-)	(-)	(4.29)	(0.55)	(198 640)	(2 124)	(25.94)	(551)	(9)
Greenwood												
Lornex Mining	44 500	0.43	-	-	-	2.06	-	16 126 103	200 805	31.67	63 595	9,10,13
Corporation Ltd.,	(43 500)	(0.45)	(-)	(-)	(-)	(2.40)	(-)	(15 927 148)	(208 962)	(30.60)	(63 942)	(9,10,13)
Lornex mine												
Highland Valley												
Molybdenum grade of ore milled: 1979, 0.016%; 1978, 0.016%.												
Noranda Mines Limited												
(Babine Division)												
Bell Copper mine	9 100	0.35	-	-	-	..	0.27	5 073 909	53 874	27.18	14 643	2
Babine Lake	(9 100)	(0.44)	(-)	(-)	(-)	(0.69)	(0.34)	(4 470 094)	(61 689)	(26.69)	(16 465)	(2)
Granisle mine	12 700	0.45	-	-	-	2.40	0.24	4 382 909	50 111	34.86	17 469	10,11,13
Babine Lake	(12 700)	(0.41)	(-)	(-)	(-)	(2.26)	(0.21)	(4 549 288)	(50 371)	(30.93)	(15 580)	(10,11,13)
(ownership transferred from Zapata Granby Corporation on November 30, 1979. Production figures for 1979 are totals for the entire year, under Zapata Granby and Noranda ownership)												
Newmont Mines Limited	-	-	-	-	-	-	-	-	-	-	-	-
Granduc mine,	(7 300)	(1.43)	(-)	(-)	(-)	(8.23)	(0.14)	(740 119)	(35 708)	(28.33)	(10 116)	(10)
Stewart												
Similkameen Division,	22 000	0.44	-	-	-	0.62	0.17	7 034 952	94 677	28.10	26 604	10
Ingerbelle pit,	(22 000)	(0.41)	(-)	(-)	(-)	(1.37)	(0.34)	(6 826 464)	(89 868)	(27.60)	(24 804)	(10)
Princeton												

Utah Mines Ltd.,	37 200	0.45	-	-	-	1.68	0.24	13 339 997	226 152	23.08	52 196	10
Island Copper mine	(37 200)	(0.40)	(-)	(-)	(-)	(1.37)	(0.21)	(14 200 278)	(213 795)	(23.14)	(49 490)	(10)
Coal Harbour												
Molybdenum grade of ore milled: 1979, 0.015%; 1978, 0.015%.												
Wesfrob Mines	7 300	0.37	-	-	-	4.46	0.10	1 009 247	15 691	20.35	3 193	10,13
Limited	(7 300)	(0.35)	(-)	(-)	(-)	(4.11)	(0.10)	(889 933)	(13 317)	(19.92)	(2 653)	(10)
Tasu Harbour												
Western Mines	900	1.32	8.45	1.37	-	131.31	2.91	266 877	10 247	27.96	3 315	10
Limited	(900)	(1.25)	(8.24)	(1.33)	(-)	(139.89)	(2.85)	(269 035)	(10 252)	(27.47)	(3 296)	(10)
Lynx and Myra mines,												
Buttle Lake												
Yukon Territory												
Whitehorse Copper	2 300	1.12	-	-	-	7.20	0.69	829 221	17 817	44.54	7 936	6
Mines Ltd.,	(2 300)	(1.40)	(-)	(-)	(-)	(7.82)	(0.86)	(782 984)	(21 272)	(44.62)	(9 491)	(6)
Little Chief mine,												
Whitehorse												
Northwest Territories												
Echo Bay Mines Ltd.	135	0.74	-	-	-	1748.57	-	36 083	..	..	231	..
Port Radium	(135)	(0.83)	(-)	(-)	(-)	(2170.29)	(-)	(34 232)	(..)	(..)	(234)	(..)
Terra Mining and	180	1.03	-	-	-	421.7	-	31 020	..	..	278	..
Exploration Limited	(180)	(0.29)	(-)	(-)	(-)	(1385.14)	(-)	(33 433)	(-)	(-)	(58)	(..)
Silver Bear Mine												
Great Slave Lake												

Sources: Company reponses to Department of Energy, Mines and Resources questionnaires, company reports and technical press.

[1] Total copper in concentrates of all metals. [2] Destination of concentrates: (1) Canadian Copper Refiners Limited, Mines Gaspé Division; (2) Noranda Mines Limited; (3) Inco Limited, 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. [4] Capacity limited by Ontario SO_2 emission regulations. [5] Included in the Inco copper production for Ontario.

- Nil; .. Not available.



PRODUCERS
(numbers correspond to those in map above)

1. ASARCO Incorporated (Buchans Unit)
2. Consolidated Rambler Mines Limited (Ming mine)
3. Brunswick Mining and Smelting Corporation Limited (Nos. 6 and 12 mines)
   Heath Steele Mines Limited
4. Noranda Mines Limited, Division Mines Gaspé (Copper Mountain and Needle Mountain mines)
5. Madeleine Mines Ltd.
8. Campbell Chibougamau Mines Ltd. (Cedar Bay, Henderson and Merrill mines)
   Lemoine Mines Limited (Patino N.V.)
   Patino Mines (Quebec) Limited (Copper Rand mine)
9. Falconbridge Copper Limited, Opemiska Division (Perry, Springer and Cooke mines)
11. Noranda Mines Limited, Mattagami Division (Mattagami, Orchan, Norita mines)
13. Falconbridge Copper Limited, Lake Dufault Division (Millenbach mine)
14. Falconbridge Nickel Mines Limited (East, Falconbridge, Lockerby, Onaping, Strathcona mines)
    Inco Metals Company (Coleman, Copper Cliff, South, Creighton, Frood Stobie, Garson, Levack, Levack West, Little Stobie mines)

16. Texasgulf Inc. (Kidd Creek mine)
    Pamour Porcupine Mines Limited
    (Schumacher, Ross mines)
17. Noranda Mines Limited, Geco Division
19. Inco Metals Comany (Shebandowan mine)
20. Falconbridge Copper Limited, Sturgeon Lake Joint Venture
    Mattabi Mines Limited
21. Union Minière Explorations and Mining Corporation Limited (Thierry mine)
22. Selco Mining Corporation Limited (South Bay mine)
24. Inco Metals Company (Pipe No. 2 and Thompson mines)
25. Hudson Bay Mining and Smelting Co., Limited (Anderson, Centennial, Chisel, Flin Flon, Ghost, Osborne, Stall, Westarm and White Lake mines)
28. Brenda Mines Ltd.
29. Newmont Mines Limited (Ingerbelle mine)
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.
37. Noranda Mines Limited (Bell Copper, Granisle mines)
38. Wesfrob Mines Limited (Tasu mine)
43. Whitehorse Copper Mines Limited
46. Terra Mining and Exploration Limited
47. Echo Bay Mines Ltd.

PROSPECTIVE PRODUCERS[1]

8. Campbell Chibougamau Mines Ltd. Grandroy and other mines)
   Patino Mines (Quebec) Limited (Portage mine)
11. Noranda Mines Limited (Phelps Dodge Corporation)
12. Selco Mining Corporation Limited - Hudson's Bay Oil and Gas Company Limited (Selbaie mine)
13. Falconbridge Copper Limited, Lake Dufault Division (Corbet mine)
    Noranda Mines Limited (New Insco mine)
14. Falconbridge Nickel Mines Limited (Fraser, Lindsley, North mines)
    Inco Metals Company (Clarabelle, Copper Cliff North, Crean Hill, Fecunis, Levack East, Totten mines)
20. Noranda Mines Limited (Lyon Lake, "F" Group mines)
24. Inco Metals Company (Birchtree, Pipe No. 1, Soab North, Soab South mines)
25. Hudson Bay Mining and Smelting Co., Limited (Rod, Spruce Point mines)
29. Newmont Mines Limited (Copper Mountain mine)
30. Teck Corporation (Highmont mine)
34. Noranda Mines Limited (Goldstream mine)
35. Equity Silver Mines Limited (Sam Goosly deposit)
39. Esso Minerals Canada (Granduc mine)

[1] Only mines with announced production plans and mines placed on standby.

OTHER PROMISING DEPOSITS AND EXPLORATION PROJECTS[1]

10. Selco Mining Corporation Limited and Muscocho Explorations Limited (Lessard option deposit)
13. Noranda Mines Limited (Magusi River deposit)
14. Falconbridge Nickel Mines Limited (Craig, Onex mines)
    Inco Metals Company (Cryderman, Whistle mines)
15. New Quebec Raglan Mines Limited
16. Teck Corporation - Metallgesellschaft Canada Limited - Domik Exploration Limited (Montcalm Twp.)
18. Great Lakes Nickel Limited
25. Hudson Bay Mining and Smelting Co., Limited (Wim mine)
    Gränges Exploration AB - Manitoba Mineral Resources Ltd. (Embury Lake deposit)
27. Copper Giant Mining Corporation Limited (Poison Mountain deposit)
29. 20th Century Energy Corporation (Gambier Island deposit)
30. Bethlehem Copper Corporation (J.A. and Maggie deposits)
    Valley Copper Mines Limited - Bethlehem Copper Corporation (Lake zone deposit)
31. Catface Copper Mines Limited (Falconbridge Nickel Mines Limited) (Catface deposit)
37. Noranda Mines Limited (Morrison deposit)

[1] A more complete inventory is available in the publication **Canadian Mineral Deposits Not Being Mined in 1980,** National Mineral Inventory Section, Energy, Mines and Resources Canada, Mineral Policy Sector Internal Report MRI 80/7.

40. Falconbridge Nickel Mines Limited (Sustut deposit)
Kennco Explorations, (Western) Limited (Huckleberry Mountain deposit)
41. Sumitomo Metal Mining Canada Ltd. - Esso Minerals Canada (Kutcho Creek deposit)
42. Liard Copper Mines Ltd. (Schaft Creek deposit)
Stikine Copper Limited
Texasgulf Inc. (Red Group)
44. Asarco Exploration Company of Canada, Limited, Silver Standard Mines Limited, Canadian Superior Exploration Limited, Falconbridge Nickel Mines Limited, and United Keno Hill Mines Limited (Minto Copper deposit)
45. Shell Canada Limited (Coates Lake, Jay deposits)
48. Texasgulf Inc. (Izok Lake, Hood River deposits)
49. Kennarctic Explorations Limited (High Lake deposit)
50. Cominco Ltd. (Hackett River deposit)
51. St. Joseph Explorations Limited (Heninga Lake deposit)

SMELTERS

4. Canadian Copper Refiners Limited
Mines Gaspé Division
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

TABLE 4. PROSPECTIVE COPPER PRODUCERS, 1979

Company and Location	Mine or Mill Capacity tonnes/day and Ore Grade	Year Production Expected or Expansion Completed	Destination of Copper Concentrates	Remarks
New Brunswick				
Brunswick Mining and Smelting Corporation Limited No. 12 mine, Bathurst	10 000 Cu 0.32% Pb 3.76% Zn 9.18% Ag 96.3 g/t	1981	Gaspé	Expanding No. 12 mine to 10 000 tpd from 6 400. Development includes new 8-m shaft, a new underground crusher, expansion of mill capacity to 10 000 tpd from 8 500 tpd.
Quebec				
Falconbridge Copper Limited, Lake Dufault Division, Corbet mine, Noranda	Cu 2.99% Zn 2.13% Ag 23.3 g/t Au	1980	Noranda	Shaft completed to 3,993 feet, underground exploration and development completed, production to commence January 1980.
Noranda Mines Limited Phelps Dodge option La Gauchetiere township	450 Cu 1.1% Zn 4.9%	1982	Noranda	Deposit acquired from Phelps Dodge Corporation of Canada, Limited. Development delayed in 1977, being developed for production in 1982 at a cost of $6 million.
Ontario				
Falconbridge Nickel Mines Limited Fraser mine, Sudbury area	Cu 8.9% Ni .52%	1981	Falconbridge	Shaft completed to 5,250 ft (between Strathcona and Fecunis mines). Project originally begun in 1970 but deferred twice before completion. Preproduction and capital expenditures $11,275,000.
North mine, Sudbury area	Cu .. Ni ..	1980	Falconbridge	Former producer, in preparation for production in 1980.
Noranda Mines Limited Lyon Lake Division, Sturgeon Lake area	900 Cu 1.24% Zn 6.53% Pb 0.63% Ag 117 g/t Au 0.34 g/t	1980	Noranda	Production originally scheduled to start late 1977 or early 1978, but development suspended November 30, 1977 pending more favourable economic conditions. Rehabilitation of mining and surface equipment begun in March 1979, with underground crusher and conveyor system completed by year-end. Diamond drilling has indicated more ore than included in 3.6 million t published reserves.

TABLE 4. (cont'd)

Company and Location	Mine or Mill Capacity tonnes/day and Ore Grade	Year Production Expected or Expansion Completed	Destination of Copper Concentrates	Remarks
Ontario (cont'd)				
Noranda Mines Limited "F" Group mine Sturgeon Lake area	.. Cu 0.98% Zn 8.10% Pb 0.49% Ag 62 g/t	1981	Noranda	Development of orebody began in July. Retaining ponds for mine water were partially completed and 810 000 t of waste rock and overburden removed.
Manitoba				
Hudson Bay Mining and Smelting Co., Limited Spruce Point mine, Reed Lake	.. Cu 2.8% Zn 4.5% values in Ag & Au	..	Hudson Bay	Shaft collared early 1979, surface plant nearly complete by year-end.
Rod mine, Snow Lake	Cu 5.38% Zn 2.28% values in Ag & Au	1982	Hudson Bay	Letter of intent signed with Falconbridge Nickel Mines Limited and Stall Lake Mines Limited to lease the orebody for a royalty of 7 per cent of the net realized value from the metals produced. Orebody to be developed for production at a cost of $14.5 million.
British Columbia				
Newmont Mines Limited Copper Mountain mine, Princeton		1981	Japan	Open-pit mine being prepared for production at old underground mine. Ore to be crushed and transported by conveyor across canyon to existing concentrator.
Noranda Mines Limited, Goldstream mine, 80 km north of Revelstoke	Cu 3.6% Zn 2.6% Ag ..	1982	Noranda	At year-end company was awaiting final B.C. government approval to develop the mine.
Teck Corporation Highmont mine, Highland Valley	22 600 Cu 0.27% Mo 0.047%	1980	Marc Rich	Production decision announced May 1979. Open pit mine and concentrator under construction, at a cost of $150 million.

TABLE 4. (cont'd)

Company and Location	Mine or Mill Capacity tonnes/day and Ore Grade	Year Production Expected or Expansion Completed	Destination of Copper Concentrates	Remarks
British Columbia				
Equity Silver Mines Limited Sam Goosly property Houston area	4 500 Cu 0.38% Ag 106.3 g/t Au 0.96 g/t Sb 0.082%	1980		Construction began April 1979, with two open-pits to be developed. Estimated cost $107 million. Initial production expected third quarter 1980, with leach plant to come into use second quarter 1981. Antimony to be recovered.
Esso Minerals Canada Granduc mine Stewart	4 080 Cu 2.0% Ag 8.6 g/t[e] Au tr	1980		Former Granduc mine had been operated by Newmont Mines Limited, and "permanently closed", June 30, 1978. Property purchased by Esso, ore reserves recalculated using a higher cutoff grade. Mill buildings needed rehabilitation to repair damage done by snow over the winter of 1978-79.

Source: Energy, Mines and Resources Canada.

[e] Estimated; tr trace; .. Not available.

TABLE 5. CANADIAN COPPER AND COPPER-NICKEL SMELTERS, 1979

Company and Location	Product	Rated Annual Capacity (tonnes)	Ore and Concentrates Treated (tonnes)	Blister or Anode Copper Produced (tonnes)	Remarks
Afton Mines Ltd. Kamloops, B.C.	Blister copper	22 500	42 860	18 040	The smelter commenced commercial operation on May 1, 1978. The uniquely low-sulphur concentrate, consisting chiefly of native copper, is smelted in a top-blown rotary converter. SO_2 produced is neutralized with limestone.
Falconbridge Nickel Mines Limited, Falconbridge, Ont.	Copper-nickel matte	570 000	..	19 260[1]	A smelter modernization program was begun in 1975 and completed in 1978 at a cost of $79 million. Fluid bed roasters and electric furnaces replaced older smelting equipment, and a 1 180 tpd sulphuric acid plant treats roaster gases. Only one of the two furnace lines was in operation in 1979. Refining of the copper-nickel matte from the smelter is carried out in Norway.
Inco Limited, Sudbury, Ont.	Blister copper, nickel, sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	3 630 000[2]	..	66 200[3]	Oxygen flash-smelting of copper concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of nickel-copper concentrate; converters for production of nickel-copper Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion to blister copper. Smelter shut down by strike from September 16, 1978 to June 3, 1979.
Noranda Mines Limited Horne smelter Noranda, Que.	Copper anodes	900 000	871 000 of which 728 000 were custom concentrates	210 467	Three reverberatory furnaces, one of which is now considered to be permanently shut down; 5 converters; 1 continuous reactor; 185 tpd oxygen plant to supply oxygen-enriched blast. Continuous reactor has been modified to produce matte instead of metal.
Canadian Copper Refiners Limited (Noranda Mines Limited) Gaspé smelter Murdochville, Que.	Copper anodes	325 000	134 000 of which 34 000 were custom concentrates	34 000	Smelter is fed with Gaspé and custom concentrates. Production was halted by a strike that lasted from October 16, 1978 until June 10, 1979, with custom concentrates diverted to other smelters. Smelter equipped with one fluid bed roaster, one reverberatory furnace and two converters.
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Man.	Copper anodes	400 000	Feed from HBMS mines in Man., Sask. and Y.T. totalled roughly 200 000 t. In addition, 31 075 t of anode copper were produced from custom concentrates	60 901	Two roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrates and custom copper concentrates, as well as zinc plant residues from slag fuming furnaces.

Source: Energy, Mines and Resources Canada.
[1] Sales. [2] Includes copper and nickel-copper concentrates and iron ore recovery plant feed. This capacity cannot all be utilized owing to Ontario government sulphur dioxide emission regulations. [3] A small portion of this copper was from Inco's Manitoba ores.

TABLE 6. COPPER REFINERIES IN CANADA, 1979

Company and Location	Rated Annual Capacity	Output in 1979	Remarks
	(tonnes)		
Canadian Copper Refiners Limited Montreal East, Quebec	435 000	329 000	Refines anodes from Noranda's Horne and Gaspé smelters and from the Flin Flon smelter; also purchased scrap. Copper sulphate and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anodes slimes. Produces C.C.R. brand electrolytic copper wirebars, ingot bars, ingots, cathodes, cakes and billets. Production in 1979 low because of the strike at Mines Gaspé Division of Noranda's Canadian Copper Refiners Limited. Refinery operations not back to normal until 4th quarter. Extensive structural renovation of refinery building continued in 1979 and new ventilation system installed.
Inco Limited Copper Refining Division Copper Cliff, Ont.	180 000	66 200	Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium recovered from anode slimes, along with platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produced ORC brand electrolytic copper cathodes, wirebars, cakes and billets in 1979. Operations interrupted by a strike from September 16, 1978 to June 3, 1979.

Source: Energy, Mines and Resources Canada.

the Jersey mine. Further increases in ore reserves around existing pits at Bethlehem's Highland Valley operation seem likely.

Noranda Mines Limited refused to extend for a third time an agreement to sell its Bell Copper mine to Zapata Granby Corporation. The agreement had been subject to approval by the Foreign Investment Review Agency (FIRA), and Noranda had extended the original deadline from January to February 15, then again to March 15. However, a third extension was refused when FIRA approval had still not been obtained by March 15. In April, Noranda announced a $19 million expansion at the property which will involve enlarging the open-pit and increasing daily mill capacity to 15 400 tpd by 1981 from 13 600 tpd. This project is expected to extend the life of the

Bell Copper operation from 1982 to 1988. Subsequently, Noranda purchased the Canadian assets of Zapata Granby Corporation, including the Granisle copper mine, for $32 million plus working capital. The Bell Copper and Granisle mines, some 13 km apart, were merged into Noranda's newly formed Babine Division.

Placer Development Limited is developing the Sam Goosly copper-silver-gold-antimony deposit, 34 km southeast of Houston, British Columbia for production at a cost of $85 million. Production is to begin in October 1980 at a rate of 4 500 tpd.

Esso Minerals Canada (a subsidiary of Imperial Oil Limited) purchased the Granduc mine, which had been closed by Newmont Mines Limited on June 30, 1978. Ore reserves were recalculated using a higher cutoff grade, and a decision was made by Esso to put the mine back into production by the fall of 1980 at a mill rate of 4 080 tpd.

SMELTERS AND REFINERIES

Production of refined copper in Canada was 397 262 t in 1979, compared with 446 278 t in 1978. Smelter production declined to 398 643 t in 1979 from 413 437 t in 1978. Canada's six copper smelters and two copper refineries and highlights from their 1979 operations are described in Table 5.

WORLD SUPPLY AND DEMAND

World mine production of copper in 1979 was 7 952 500 t, up from 7 873 200 t in 1978. World refined production was 9 355 000 t in 1979, up from 9 201 200 t in 1978.

World consumption of refined copper (from primary and secondary sources) increased to 9 795 300 t in 1979 from 9 449 200 t in 1978. In the non-communist world (but including Yugoslavia) consumption rose to 7 505 200 t in 1979 from 7 217 100 t in 1978. The 1979 shortfall in refined production relative to refined consumption was made up from stocks.

STOCKS

World stocks of refined copper, continued to decline through 1979. London Metal Exchange (LME) and New York Commodity Exchange (COMEX) stocks, which are usually indicative of the total stock picture, declined substantially throughout the year. LME stocks fell from some 325 000 t at the end of 1978 to 126 500 t at year-end 1979. COMEX stocks declined from 171 300 t at the end of 1978 to 89 700 t at the end of 1979.

According to World Bureau of Metal Statistics, total commercial world stocks of refined copper which were 1 534 600 t at the end of 1978 had fallen to 1 083 600 t by the end of 1979.

TABLE 7. WORLD MINE PRODUCTION OF COPPER, 1978 AND 1979

	1978	1979P
	(000 tonnes)	
United States	1 357.6	1 456.0
U.S.S.R.	1 140.0	1 140.0
Chile	1 035.5	1 060.6
Canada	659.4	643.8
Zambia	643.0	588.3
Zaire	423.8	400.3
Peru	366.4	398.0
Poland	318.0	320.0
Philippine Republic	263.4	297.6
Australia	219.3	234.2
Republic of South Africa	209.3	194.4
Papua New Guinea	198.6	170.8
Yugoslavia	123.3	108.0
Mexico	87.2	90.9
Indonesia	58.0	61.0
Japan	73.4	60.0
Other communist countries	320.6	310.4
Other non-communist countries	376.5	355.6
Total	7 873.3	7 889.9

Sources: World Bureau of Metal Statistics, April 1980; Energy, Mines and Resources Canada.
P Preliminary

NATIONAL STOCKPILES

The United States strategic stockpile goal for copper remained at 1 100 000 t with a present holding of 20 200 t, with no purchases having been made in 1979 owing to the rise in the price of copper.

Sales from the Japanese copper stockpile resulted in a decline in its holdings from 71 900 t at the end of 1978 to 36 900 t at the end of 1979.

TABLE 8. WORLD PRODUCTION OF REFINED COPPER, 1978 AND 1979

	1978	1979P
	(000 tonnes)	
United States	1 843.4	1 989.0
U.S.S.R.	1 480.0	1 500.0
Japan	959.1	983.7
Chile	749.1	779.5
Zambia	621.1	570.6
Canada	446.3	397.3
Belgium	388.6	386.0
West Germany	404.5	382.5
Poland	332.0	330.0
Peru	186.2	229.0
Australia	174.5	176.0
Spain	147.0	144.4
Republic of South Africa	152.5	138.8
Yugoslavia	150.8	138.0
United Kingdom	125.6	121.7
Zaire	102.8	103.2
Mexico	83.0	100.4
Sweden	64.4	61.7
Other communist countries	498.1	505.0
Other non-communist countries	315.6	370.8
Total	9 224.6	9 407.6

Sources: World Bureau of Metal Statistics, April 1980; Energy, Mines and Resources Canada.
P Preliminary

TABLE 9. WORLD CONSUMPTION OF REFINED COPPER, 1978 AND 1979

	1978	1979P
	(000 tonnes)	
United States	2 181.1	2 225.0
U.S.S.R.	1 330.0	1 350.0
Japan	1 241.4	1 306.9
West Germany	800.0	836.1
United Kingdom	501.6	498.8
Italy	344.0	301.0
France	319.0	342.8
Belgium	289.5	304.6
Canada	228.7	210.7
Brazil	180.8	228.7
Poland	185.0	190.0
Spain	128.5	130.9
Sweden	103.5	109.0
Yugoslavia	149.2	207.0
Australia	115.4	124.8
East Germany	118.0	120.0
Other communist countries	604.3	611.0
Other noncommunist countries	655.2	730.0
Total	9 475.2	9 827.3

Sources: World Bureau of Metal Statistics, April 1980; Energy, Mines and Resources Canada.
P Preliminary

INTERNATIONAL DEVELOPMENTS

UNCTAD Copper Discussions

The intergovernmental discussions on copper between producing and consuming countries continued within UNCTAD during 1979. The Sixth Preparatory Meeting was held from February 26 to March 2, the second meeting of the Intergovernmental Group of Experts on Copper (IGEC), met in Geneva from June 25 to July 6, and the Seventh Preparatory Meeting was held September 24-28, to be reconvened early in 1980.

At the Sixth Preparatory Meeting, the U.S. indicated an apparent major policy change on its part, by presenting a paper on a price stabilization scheme with an international buffer stock as the sole instrument of stabilization. Export and production controls were excluded from the scheme. A consensus emerged that a further period of expert study was needed, and the summer IGEC meeting was given the task of examining the technical elements of a possible international copper arrangement and, if agreement was forthcoming, to recommend to the Seventh Preparatory Meeting the most appropriate mechanisms and their mode of operation for stabilization. The results of the IGEC meeting were inconclusive, with no consensus reached.

The Seventh Preparatory meeting reached a deadlock by mid-week. In an effort to break this deadlock, the chairman tabled a discussion paper as a basis for further negotiations. In essence, the chairman's proposal was that nations agree to begin negotiations on a International Commodity Agreement for copper, which would be implemented in three stages, each of two years duration. The first stage would consist of establishing the machinery for further consultation, data collection, assembling and interpretation of statistics and the like. The second stage would

TABLE 10. WORLD COPPER PRODUCTION AND CONSUMPTION, 1979P

	Mine Production	Refined Production	Refined Consumption
		(000 tonnes)	
United States	1 456.0	1 989.0	2 225.0
U.S.S.R.	1 140.0	1 500.0	1 350.0
Japan	60.0	983.7	1 306.9
CIPEC[1]	2 844.3	1 993.3	563.3
Europe	159.3	1 259.9	2 693.4
Canada	643.8	397.3	210.7
Other communist countries	642.1	835.0	907.3
Other noncommunist countries	944.4	449.4	570.7
Total	7 889.9	9 407.6	9 827.3

Sources: World Bureau of Metal Statistics, April 1980; Energy, Mines and Resources Canada.
[1] Intergovernmental Council of Copper Exporting Countries includes: Australia, Chile, Indonesia, Mauritania, Papua New Guinea, Peru, Yugoslavia, Zaire and Zambia.
[p] Preliminary

involve the introduction of an international buffer stock, and the third stage would consist of the application of other supporting measures such as production and export controls. The meeting was adjourned so that participants would have time to consider the proposal and its implications. The reconvened Seventh Preparatory Meeting was to take place early in 1980.

U.S. FEDERAL TRADE COMMISSION

ARCO Consent Orders

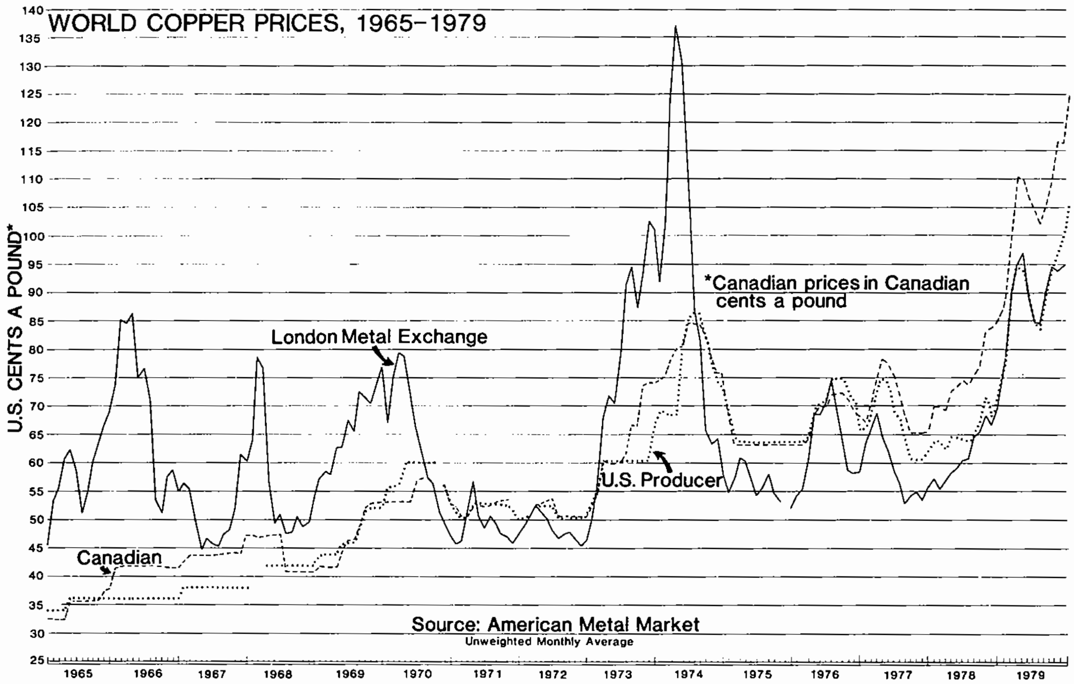
Following acquisition of The Anaconda Company by the Atlantic Richfield Company (ARCO), the U.S. Federal Trade Commission (FTC) brought suit against ARCO under anti-trust laws. A negotiated settlement resulted in a Consent Order requiring ARCO to divest itself of several U.S. copper properties. A condition attached to the sale was that the properties not be sold to a list of ineligible purchasers of eight U.S. and three Canadian companies, or any other producers having more than 5 per cent of the U.S. copper market. The Canadian and Canadian-related producers were Noranda Mines Limited, Inco Limited, and the Anglo American group, including Hudson Bay Mining and Smelting Co., Limited and Inspiration Consolidated Copper Company of the U.S. (50 per cent owned by Hudson Bay).

Following formal objections by the eight "ineligible" U.S. producers, a modified Consent Order from FTC reduced the list of disqualified producers to only the three Canadian companies and raised the market share for disqualification of other purchasers from 5 to 10 per cent, with any company having between 5 and 10 per cent of the market having to secure FTC approval of any planned purchases of the divested properties.

Subsequently, the Canadian Embassy in Washington, D.C. brought this apparently discriminatory treatment of the three Canadian companies (each of which held less than 5 per cent of the U.S. market) to the attention of the United States State Department and sought an explanation of the apparent discimination to the Canadian companies. At year-end, one of the Canadian companies was planning to ask FTC to reopen and modify the Consent Order.

PRICES

In terms of the U.S. and Canadian dollar, copper prices, which had risen steadily throughout 1978, continued to rise until April 1979, dropped until July, then rose again until the end of the year. The average LME cash price for wirebars in January was ¢U.S. 75.6 a pound, and in



December was ¢U.S. 99.8 a pound. The U.S. price for cathode rose from an average of 76.1 cents a pound in January to an average of 94.4 cents in April, dropped to a monthly average of 83.4 cents in July, and then reached 105.7 cents in December.

Canadian producer prices for wirebar and cathode averaged 88.505 cents and 89.130 cents a pound respectively in Janaury and 124.100 cents and 123.475 cents a pound in December. Part of this price rise was a reflection of currency exchange rates as the U.S. and Canadian dollars dropped in value relative to other world currencies.

The British pound rose in value from $Cdn. 2.39 in January to $Cdn. 2.57 in December. The U.S. dollar was $Cdn. 1.19 in January, declined to $Cdn. 1.15 in April and was about $Cdn. 1.17 for the remainder of the year.

OUTLOOK

Although copper stocks were still falling at year-end, world copper consumption seemed likely to grow more slowly in 1980 and 1981, or even to drop somewhat owing to an economic slowdown in the United States and the rest of the western industrialized world. As long as stocks continue to fall, copper prices should continue to firm. Although there has been a low rate of growth in world production capacity in the past few years, the new mines and mine expansion projects announced during 1979 following improving prices and declining copper stocks that occurred in 1978 and early 1979, indicate that a noteable increase in world copper capacity seems likely in the early 1980s. As a result, copper supplies will likely be adequate to meet demand for the metal unless the world economy should become "overheated".

A potential for major supply disruption exists in the United States copper industry labour negotiations scheduled for the late spring. The past record suggests that strikes are a real possibility, and with U.S. mine production amounting to about 18 per cent of total world mine production of copper, a strike that lasted for several months could continue to deplete stocks, or would at least prevent the rise in stocks that would normally result from the anticipated economic recession.

The long-term average copper price, expressed in 1979 Canadian dollars, has been about $1.30 a pound. One would normally expect that a copper price near that price would be required to continue to bring on new production to meet normal increases in world demand for copper and to replace depleted mines. However, even without the copper price having reached that level, substantial new production capacity was announced in Canada and in other countries. If this trend should continue, future long-term copper prices seem likely to be significantly lower than has been the experience much of the time since the end of World War II.

Canadian copper production seems likely to rise to record high levels in the next few years, provided copper prices do not fall below late 1979 levels.

TARIFFS

CANADA

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
32900-1	Copper in ores and concentrates	free	free	free	free
33503-1	Copper oxides	free	free	1.5%	2.5%
34800-1	Copper scrap, matte and blister and copper in pigs, blocks or ingots; cathode plates of electrolytic copper for melting, per lb	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, 1980)	free	free	free	10%
34845-1	Electrolytic copper wire bars, per lb (expires June 30, 1980)	free	free	free	1.5¢
35800-1	Anodes of copper	free	free	free	10%

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
33503-1	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
34820-1	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

TARIFFS (cont'd)

UNITED STATES (MFN)		1979	1980	1981	1982	1983	1984	1985	1986	1987
					(¢ per pound)					
602.30	Copper, ores etc.	.8	Remains free							
612.02	Unwrought copper etc.	1.7%	Remains on value of copper content							
612.08	Copper waste and scrap		¢ per pound on 99.6% of copper content +2%							
		1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.4

EUROPEAN ECONOMIC COMMUNITY (MFN)		1979	Base Rate	Concession Rate
26.01	Copper, ores and conc.	free	free	free
74.01	Copper in matte etc.	free	free	free
JAPAN (MFN)				
26.01	Copper, ores and conc.	free	free	free
74.01	(1) Copper in matte etc.	free	free	free
	(2) Copper, unwrought			
	(a) containing not more than 99.8% by weight of copper etc.	8.5%	8.5%	7.3%
	(b) Other		24 yen kg	21 yen kg
	(3) Waste and scrap			
	(a) Unalloyed	2.5%	2.5%	free
	(b) Other: containing more than 10% by weight of nickel	22.5%	22.5%	free
	(c) Other	2.5%	2.5%	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20 No L289, 1977; Customs Tariff Schedules of Japan, 1977; GATT Documents, 1979.

Crude Oil and Natural Gas

R.L. THOMAS

Remaining established reserves of crude oil and natural gas liquids in Canada continued to decline during 1979 as production of total liquid hydrocarbons exceeded new additions to reserves. The net production of crude oil increased by some 18 per cent while the net production of liquids increased by almost 3 per cent, averaging a total increase over 1978 of 15 per cent.

The remaining reserves of marketable natural gas again increased with gross additions being almost four times that of net production. During 1979, the production of natural gas decreased by 3 per cent over 1978.

Total revenues from the sales of crude oil, liquids and natural gas amounted to an estimated $12,980 million, an increase over 1978 of $2,500 million. Of this total amount, crude oil accounted for $7,400 million, natural gas liquids accounted for $1,200 million and natural gas amounted to $4,380 million.

Expenditures by the industry for exploration and development of oil and gas, including royalty and land payments, increased over 1978 by 27 per cent to an estimated $11,285 million. Of the total expenditures: royalties were 35 per cent; exploration, 21 per cent and land costs, 14 per cent. Most of the land costs can be attributed to the "bidding" system used toward purchasing the rights to explore for and develop the oil and natural gas resources. While the prairie provinces accounted for 85 per cent of the expenditures, the petroleum industry spent approximately 79 per cent of the total amount in Alberta.

During 1979, the Canadian drilling industry was able to register another record year by completing a total of 7,695 wells, a slight increase of 83 wells over 1978. A total depth of 8.7 million metres (m) was drilled, an increase of 1.1 million m over 1978. Although the number of completions in Alberta declined over the previous year, that province still accounted for 75 per cent of the total activity in Canada. Saskatchewan, Manitoba, Ontario, and Canada's north showed a marked increase in drilling activity during the year. The number of development wells accounted for 61 per cent of the completions and the corresponding metrage was 52 per cent. The success ratio of all well completions remained very much the same as that of the previous year, with 1979 overall being 76.3 per cent successful compared with 76.5 per cent in 1978.

Crude oil refining capacity in Canada remained stable throughout 1979 as many refineries continued to be under-utilized due to domestic demand. All refineries averaged receipts of 310 000 cubic metres per day (m^3/d) during the year, an increase of 21 000 m^3/d over 1978, and increasing the utilized capacity to 81 per cent. Shell Canada Limited announced plans to construct a refinery near Edmonton designed to process only synthetic crude oil from the

Athabasca oil sands. It will initially process 7 000 m^3/d, later rising to 10 800 m^3/d. Production will be gasolines, stove oil, diesel and jet fuel. It is anticipated that the plant will commence operations in 1983 and the capital cost will be $350 million, including a distribution terminal. Meanwhile, the 16 000 m^3/d refinery at Come-by-Chance in Newfoundland remains idle as negotiations continue for a buyer to once again allow the complex to operate.

In oil sands development, construction of a facility by the Alsands Project Group has been delayed for one year. This plant, which was to be onstream in 1987 and producing 9 500 m^3/d of synthetic crude, is now expected to cost an estimated $8,000 million. A fourth oil sands plant has recently been planned by Petro-Canada and The Alberta Gas Trunk Line Company Limited which is to be very similar in size and cost to the Alsands plant. The two existing oil sands plants, Syncrude Canada Ltd. and Suncor Inc. (formerly Great Canadian Oil Sands Limited), both averaged production of 15 000 m^3/d from their facilities and this amount was well below their rated capacities.

OUTLOOK

Again, during 1979, the additions to natural gas reserves from established producing areas are well above the annual consumption rate and it is anticipated that this trend will continue, as other new gas discoveries have not yet been fully evaluated. In February and November of 1979 the National Energy Board (NEB) published results of hearings conducted in various cities across the country in order to determine the future supply and requirements of natural gas in Canada. At each of these hearings, it was concluded that additional exports of gas could be allowed to the United States. The present surplus of natural gas to Canadian domestic requirements offers possibilities of substituting gas for oil in eastern Canada, thereby reducing this country's dependence on imports of insecure, high-cost oil.

The outlook for Canadian crude oil is not as promising as natural gas as production continued to surpass additions to reserves. During 1978, the oil region of West Pembina in Alberta was the centre of activity and although almost fully evaluated, it has not achieved the total reserves as the industry and governments had expected. In the Beaufort Sea, Dome Petroleum Limited continues to further evaluate what could be a major oil discovery at Kopanoar. Panarctic Oils Ltd. had been able to test large volumes of natural gas from their Whitefish well in the Arctic Islands.

The recent oil discovery of Hibernia, east of St. John's, Newfoundland in Canada's offshore, has received a lot of attention. Should this structure contain the preliminary estimated reserves, it could open new possibilities of an assured supply of oil for the Atlantic provinces. Chevron Canada Limited, acting as the operator of a consortium for the discovery well, tested extended flow rates of 588 m^3/d.

In regard to future development of oil sands, there are two plants waiting for approvals and price agreements between the Government of Canada and the Province of Alberta. The Alsands Project Group is prepared to begin construction of a facility designed to produce, ultimately, an estimated 22 258 m^3/d of synthetic crude oil at a revised cost approaching $8,000 million. The second proposal, a joint venture between AGTL and Petro-Canada, is for a plant to be in operation before 1990. This facility is to be very similar in size to the Syncrude and Alsands plants.

Should the two existing plants and the two proposed produce at their rated capacities, this would result in an improvement in the supply forecast for oil. Oil sands development involves the construction of five plants by 1990, producing 105 000 m^3/d, and this is expected to achieve the national policy objectives. The federal government's policy of self-sufficiency is directed toward minimizing the risks to the nation inherent in over-dependency on imported oil. If Canada is to attain this goal, development of petroleum resources in the frontier areas and the heavy oil belt of eastern Alberta and western Saskatchewan are also indicated.

RESERVES

The Canadian Petroleum Association (CPA), in its 1979 reserves report, has booked Canada's remaining liquid hydrocarbon reserves at 1 289 million m^3, a decline in reserves of some 30 million m^3. This is comprised of 1 082 million m^3 of conventional crude oil and 207 million m^3 of natural gas liquids, after a total production of 92.86 million m^3. At that rate of production, the new life index (reserve-to-production ratio) has decreased to 13.8 years or a decline of 2.5 years over 1978.

TABLE 1. CANADA, RESERVES OF LIQUID HYDROCARBONS AT END OF 1979

	Crude Oil	Pentanes Plus	Propane, Butane and Ethane	Total	Per cent of Total
	(thousand cubic metres)				
Northern Canada	21 148	8 302	-	29 450	2.3
Alberta	908 403	82 424	109 920	1 100 747	85.4
Saskatchewan	117 723	350	1 146	119 219	9.2
British Columbia	27 588	2 416	2 480	32 484	2.5
Eastern Canada	7 142	-	-	7 142	0.6
Total	1 082 004	93 492	113 546	1 289 042	100.0

Source: Canadian Petroleum Association.

Alberta, containing more than 85 per cent of Canada's total oil and therefore the largest producer, showed a net decline in reserves of 23.2 million m^3. Of the more than 1 100 million m^3 of liquid hydrocarbons remaining in that province, 908.4 million m^3 are crude oil, 82.4 million m^3 are pentanes plus and 109.9 million m^3 are propane, butane and ethane. Total production of crude and liquids in Alberta amounted to 80.5 million m^3 or 87 per cent of Canadian production. In Saskatchewan, the reserves of crude oil increased by 0.5 million m^3 to 117.7 million m^3 and the total liquid hydrocarbon reserves as of year-end 1979 were 119.2 million m^3.

The remaining established reserves of marketable natural gas in Canada increased by 173 844 million m^3 in 1979 to 2 496 057 million m^3. The gross additions to reserves amounted to 237.3 million m^3 or 3.7 times the net production, which was 63 759 million m^3. Using this level of production the life index had risen to 39 years whereas it had been 35 years in 1978.

TABLE 2. CANADA, ESTIMATED YEAR-END MARKETABLE RESERVES OF NATURAL GAS, 1978 AND 1979

	1978	1979
	(million cubic metres)	
Alberta	1 549 716	1 646 392
British Columbia	218 365	207 363
Saskatchewan	35 333	35 431
Eastern Canada	9 439	8 918
Northern Canada	509 360	597 953
Total	2 322 213	2 496 057

Source: Canadian Petroleum Association.

The remaining reserves of natural gas in Alberta are 1 646 392 million m^3, an increase of 96 676 million m^3 over 1978. The net production from the province was 53 064 million m^3, a decrease of some 3.5 million m^3 over 1978. A major upward revision of 91 million m^3 was recorded in the Arctic islands by year-end bringing the remaining reserves of gas to 397.6 million m^3. A figure of 78.9 was attributed to new discoveries and 12.1 was a positive revision to existing reserves.

In November 1979, the National Energy Board released a gas report "Reason For Decision" in which remaining established reserves of marketable natural gas were estimated to be 2 039 660 million m^3, excluding all frontier areas. The NEB does not quote frontier reserves figures until these regions are connected to the mainland either by pipeline or other transport.

PRODUCTION

Average net production of crude oil, including synthetic and natural gas liquids totalled 281 000 m^3/d in 1979, an increase of 12.4 per cent over 1978. Crude oil production, including condensates, increased from almost 200 000 m^3/d in 1978 to 222 000 m^3/d in 1979, an increase of 11 per cent. The production of natural gas liquids rose from 42 000 m^3/d in the previous year to 44 000 m^3/d, consisting of 19 000 m^3/d of pentanes plus and the remainder being propane, butane and ethane. The production of synthetic crude oil averaged 15 000 m^3/d during the year, an increase over 1978 of 6 000 m^3/d. The Suncor plant was able to produce almost 7 000 m^3/d and the Syncrude plant averaged 8 000 m^3/d.

TABLE 3. PRODUCTION[1] OF LIQUID HYDROCARBONS BY PROVINCE, 1978 AND 1979

	1978		1979	
	(000 m^3)	(m^3/day)	(000 m^3)	(m^3/day)
Alberta				
Crude oil	63 586	174 208	74 322	203 622
Condensate	143	392	149	408
Propane	5 040	13 808	5 542	15 184
Butane	3 210	8 795	3 475	9 521
Pentanes plus	6 560	17 973	6 475	17 740
Ethane	1 000	2 740	3 256	8 921
Total	79 539	217 915	93 219	255 395
Saskatchewan				
Crude oil	9 599	26 299	9 332	25 567
Condensate	19	52	19	52
Propane	80	219	76	208
Butane	39	109	36	99
Pentanes plus	25	68	24	66
Total	9 762	26 745	9 487	25 992
British Columbia				
Crude oil	2 005	5 493	2 132	5 841
Condensate	24	66	32	88
Propane	86	236	81	222
Butane	107	293	116	318
Pentanes plus	155	425	184	504
Total	2 377	6 512	2 545	6 973
Canada				
Crude oil	76 029	208 299	86 604	237 271
Condensate	186	510	200	548
Propane	5 205	14 260	5 699	15 614
Butane	3 356	9 195	3 628	9 940
Pentanes plus	6 740	18 466	6 684	18 312
Ethane	1 000	2 740	3 256	8 921
Total	92 516	253 468	106 071	290 605

Source: Statistics Canada.

[1] Excludes synthetic crude oil production.

In terms of gross production of liquid hydrocarbons, Alberta accounted for 88 per cent of total Canadian output. Alberta's daily production increased by 17 per cent over 1978 to 255 395 m^3/d, of which 204 000 m^3/d was crude oil and condensate. All production of synthetic crude oil in Canada comes from this province, which has been excluded from the above figure. The production of crude and liquids decreased in Saskatchewan to 25 992 m^3/d from 26 745 m^3/d in 1978. British Columbia, showing a slight increase in production of almost one per cent, produced 6 973 m^3/d of crude oil and natural gas liquids. It should be noted that the production of ethane in Canada, and particularly in Alberta, increased during the year to 8 921 m^3/d from the previous year's level of 2 740 m^3/d.

In 1979 the net withdrawals of natural gas amounted to 94 473 million m^3, or 259 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 again accounted for 12 per cent of total production with the balance coming from Saskatchewan, Ontario and the Northwest Territories.

TABLE 4. CANADA, LIQUIDS AND SULPHUR RECOVERED FROM NATURAL GAS, 1968-79

	Propane	Butane	Condensate Pentanes Plus	Sulphur
	(cubic metres)	(cubic metres)	(cubic metres)	(tonnes)[1]
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	5 205 100	3 355 900	6 926 300	6 310 511
1979	5 698 800	3 628 100	6 883 500	6 086 316

Source: Statistics Canada.

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

Not all of the natural gas produced from a well is delivered to market. Some of this gas is processed, to remove any liquids and sulphur that may be present, and then reinjected into the well in order to maintain the reservoir pressure. Sometimes the reinjected gas is part of the distributor's storage operations. Various volumes are 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 also 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 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.

ACTIVITY

The level of drilling activity during 1979 surpassed the record achieved in 1978. Of the 7,534 wells drilled during the year, 2,317 were successful oil wells and 3,534 were successful gas wells. The overall increase in wells drilled in Canada, excluding miscellaneous and service wells, was 7 per cent above that for the previous year. Western Canada, being the centre of activity, accounted for 7,409 of the wells drilled during the year, of which 77 per cent were drilled in Alberta.

Although the number of wells in all categories decreased in Alberta in 1979 to 5,753 from 6,056 in 1978, the total metrage increased by 14 per cent to 6 852 496 m. Much of the increased metrage can be attributed to deeper drilling on single wells in regions such as the Foothills and Deep Basin. Exploration is expected to continue in these areas to better define the Elmworth gas play and the Cutbank-Kakwa oil play. Natural gas is now flowing from the Elmworth area with two processing plants having been constructed during the year. The plant being operated by Canadian Hunter Exploration Limited has the capacity to process 1.4 million m^3/d, while the other operated by Sulpetro Limited has the capacity to process the same amount, but in fact much less is being processed from both, due to market conditions. In the southeast corner of the Deep Basin region, normally a gas prone area, a number of wells were able to produce quantities of oil with some of the better wells producing 30 m^3/d. This area, bounded in a triangle by the Cutbank and Kakwa rivers, has been labelled the Cutbank oil play. The oil is produced from the Cardium formation, in tight sands having low porosity and therefore, low deliverability. Dome Petroleum Limited and other companies had done a considerable amount of leasing in the area. The costs for drilling deep wells, such as those being placed in the Foothills and Deep Basin, had been estimated to cost approximately $2.5 million per well.

TABLE 5. OIL AND GAS WELLS IN WESTERN CANADA AT END OF 1979

	Wells Capable of Production		Wells Actual Producing	
	Oil	Gas	Oil	Gas
Alberta	17,673	17,173[1]	12,805	14,760
Saskatchewan	9,310	811	8,039	688
Manitoba	812	-	706	-
British Columbia	876	1,599	597	616
Northwest Territories and Arctic Islands	61	9	33	7
Total	28,732	19,592	22,180	16,071

Sources: Provincial and federal government reports.

[1] Does not include 8,531 capped gas wells.

In British Columbia, the number of wells completed during the year increased to 395 from 386 the year before with an aggregate metrage of 685 170 m. Wainoco Oil & Gas Limited made a significant gas find near Fort St. John which tested 120 000 m^3/d.

In the Northwest Territories, Esso Resources Canada Limited conducted a drilling program in the Mackenzie River to further determine the reserves contained in the Norman Wells field. Industry estimates of oil in-place had been assumed to be around 100 million m^3, and it is believed that the producibility of the field could be as high as 4 000 m^3/d compared to the existing 480 m^3/d, when a pipeline is built.

Offshore from the Mackenzie Delta in the Beaufort Sea, Dome Petroleum Limited continued their multi-well deep-water drilling program that had begun in 1976. The company was successful in discovering oil in the Kopanoar I-44 well which on test had flow rates of 1 910 m^3/d.

In Canada's High Arctic, west of Lougheed Island, Panarctic Oils Ltd. had made a significant natural gas discovery, estimated to contain at least 85 000 million m^3. The discovery well, Whitefish H-63, found gas in two zones and in further testing, was able to produce an average of 229 000 m^3/d.

TABLE 6. WELLS DRILLED BY PROVINCE, 1978 AND 1979

	Oil		Gas		Dry[1]		Total	
	1978	1979	1978	1979	1978	1979	1978	1979
Western Canada								
Alberta	946	1,256	3,090	3,216	1,483	1,263	5,519	5,735
Saskatchewan	766	956	40	45	168	232	974	1,233
British Columbia	72	80	186	187	128	128	386	395
Manitoba	10	16	-	-	6	9	16	25
Yukon and Northwest Territories and Arctic Islands	1	2	3	2	13	17	17	21
Westcoast offshore	-	-	-	-	-	-	-	-
Sub-total	1,795	2,310	3,319	3,450	1,798	1,649	6,912	7,409
Eastern Canada								
Ontario	11	6	70	83	62	120	143	209
Quebec	-	-	-	-	6	7	6	7
Atlantic provinces	-	-	-	-	-	3	-	3
Eastcoast offshore	-	1	1	1	6	4	7	6
Hudson Bay offshore	-	-	-	-	-	-	-	-
Sub-total	11	7	71	84	74	134	156	225
Total Canada	1,806	2,317	3,390	3,534	1,872	1,683	7,068	7,534

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells, but excludes miscellaneous and service wells.
- Nil.

TABLE 7. CANADA, WELLS COMPLETED AND METRES DRILLED, 1978 AND 1979

	1978		1979	
	(No.)	(metres)	(No.)	(metres)
Western Canada				
British Columbia				
New field wildcats	22	59 413	31	72 652
Other exploratory	179	297 232	153	272 947
	201	356 645	184	345 599
Development	185	279 196	211	339 571
Total	386	635 841	395	685 170
Alberta				
New field wildcats	230	352 245	213	417 811
Other exploratory	2 154	2 439 698	1 880	2 828 645
	2 384	2 791 943	2 093	3 246 456
Development	3 672	3 215 794	3 660	3 606 040
Total	6 056	6 007 737	5 753	6 852 496
Saskatchewan				
New field wildcats	144	117 635	203	161 474
Other exploratory	319	224 059	396	305 150
	463	341 694	599	466 624
Development	518	377 917	659	501 181
Total	981	719 611	1 258	967 805
Manitoba				
New field wildcats	4	4 360	9	8 805
Other exploratory	3	2 699	-	-
	7	7 059	9	8 805
Development	9	6 366	16	11 732
Total	16	13 425	25	20 537
Yukon and Northwest Territories and Arctic Islands				
New field wildcats	10	32 124	16	43 785
Other exploratory	-	-	-	-
	10	32 124	16	43 785
Development	7	19 671	11	11 151
Total	17	51 795	27	54 936
Total western Canada				
New field wildcats	410	565 777	472	704 527
Other exploratory	2 655	2 963 688	2 429	3 406 742
	3 065	3 529 465	2 901	4 111 269
Development	4 391	3 898 944	4 557	4 469 675
Total	7 456	7 428 409	7 458	8 580 944
Eastern Canada				
Eastcoast offshore				
New field wildcats	5	19 689	6	27 239
Other exploratory	2	6 553	-	-
	7	26 242	6	27 239
Development	-	-	-	-
Total	7	26 242	6	27 239

TABLE 7 (concl'd.)

	1978		1979	
	(No.)	(metres)	(No.)	(metres)
Eastern Canada (cont'd)				
Ontario				
New field wildcats	40	26 741	38	26 782
Other exploratory	26	34 561	31	18 947
	66	61 302	69	45 729
Development	77	47 617	152	76 042
Total	143	108 919	221	121 771
Quebec				
New field wildcats	5	14 743	7	12 641
Other exploratory	1	3 350	-	-
	6	18 093	7	12 641
Development	-	-	-	-
Total	6	18 093	7	12 641
Atlantic provinces				
New field wildcats	-	-	3	1 539
Other exploratory	-	-	-	-
	-	-	3	1 539
Development	-	-	-	-
Total	-	-	3	1 539
Total eastern Canada				
New field wildcats	50	61 173	54	68 201
Other exploratory	29	44 464	31	18 947
	79	105 637	85	87 148
Development	77	47 617	152	76 042
Total	156	153 254	237	163 190
Total Canada				
New field wildcats	460	626 950	526	772 728
Other exploratory	2 684	3 008 152	2 460	3 425 689
	3 144	3 635 102	2 986	4 198 417
Development	4 468	3 946 561	4 709	4 545 717
Total	7 612	7 581 663	7 695	8 744 134

Source: Canadian Petroleum Association.
\- Nil.

The total number of wells drilled during the year in regions north of 60° increased by 10 to 27 for an aggregate metrage of 54 936 m.

In Ontario, including offshore Lake Erie, a total of 221 wells were drilled for an aggregate metrage of 121 771 m, and of these wells, 69 were classified as exploratory. The province was able to record six wells as oil discoveries and 83 as gas.

Quebec completed seven wells for a total metrage of 12 641 m during the year and all wells were dry holes.

In Canada's East Coast offshore, under the jurisdiction of EMR's Resource Management Branch, the year 1979 proved to be highly successful in terms of activity, new discoveries and increased drilling expenditures. The "Discoverer Seven Seas", a dynamically-positioned drillship, established a world record for deep water drilling. The well, Texaco-Shell et al Blue H-28, was drilled in 1 486 m of water and reached a total depth of 6 103 m. Mobil Oil Canada, Limited completed a five-well program in the area and their last well, the Mobil-Texaco PEX Venture D-23, found significant quantities of natural gas near Sable Island. It is reported that the well proved up as much as 28 000 million m^3 and if so, then the entire structure could contain some 85 000 million m^3 of natural gas. A current centre of attention is the oil discovery of Hibernia located in the Grand Banks region southeast of Newfoundland. Chevron, acting as the operator, was able to record flow rates of 588 m^3/d from the discovery well. It has been estimated that the recoverable reserves of this field may range upwards from 80 million m^3 of crude oil. It is anticipated that through further development, this field may in the future contribute substantially to the oil requirements of eastern Canada and thus, lessen the need for imported oil.

TRANSPORTATION

The construction of oil and gas pipelines in Canada during 1979 was somewhat disappointing as approximately 4 900 kilometres (km) of pipeline were built in all categories, which includes gathering, transmission and distribution lines. Much of the activity took place in Alberta and Saskatchewan where a number of new oil and gas wells were tied into existing systems. It is expected that the amount of new lines will increase in the near future as a result of increased gas exports and construction of the Alaska Highway Natural Gas Pipeline.

This 7 700 km pipeline is expected to transport 68 million m^3/d of gas from Prudhoe Bay through Canada to southern U.S. markets. The Alaskan gas is scheduled to flow by the end of 1985 and capital cost estimates have been placed in excess of $20 billion with the Canadian portion costing over $8.4 billion. The Canadian section of the line is to be built first, carrying Alberta gas until the northern portion is completed.

Upon completion of the Alaska Highway gas line, a pipeline from the Mackenzie Delta to Whitehorse has been proposed by Foothills Pipe Lines (Yukon) Ltd. to carry gas from the Delta and through the Alaska line to southern Canadian markets. This line, called the Dempster pipeline, is expected to carry up to 34 million m^3/d and cost of the project is estimated to be $3.5 billion.

The Arctic Pilot Project (APP), a joint undertaking of Petro-Canada, AGTL, Dome Petroleum and Melville Shipping Ltd., proposes to construct two ice-breaking liquified natural gas (LNG) tankers to transport seven million m^3/d of gas from Melville Island in the eastern Arctic Islands to an LNG terminal in Quebec or the Maritimes. The earliest start-up date is expected to be 1986 and estimated cost of the project is over $2 billion.

Polar Gas has proposed to construct a Y-line pipeline connecting both Arctic Islands and Mackenzie Delta gas reserves for delivery to southern Canadian markets targeted to commence in 1990. This system would be over 5 000 km long and the throughput is expected to be 61 million m^3/d. The pipeline is expected to cost over $15 billion.

TABLE 8. LENGTH OF PIPELINES IN CANADA FOR TRANSPORTING CRUDE OIL NATURAL GAS LIQUIDS AND PRODUCTS, 1962-79

Year-end	Kilometres	Year-end	Kilometres[1]
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	34 421
1970	27 459	1979	34 868

Source: Statistics Canada

[1] Includes producer gathering lines from 1969 to 1979.

In November 1979, TransCanada PipeLines Limited (TCPL) and Q&M Pipe Lines Ltd. submitted a joint application proposing an extension of the natural gas transmission system from Montreal to Quebec City, the Eastern Townships, New Brunswick, and Nova Scotia at a cost of approximately $800 million. The National Energy Board has agreed to the construction of the system in Quebec but the Maritime proposal was deferred pending further environmental work and assessment of gas resources off Nova Scotia.

Interprovincial Pipe Line (NW) Ltd. has proposed to construct an 866 km crude oil pipeline to transport 4 000 m^3/d of crude oil from Norman Wells, NWT to Zama in northern Alberta and then through existing lines to southern Canadian markets. Should this system costing $360 million be approved, oil could be flowing by 1983.

TABLE 9. KILOMETRES OF EXISTING GAS PIPELINES IN CANADA, 1974-79

	1974	1975	1976	1977	1978	1979p
Gathering						
New Brunswick	9.7	9.7	20.8	20.8	20.8	20.8
Quebec	1.6	1.6	2.1	-	-	-
Ontario	1 825.0	1 839.5	1 992.0	1 939.1	1 946.2	2 062.9
Saskatchewan	1 208.6	1 643.1	2 290.1	2 757.2	1 813.4	1 899.7
Alberta	9 025.2	10 050.4	12 848.4	13 822.3	13 816.2	14 355.0
British Columbia	1 736.5	1 907.1	2 069.8	2 120.3	2 590.6	2 708.3
Northwest Territories and Yukon	54.7	54.7	55.0	55.0	55.0	55.0
Total	13 861.3	15 506.1	19 278.2	20 715.2	20 242.2	21 101.7
Transmission						
New Brunswick	20.9	20.9	21.6	21.6	21.6	21.6
Quebec	238.2	238.2	237.7	265.0	256.4	256.3
Ontario	9 239.2	9 224.8	9 387.8	9 345.9	9 242.6	9 314.4
Manitoba	2 645.8	2 743.9	2 743.4	2 779.0	2 778.9	2 806.7
Saskatchewan	10 513.8	10 581.4	10 614.9	10 862.5	10 702.8	10 666.9
Alberta	12 853.8	13 930.5	15 596.0	17 075.4	17 739.5	18 000.0
British Columbia	4 894.0	5 042.1	5 087.5	5 177.1	5 249.3	5 230.6
Total	40 405.7	41 781.8	43 688.9	45 526.5	45 991.1	46 296.5
Distribution						
New Brunswick	51.5	51.5	146.1	146.1	146.1	146.1
Quebec	2 764.9	2 975.7	2 890.0	2 938.9	2 972.1	2 999.4
Ontario	27 395.9	28 033.2	28 715.7	29 378.8	34 477.1	35 272.4
Manitoba	2 937.1	2 655.4	2 738.8	2 815.1	2 876.1	2 976.7
Saskatchewan	4 615.6	4 789.4	4 966.3	5 078.8	5 287.8	5 421.2
Alberta	16 523.1	18 851.9	21 554.1	25 065.1	26 850.2	28 950.8
British Columbia	8 946.3	9 285.9	9 397.6	9 789.3	10 072.1	10 188.5
Total	63 234.4	66 643.0	70 409.5	75 212.1	82 681.5	85 955.1
Total Canada	117 501.4	123 930.9	133 376.6	141 453.8	148 914.8	153 353.3

Source: Statistics Canada.

p Preliminary; - Nil.

There are currently two proposals being considered by which Alaskan crude oil would be delivered to markets in the United States: the Northern Tier Pipeline, an all-U.S. proposal, and the Trans Mountain Pipe Line, a joint Canada-U.S. proposal. Trans Mountain Pipe Line Company Ltd., in an application to the NEB, has proposed to carry Alaskan crude from the Alaska-British Columbia border to Edmonton, a distance of 928 km, and then on to the United States through existing systems. The estimated cost of the Trans Mountain system - the Canadian portion only - would be approximately $600 million.

Oil production developed at Hibernia and in the Beaufort Sea is expected to be transported by tanker and a number of proposals are under study.

MARKETS AND TRADE

The total sales of natural gas increased by 8 per cent to an estimated 71 839 million m^3 in 1979. Exports of Canadian natural gas to the U.S. increased by almost 14 per cent over last year to an estimated 28 344 million m^3 or approximately 78 million m^3/d.

TABLE 10. CONSUMPTION OF PETROLEUM PRODUCTS BY PROVINCE, 1979

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oil No. 2 and 3	Heavy Fuel Oil No. 4, 5 and 6
	(thousand cubic metres)				
Atlantic provinces	3 277	358	1 463	2 223	4 866
Quebec	8 772	559	2 850	5 411	6 100
Ontario	13 312	265	3 373	5 095	3 426
Manitoba	1 671	140	760	211	132
Saskatchewan	2 094	180	1 078	224	15
Alberta	4 878	82	2 599	125	22
British Columbia	4 205	137	2 308	880	1 350
Northwest Territories and Yukon	93	50	218	126	23
Total	38 302	1 771	14 649	14 295	15 934

Source: Statistics Canada.

Gas sales to domestic consumers increased during the year by an additional five million m^3/d to a new level of 119 million m^3/d. The requirements by sector were as follows: residential, 26 million m^3/d; industrial, 67 million m^3/d; and commercial, 25 million m^3/d; with all sectors averaging an increase in demand of 4 per cent.

Ontario, experiencing an overall increase in demand of some 241 million m^3 during the year, remains to be the largest consuming province of natural gas at 18 915 million m^3 (52 million m^3/d) or accounting for 43 per cent of total Canadian sales. The prairie provinces accounted for almost 41 per cent of sales, an increase over 1978 of some 6 per cent, British Columbia increased sales by 6 per cent to account for over 4 000 million m^3 and New Brunswick and Quebec showed an increase in sales of 12 per cent to a new level of 2 700 million m^3. Nova Scotia, Prince Edward Island and Newfoundland do not have natural gas service but it is anticipated that this may become available to these provinces from both western Canada and East Coast sources.

Crude oil deliveries to Canadian refineries during 1979 averaged 310 000 m^3/d, an increase of 21 000 m^3/d over 1978. The deliveries of domestic crude to refineries increased by some 25 000 m^3/d to 211 600 m^3/d for a 13 per cent gain. Ontario, requiring the largest amount of crude for refining, showed an increase of almost 12 000 m^3/d of domestic receipts for an annual average of 87 255 m^3/d. The amount of western crude delivered to Quebec during the year averaged 43 189 m^3/d, an increase in requirements of almost 8 per cent.

TABLE 11. CANADA, EXPORTS AND IMPORTS OF REFINED PETROLEUM PRODUCTS, 1978 AND 1979

	Exports		Imports	
	1978	1979	1978	1979
	(thousand cubic metres)			
Propane and butane	5 751	99	11	1
Aviation gasoline	-	-	-	-
Motor gasoline	870	825	2	79
Aviation turbo fuel	399	184	52	-
Kerosene, stove oil and tractor fuel	-	8	1	-
Diesel fuel oil	129	316	24	141
Light fuel oil No. 2 & No. 3	1 320	1 785	13	23
Heavy fuel oil No. 4, 5 & 6	4 109	2 788	1 648	704
Asphalt	62	89	15	18
Petroleum coke	-	-	819	587
Lubricating oils & greases	12	11	210	128
Other products	538	497	83	144
Total, all products	13 190	6 602	2 878	1 825

Source: Statistics Canada.
- Nil.

TABLE 12. CANADA, CRUDE OIL PRODUCTION, TRADE AND REFINERY RECEIPTS, 1967-79

	Production	Imports	Exports	Refinery Receipts[1]		
				Domestic	Imports	Total
	(thousand cubic metres)					
1967	55 851	27 153	23 903	35 704	25 939	61 643
1968	60 319	28 258	26 628	37 549	28 187	65 736
1969	65 342	30 704	31 375	38 480	30 284	68 764
1970	73 322	33 011	38 299	41 172	33 123	74 295
1971	78 339	38 947	43 049	41 852	38 829	80 681
1972	89 347	44 781	54 255	43 441	45 908	89 349
1973	104 272	52 057	66 784	47 716	49 491	97 207
1974	97 742	46 290	53 015	55 250	47 582	102 832
1975	82 802	47 416	41 727	50 963	47 777	98 740
1976	76 075	43 930	29 030	56 455	41 871	98 326
1977	76 447	39 593	19 783	65 420	38 819	104 239
1978	76 001	36 821	15 578	68 055	35 691	103 746
1979	86 604	37 230	16 750	77 484	35 440	112 924

Source: Statistics Canada.

[1] Includes condensate and pentanes plus.

TABLE 13. CANADA, CRUDE OIL RECEIVED AT REFINERIES, 1979 AND 1978

Location of Refineries		Country of Origin					Total Received
		Canada	Middle East	Venezuela	Africa	Other	
		(thousand cubic metres)					
Atlantic provinces	1979	-	12 196	5 906	249	306	18 657
	1978	-	9 936	5 658		314	15 908
Quebec	1979	15 764	3 513	6 355	751	3 105	29 488
	1978	14 604	5 623	6 454		3 717	30 398
Ontario	1979	31 848	-	-	-	2 904	34 752
	1978	27 544	-	-	-	3 802	31 346
Prairies	1979	19 846	-	-	-	134	19 980
	1978	17 067	-	-	-	205	17 272
British Columbia	1979	9 639	-	-	-	-	9 639
	1978	8 728	-	-	-	-	8 728
Northwest Territories	1979	144	-	-	-	-	144
and Yukon	1978	144	-	-	-	-	144
Total	1979	77 241	15 709	12 261	1 000	6 449	112 660
	1978	68 087	15 559	12 112	-	8 038	103 796

Source: Statistics Canada.

\- Nil.

The amount of crude imported into Canada for the year totalled 35 405 000 m^3 or 97 000 m^3/d, a decrease of 1 000 m^3/d. The Atlantic provinces, which rely completely on imported crude, received an average of 51 115 m^3/d, an increase of 7 500 m^3/d over the previous year. Refineries in Quebec received 37 600 m^3/d of imported oil compared to 43 272 m^3/d in the previous year, a decrease in import receipts of 5 672 m^3/d. In Ontario, the consumption of domestic plus imported crude amounted to 95 211 m^3/d, an increase of 11 per cent over 1978 and domestic crude accounted for 92 per cent of total requirements. 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. During the year Canada exchanged an average of 20 000 m^3/d of crude with the United States.

By year-end 1979, the demand for Canadian crude oil, natural gas liquids and products, both for domestic use and the amount for export, had increased by almost 10 million m^3 or 7.6 per cent to an average of 383 000 m^3/d. The amount of crude, liquids and products exported during the year increased by 6 per cent to a rate of 84 088 m^3/d.

The price of Canadian domestic crude oil is lower than the price of imported crude. Refineries receiving imported oil are compensated for the higher costs to maintain a uniform price across Canada, subject only to transportation cost differences.

During the year, the Toronto city gate price of domestic natural gas was increased from $2.00 per million British Thermal Units (BTUs) in February, to $2.15 per million BTUs in October. The comparable price of exported natural gas was: in January, $U.S. 2.16; May, $2.30; August, $2.80; and in November, $3.45.

In January 1979, the average wellhead price of crude oil in Canada was $\$80.23/m^3$, but this was increased in July by $\$6.30/m^3$ to a new price of $86.53. The export price of crude oil was: in January, $118.93; April, $130.58; July, $168.38; and in October, $187.28.

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.

TABLE 14. CANADA, SUPPLY AND DEMAND OF OILS, 1978 AND 1979

	1978	1979
	(000 cubic metres)	
Supply		
Production		
Light-medium	60 955	68 985
Heavy	11 680	12 045
Synthetic	3 285	5 475
Pentanes plus	6 935	6 935
Natural gas liquids	8 395	9 125
Total production	91 250	102 565
Imports		
Crude oil	35 770	35 405
Products	2 920	1 825
Total imports	38 690	37 230
Total supply	129 940	139 795
Demand		
Domestic	105 485	110 230
Exports		
Light-medium	7 300	9 490
Heavy	6 570	6 570
Pentanes plus	1 460	730
Products	7 665	6 602
Natural gas liquids	5 840	7 300
Total exports	28 835	30 692
Stock changes	-3 650	730
Uses and losses	-730	-1 127
Total demand	129 940	139 795

Source: Energy, Mines and Resources Canada.

TABLE 15. CANADA, SUPPLY AND DEMAND OF NATURAL GAS, 1978 AND 1979

	1978	1979
	(million cubic metres)	
Supply		
Gross new production	100 862	107 175
Field waste and flared	-1 301	-1 597
Reinjected	-11 237	-11 105
Net withdrawals	88 324	94 473
Processing shrinkage	11 844	12 691
Net new supply	76 480	81 782
Removed from storage	3 996	3 964
Placed in storage	-4 550	-4 659
Net storage	-554	-695
Total net domestic supply	75 926	81 087
Imports	2	2
Total supply	75 928	81 089

TABLE 15. (cont'd.)

	1978	1979
	(million cubic metres)	
Demand		
Domestic sales		
Residential	9 320	9 603
Industrial	23 400	24 628
Commercial	9 025	9 264
Total	41 745	43 495
Field and pipeline use in production	6 577	6 662
Pipeline	2 149	2 440
Other	1 346	1 601
Adjustment metreing differences	-201	-680
Line pack changes	49	103
Total field and pipeline use	9 920	10 126
Gas unaccounted for	-148	-876
Total domestic demand	50 967	52 745
Exports	24 961	28 344
Total demand	75 928	81 089

Source: Statistics Canada.

Gold

S.A. HAMILTON

Gold production in Canada in 1979 was estimated to be 49 175 000 grams (g) valued at $Cdn.543,068,000 compared with 53 966 927 g valued at $Cdn.382,423,117 in 1978. The average yearly afternoon fixing price of gold on the London Gold Market in Canadian dollars for 1978 and 1979, was $7.09 per g, ($220.52 per ounce) (oz.) and $11.55 per g, ($359.28 per oz.) respectively. The volume of production in 1979 was 9 per cent lower than the previous year but value increased by 42 per cent, owing to a sharp rise in the U.S. dollar world gold price and a drop in the value of the Canadian dollar relative to the U.S. dollar. Byproduct gold production from base-metal ores was slightly less than in 1978. Despite the opening of new lode gold mines, lode gold output was 10.5 per cent lower because higher gold prices enabled mine operators to treat lower grade ores. Record Canadian gold production was 166 253 668 g (5,345,179 oz) achieved in 1941.

In 1979 lode gold mines in Canada accounted for 66 per cent of the country's gold output compared with 67 per cent in 1978. At the end of 1979 there were 24 operating lode gold mines in Canada, the ore being treated at 19 mills. In addition, Giant Yellowknife Mines Limited mined and milled ore from the adjacent properties of Lolor Mines Limited and Supercrest Mines Limited, and Pamour Porcupine Mines, Limited salvaged ore from the Romfield, Timmins (Hollinger), New Joburke and Matachewan Consolidated properties in the Timmins area. 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 39 per cent of the national total, followed by Quebec with 28 per cent, British Columbia 16 per cent, and the Northwest Territories 11 per cent.

In 1979 all gold produced in the Atlantic provinces and the Prairie provinces was a byproduct of base-metal ores mined in Newfoundland, New Brunswick, Manitoba and Saskatchewan. In Quebec and Ontario, gold was recovered both from lode gold mines and base-metal mines. In British Columbia gold production came from base-metal mines, from three small lode gold mines and some placer mining activity. Yukon gold production came from a copper mine and from various placer operations. All gold production in the Northwest Territories was from lode gold mines at Yellowknife.

Five new gold mines commenced production during the year, and one mine closed, then partially re-opened. A significantly increased gold price enabled all other Canadian gold mines to operate successfully throughout the year, with greatly increased profitability in most cases. Costs per unit of gold produced continued to increase in 1979, not only because of inflation, but also because of the lower ore grades that could be economically mined given the higher gold prices. If gold prices remain at record highs, Canadian gold mines will continue to operate profitably during 1980, although several of the older mines are operating on a salvage basis.

Gold exploration activity in Canada increased substantially during the second half of 1979 and early 1980. The initial modest increase in gold exploration was likely a result of the gold price having been at record levels for only a short period, and of the uncertainty surrounding future gold prices owing to their highly speculative nature. Momentum in exploration is picking up as entrepreneurs gain confidence in the basic strength of the gold market. Current Canadian gold exploration efforts seem to be concentrated in existing and former gold mining areas of Canada, especially on further exploration and evaluation of gold deposits and showings that have been known for many years.

BULLION COIN PROGRAM

On February 23, 1979 the Government of Canada approved the "Gold Maple Leaf" bullion coin program, on a three-year trial basis. The Royal Canadian Mint received authority to issue a maximum of one million coins in 1979, and two million coins each year in 1980 and in 1981. The selling price to the eight principal distributors is based on the price of gold (established daily) plus a premium (currently 3 per cent) to cover manufacturing and distribution costs plus a marginal profit to the Mint. The total premium paid by final purchasers amounts to 6 or 7 per cent, with provincial sales tax applicable in most provinces. The $50 legal tender coin is stamped 999 fine gold, but assay results indicate that its purity actually ranges from 9998 to 9999. It has a diameter of 30 mm, a thickness of 2.8 mm, and contains one troy ounce of fine gold. Only Canadian produced gold is being used in the minting of the "Gold Maple Leaf". Production began in June, and the coin went on sale early in September. The 1979 coin program was a success, with the full issue of one million coins having been sold out by late December.

As Canadian gold production amounts to only about 1,700,000 ounces per year, the gold likely to be required for the 1980 and 1981 bullion coin program will exceed Canadian production for those years, especially because only about 85 to 90 per cent of the gold from Canadian gold and base-metal mines is actually recovered as refined gold in Canada, the balance being exported in base-metal concentrates and mattes destined to foreign smelters and refineries. Any shortfall in the Canadian gold needed for the bullion coins is to be made up with Canadian-produced gold already held in Canada's official monetary gold reserves.

As Canadian gold producers can already sell their entire output, the gold bullion coin program will not directly affect the demand for Canadian-produced gold, but may possibly increase total world demand, thereby exerting an upward pressure on the price and assisting Canadian gold producers. Total annual world gold production is currently close to 1 134 000 kg (40,000,0000 ounces), so that gold consumed in production of the "Gold Maple Leaf" will be about 2.5 per cent of world gold production in 1979, and about 5 per cent in 1980 and 1981.

The Canadian government minted 250,000 legal tender gold coins in 1979 to commemorate the International Year of the Child. The coin contains 91.66 per cent gold (22 karat) and 8.34 per cent silver. Each coin is 27 mm in diameter and weighs 16.965 g of which 15.551 g (1/2 troy ounce) are fine gold. The selling price was $185.

In December the Royal Canadian Mint announced that it would strike a $100 gold coin and a $1.00 silver coin to commemorate the 1880 transfer of Arctic Territories to Canada from Britain. Production of the $100 face value gold coin, containing half an ounce of fine gold, will be limited to 300,000 coins. The selling price was fixed at $430 each.

CANADIAN DEVELOPMENTS

Atlantic Provinces. All gold produced in the Atlantic provinces in 1979 was derived as a byproduct of base metal ores. The Buchans mine of ASARCO Incorporated which was expected to close in 1979 continues to operate on a salvage basis. Exploratory work was carried out on some gold prospects in Nova Scotia.

Quebec. Noranda Mines Limited brought the Chadbourne gold deposit into production during the year, with ore being treated at Noranda's Horne mill. Reserves at the start of production were about 1 230 000 tonnes (t) grading 4.1 g of gold per t. In June, Les Mines d'Or Thompson-Bousquet Ltée (63

TABLE 1. CANADA, PRODUCTION OF GOLD, 1978 and 1979

	1978	1979P
	(grams)	
Newfoundland		
Base-metal mines	548 728	373 000
New Brunswick		
Base-metal mines	339 743	187 000
Quebec		
Auriferous quartz mines		
Bourlamaque-Louvicourt	4 040 590	3 566 000
Malartic and Matagami	6 022 442	5 760 000
Total	10 063 032	9 326 000
Base-metal mines	5 066 632	4 328 000
Total Quebec	15 129 664	13 654 000
Ontario		
Auriferous quartz mines		
Larder Lake	4 316 976	3 639 000
Porcupine	7 799 663	7 216 000
Red Lake and Patricia	7 698 982	7 060 000
Total	19 815 621	17 915 000
Base-metal mines	1 981 758	1 338 000
Total Ontario	21 797 379	19 253 000
Manitoba-Saskatchewan		
Base-metal mines	1 876 659	1 648 000
Alberta		
Placer operations	34 711	-
British Columbia		
Base-metal mines	6 542 430	7 994 000
Placer operations	36 515	-
Total British Columbia	6 578 945	7 994 000
Yukon		
Base-metal mines	717 713	529 000
Placer operations	484 437	249 000
Total Yukon	1 202 150	778 000
Northwest Territories		
Auriferous quartz mines	6 456 771	5 288 000
Placer operations	2 177	-
Total Northwest Territories	6 458 948	5 288 000
Canada		
Auriferous quartz mines	36 335 424	32 529 000
Base-metal mines	17 073 663	16 397 000
Placer operations	557 840	249 000
Total	53 966 927	49 175 000
Total value[1]	382 423 117	543 068 000
Average value per oz[2]	220.41	359.29

Source: Energy, Mines and Resources Canada.
[1] Value not necessarily based on average gold price for 1979. [2] Average of London Gold Market afternoon fixings in Canadian funds.
P Preliminary; - Nil.

per cent owned by Long Lac Mineral Exploration Limited) commenced production at its new gold mine near Cadillac, Quebec. Ore is being custom-milled by Les Mines Est-Malartic Ltée at a rate of 18 200 t to 22 700 t of ore per month. Ore reserves are estimated to be about 379 900 t of proven ore averaging about 7.13 g of gold per t, and an equal amount of probable ore grading about 7.68 g of gold per t. The mine currently employs about 60 people.

Also near Cadillac, Long Lac Mineral Exploration and Quebec Mining Exploration Company (SOQUEM) have agreed to spend $2.25 million for "preliminary construction and equipment purchases" at the Silverstack Mines Ltd. gold property, with Silverstack (controlled by Long Lac) to be the operator. Construction began on a building to include offices, a dry, a garage, a warehouse and repair shops and arrangements were being made for construction of a power line to the property.

Some 22 700 t of ore were shipped from the Silverstack property to Noranda Mines Limited during the first half of 1979 and a second 22 700 t between October and December to determine its suitability as a smelter flux. Another 22 700 t were shipped to the mill of Les Terrains Auriferes Malartic (Quebec) Limitée for cyanidation mill tests. Shipments of ore from the open pit began in March 1980 with 780 tpd going to Noranda's Horne smelter and 550 tpd going to Les Terrains Auriferes Malartic (Quebec) Limitée. Drill-indicated material available for open-pit mining in the No. 2 zone, amounts to 2 528 026 t averaging about 6.38 g of gold per t, after allowing for 15 per cent dilution. Potential underground ore amounts to another 1 424 217 t having an average grade of about 5.38 g of gold per t, with a 20 per cent allowance for dilution.

Belmoral Mines Ltd. commenced production from its Ferderber Mine near Val d'Or, Quebec during the summer of 1979, with the first gold bullion poured in late September. The ore is being milled under a short-term custom contract at the Louvem Mining Company Inc., mill pending re-erection of the former Solbec mill purchased by Belmoral from the Sullivan Mining Group Ltd.

Kiena Gold Mines Limited (68 per cent owned by Falconbridge Nickel Mines Limited) is spending about $22 million to bring its Val d'Or, Quebec gold deposit into production. The company expects to have the property in production in 1981 at a rate of about 272 000 tpy.

Campbell Chibougamau Mines Ltd. resumed development of its Gwillim Lake gold property, 29 km from the company's mill. The mine was dewatered, a road constructed, and a gold circuit added to the present mill.

Les Mines Est-Malartic Mines Ltée closed both its gold mines at Malartic, Quebec at the end of September because of poor ground conditions, then re-opened the Barnat Mine. The company plans to mine between 11 000 t and 13 500 t of ore a month from the Barnat Mine over a period of 6 to 12 months, with the ore to be stockpiled on surface and milled at the Est-Malartic mill when capacity becomes available. The mill has been altered and is currently treating ore from the mine of Les Mines d'Or Thompson-Bousquet Ltée. The Est-Malartic mine had operated since 1938.

TABLE 2. CANADA, GOLD PRODUCTION, 1965, 1970 AND 1975-79

	Auriferous Quartz Mines		Placer Operations		Base-metal ores		Total
	(grams)	(%)	(grams)	(%)	(grams)	(%)	(grams)
1965	92 031 269	82.1	1 387 153	1.2	18 741 680	16.7	112 160 102
1970	58 591 610	78.2	228 890	0.3	16 094 525	21.5	74 915 025
1975	37 529 456	73.0	335 077	0.6	13 568 581	26.4	51 433 114
1976	38 333 013r	72.8	517 375	1.0	13 770 722r	26.2	52 621 110
1977	37 831 875r	70.1r	526 986	1.0	15 562 469r	28.9r	53 921 330
1978	36 335 424	67.3	557 840	1.1	17 073 663	31.6	53 966 927
1979P	32 529 000	66.2	249 000	0.5	16 397 000	33.3	49 175 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; r Revised.

TABLE 3. CANADA, GOLD PRODUCTION, AVERAGE VALUE PER GRAM AND RELATIONSHIP TO TOTAL VALUE OF ALL MINERAL PRODUCTION[1], 1965, 1970 AND 1975-79

	Total Production (grams)	Total Value ($ Cdn.)	Average Value per Gram[2] ($ Cdn.)	Gold as per cent of Total Value of Mineral Production (%)
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	53 966 927	382 423 117	7.09	1.9
1979P	49 175 000	543 068 000	11.04	2.1

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Includes structural minerals and mineral fuels. [2] Value not necessarily based on average gold price for 1979.
P Preliminary.

Ontario. Total gold production in Ontario in 1979 was 19 253 000 g, a decrease from 1978. Lode gold mines accounted for 93 per cent of output, with the balance derived from base-metal ores.

Campbell Red Lake Mines Limited, in the Red Lake district, continued to be the leading gold producer in Canada with an output in 1979 of 5 754 kg and bullion revenue of $70,055,000, up from $42,138,000 in 1978. Expansion planned to come on stream through 1981 and 1982, will raise output to 6 600 kg gold per year while milling lower grade ore.

Pamour Porcupine Mines, Limited is carrying out a major exploration program on former producing properties and gold prospects in the Timmins district to ensure a continuing supply of feed for its two central mills.

During the summer, Texasgulf Inc. began underground exploration on the Owl Creek gold deposit originally discovered by Canadian Nickel Company Limited in 1966. Texasgulf has an agreement with Inco Limited (the parent company of Canadian Nickel) covering underground exploration and possible development of the deposit which is located 4 km west of the Texasgulf mill and smelter complex in Hoyle Township at Timmins, Ontario. A ramp is being driven for access, and a planned two-year development and underground diamond drill program is under way. Under the agreement, ore would be processed at the nearby Texasgulf mill, with Texasgulf to have a 60 per cent interest in a joint venture operation. Drill indicated reserves are reported at 2.3 million t averaging 5.78 g/t gold. Of this, approximately one million t averaging 3.77 g/t Au can be mined by open pit.

In August Amoco Canada Petroleum Company Ltd. reached agreement in principle with Dome Mines, Limited and Campbell Red Lake Mines Limited for the joint development of Amoco's Detour Lake gold deposit, some 130 km northeast of Cochrane near the Quebec-Ontario border. Dome and Campbell will each have a 25 per cent interest, and Amoco will retain a 50 per cent interest. An extensive underground program is under way to further evaluate the deposit and determine how best to mine it. The deposit, discovered by Amoco in 1974, has published reserves of 10 000 000 t grading 6.5 g of gold per t.

Goldlund Mines Limited is driving a 460-m decline, dewatering old underground workings and carrying out a major surface and underground drilling program on its gold deposit, some 42 km southwest of Sioux Lookout in northwestern Ontario. Some 15 240 m of underground diamond drilling and 9 750 m of surface drilling were planned for a seven month period, and two test stopes are to be established to remove about 4 500 t of ore from the gold-bearing zone.

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. Some exploration activity is taking place in the former gold producing area of eastern Manitoba with interest centred on former producers and properties with known reserves.

British Columbia. In British Columbia, Erickson Gold Mining Corp. began production at its Erickson Creek gold mine, 11 km southeast of Cassiar. Mill capacity is about 135 tpd. Average grade of ore mined in 1979 was about 20 g of gold and 20 g of silver per t.

The Mosquito Creek Gold Mining Company Limited is developing its gold deposit near Wells for production at a rate of 90 tpd. Ore reserves are estimated to be about 25 400 t grading not less than 31 g of gold and about 8 g of silver per t.

Carolin Mines Ltd. announced completion of a $20.4 million financing commitment and is going ahead with production plans for its Ladner Creek gold property, 16 km northeast of Hope. Mine construction is expected to be completed and production is scheduled to begin by early 1981. Development has indicated some 1 387 000 t of ore grading about 4.8 g of gold per t. Mining is to be by sublevel open stoping, with an 83 per cent recovery expected by cyanidation of a flotation concentrate.

Yukon Territory. Activity continues to be strong 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 Hudson Bay Mining and Smelting Co., Limited, Whitehorse Copper Division.

Northwest Territories. All gold produced in the Northwest Territories in 1979 came from the lode gold mines in the Yellowknife district.

Echo Bay Mines Ltd., a wholly owned subsidiary of IU International Corporation optioned the Lupin (Contwoyto Lake) gold deposit from Canadian Nickel Company Limited (a wholly owned subsidiary of Inco Limited). The deposit at Contwoyto Lake, about 400 km northeast of Yellowknife was discovered by Canadian Nickel in the early 1960s and explored by that company by diamond drilling. Echo Bay is currently carrying out an underground exploration program to determine the feasibility of developing the property.

REGULATORY ACTIVITY

In October Environment Canada announced that regulations will be enacted under the Clean Air Act that will prescribe national limits for emissions of arsenic into the ambient air by gold roasting plants in Canada. These regulations are intended to minimize toxic and carcinogenic arsenic trioxide emissions that would constitute a significant danger to the health of persons, in the communities of Red Lake, Ontario and Yellowknife, Northwest Territories. Incremental costs to the Canadian gold mining industry of meeting the new regulations will be approximately $1 million. The new regulations are to come into force on July 1, 1980, and will limit emissions of arsenic from gold roasting operations to 20 mg per standard cubic metre (SCM) for operations using direct cooling, 75 mg per SCM for operations using indirect cooling, and 20 mg per SCM for handling operations associated with the disposal of the collected arsenic dust. The four Canadian gold mines that currently roast arsenic-bearing sulphide concentrates and will be affected by the proposed regulations are Giant Yellowknife Mines Limited, Campbell Red Lake Mines Limited, Dickenson Mines Limited, and Kerr Addison Mines Limited.

WORLD INDUSTRY

In 1979 the Republic of South Africa was by far the leading gold producing country, followed by the U.S.S.R. Other significant producers, in decreasing order of importance[1], were Canada, the United States, Papua/New Guinea, Zimbabwe (Rhodesia), Australia and the Philippines. There is no published information on gold production in the People's Republic of China but recent estimates based on visits by mining industry personnel from western countries to gold

[1] U.S. Bureau of Mines Minerals Yearbook 1978-79 preprint **Gold.**

TABLE 4. PRINCIPAL GOLD (MINE) PRODUCERS IN CANADA, 1979 AND (1978)

Company and Location	Mill or Mine Capacity (tonnes of ore/day)	Grade of Ore Treated: Gold (grams/tonne)	Silver (grams/tonne)	Copper %	Combined Lead and Zinc %	Ore Treated (tonnes)	Gold contained in Concentrate (kilograms)	Remarks
NEWFOUNDLAND								
ASARCO Incorporated, (Buchans Unit), Buchans	1 100 (1 100)	0.82 (0.79)	109.71 (104.91)	1.04 (1.04)	18.15 (16.85)	113 398 (183 251)	76.1 (111.3)	Property continues to operate on salvage basis.
Consolidated Rambler Mines Limited, Baie Verte	1 100 (1 100)	2.67 (2.88)	23.52 (26.47)	3.90 (4.70)	- (-)	196 918 (247 874)	351.4 (511.7)	Limited ore reserves.
NEW BRUNSWICK								
Heath Steele Mines Limited, Newcastle	3 650 (3 175)	0.69 (0.89)	55.20 (77.49)	0.91 (1.03)	6.08 (5.96)	1 172 737 (1 137 767)	263.3 (435.4)	
QUEBEC								
Agnico-Eagle Mines Limited, Joutel	1 000 (900)	6.58 (6.55)	1.71 (1.44)	- (-)	- (-)	333 481 (328 287)	2 010.9 (1 964.3)	Developing lower levels.
Belmoral Mines Ltd. Val d'Or	500	6.79	-	-	-	26 900		Production began Sept. 1979. Ore custom milled by Louvem Mining Company Inc.
Camflo Mines Limited, Malartic	1 170 (1 180)	5.38 (5.79)	0.14 (0.69)	- (-)	- (-)	427 013 (427 083)	2 196.6 (2 367.1)	
Campbell Chibougamau Mines Ltd., Cedar Bay, Henderson and Merrill Pit Mines, Chibougamau	2 950 (2 950)	2.26 (3.46)	7.54 (8.57)	1.17 (1.38)	- (-)	396 822 (230 489)	772.8 (689.0)	Proceeding with development of Gwillim gold mine.
Les Mines Est-Malartic Ltée Malarctic	1 630 (1 540)	4.08 (3.04)	0.75 (0.53)	- (-)	- (-)	433 630 (548 498)	1 739.7 (1 528.9)	Les Mines Est-Malartic and Barnat Mine closed September. Barnat re-opened in November on salvage basis.

TABLE 4. (CONT'D.)

Company and Location	Mill or Mine Capacity	Grade of Ore Treated: Gold	Silver	Copper	Combined Lead and Zinc	Ore Treated	Gold contained in Concentrate	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(grams/ tonne)	%	%	(tonnes)	(kilograms)	
QUEBEC (cont'd.)								
Falconbridge Copper Limited, Lake Dufault Division, Millenbach and Norbec mines, Rouyn-Noranda	1 400 (1 450)	0.89 (0.82)	48.69 (43.54)	3.60 (3.36)	4.90 (3.85)	419 827 (372 722)	316.6 (254.1)	
Falconbridge Copper Limited, Opemiska Division Perry, Springer and Cooke mines, Chapais	2 600 (2 900)	1.34 (1.89)	12.34 (14.06)	1.79 (1.99)	- (-)	954 801 (967 823)	1 064.7 (1 561.2)	
Gaspé Copper Mines, Limited Copper Mt. Mill Murdochville	27 735 (28 620)	0.07 (0.07)	2.74 (2.74)	0.43 (0.42)	- (-)	5 065 084 (7 105 771)	34.1 (46.0)	Production reduced by 7 month strike during 1978-79.
Gaspé Copper Mines, Limited Needle Mt. Mill Murdochville	2 930 (4 150)	0.07 (0.07)	6.86 (6.86)	1.24 (1.21)	- (-)	570 510 (879 502)	9.5 (15.0)	
Lamaque Mining Company Limited, Val d'Or	1 900 (1 900)	3.63 (4.49)	0.55 (0.65)	- (-)	- (-)	392 793 (421 823)	1 326.3 (1 773.7)	Developing "flats" in north end of property.
Lemoine Mines Limited, Chibougamau	300 (300)	5.25 (5.31)	92.91 (94.63)	5.07 (4.97)	11.61 (11.18)	108 267 (105 611)	510.8 (502.2)	
Les Mines d'Or Thompson Bousquet Ltée. Malartic	725	7.89	0.82	-	-	52 814	378.0	Commenced operation July 1979. Ore trucked to Les Mines Est-Malartic Ltée mill.
Louvem Mining Company Inc., Val d'Or	900 (900)	0.93 (1.75)	137.83 (87.77)	0.04 (0.15)	5.06 (5.62)	72 261 (248 073)	48.9 (388.0)	
Mattagami Lake Mines Limited, Matagami	4 000 (3 500)	0.58 (0.51)	26.85 (32.57)	0.73 (0.52)	5.37 (7.56)	1 329 428 (878 484)	244.9 (179.3)	Merged into Noranda Mines Ltd. in fall 1979.
Noranda Mines Limited Horne Mill (Chadbourne Circuit) Noranda	1 800	4.66	4.18	-	-	93 154	390.3	Chadbourne Mine began production in July 1979.

Orchan Matagami	- (2 000)	- (0.69)	- (34.29)	- (0.61)	- (5.89)	- (368 602)	- (24.3)	
Patino Mines (Quebec) Limited, Chibougamau	2 170 (2 585)	3.19 (3.39)	9.50 (9.70)	1.64 (1.60)	- (-)	606 995 (616 381)	1 612.2 (1 724.8)	
Sigma Mines (Quebec) Limited, Val d'Or	1 315 (1 290)	4.89 (5.25)	0.93 (1.71)	- (-)	- (-)	445 752 (447 524)	2 111.5 (2 273.6)	Mine reserves being re-evaluated in light of improved gold prices.
ONTARIO								
Campbell Red Lake Mines Limited, Red Lake	750 (750)	22.49 (22.39)	.. (..)	- (-)	- (-)	272 314 (272 611)	5 754.3 (5 706.3)	30 per cent expansion of production capacity to be completed by 1981.
Dickenson Mines Limited, Red Lake	455 (430)	13.89 (19.75)	1.41 (1.71)	- (-)	- (-)	106 790 (100 187)	1 381.0 (1 864.9)	Dickenson & Robin Red Lake Mines Ltd. amalgamated in 1978. Figures are consolidation of operations. Re-evaluation of ore reserves in progress.
Dome Mines, Limited, South Porcupine	1 800 (1 800)	5.11 (4.94)	0.81 (1.14)	- (-)	- (-)	602 280 (616 160)	2 945.6 (2 928.7)	Announced 50 per cent expansion of production capacity to cost $50 million.
Falconbridge Copper Limited, Sturgeon Lake Joint Venture Sturgeon Lake	1 090 (1 090)	0.62 (0.72)	169.71 (171.77)	2.17 (2.73)	9.93 (10.31)	373 953 (370 087)	154.1 (184.1)	Deposit will be mined out in 1980.
Falconbridge Nickel Mines Limited, Sudbury district	10 340 (10 340)	0.07 (0.078)	3.43 (3.43)	0.85 (0.78)	- (-)	2 500 190 (2 073 500)	172.4 (160.5)	Gold and silver grades are Mineral Policy Sector estimates.
Inco Limited, Sudbury and Shebandowan districts	49 500 (55 000)	0.17 (0.07)	4.46 (3.43)	1.39 (1.358)	- (-)	5 339 227 (7 021 029)	544.6 (460.8)	1979 production reduced by strike at Sudbury operations that began September 16, 1978 and ended June 5, 1979. Gold and silver grades are Mineral Policy Sector estimates.
Kerr Addison Mines Limited, Virginiatown	1 225[1] (1 225)[1]	11.31 (11.31)	0.69 (0.69)	- (-)	- (-)	175 029 (232 404)	1 938.8 (2 588.3)	Limited ore reserves. Improved gold prices should allow continued production through 1981.

TABLE 4. (CONT'D.)

Company and Location	Mill or Mine Capacity	Gold	Silver	Copper	Combined Lead and Zinc	Ore Treated	Gold contained in Concentrate	Remarks
		Grade of Ore Treated						
	(tonnes of ore/day)	(grams/ tonne)	(grams/ tonne)	%	%	(tonnes)	(kilograms)	
ONTARIO (cont'd.)								
Mattabi Mines Limited, Sturgeon Lake	2 720 (2 720)	0.38 (0.41)	97.71 (93.26)	0.55 (0.83)	7.68 (7.16)	945 015 (871 675)	194.2 (152.3)	
Noranda Mines Limited Geco Division Manitouwadge	4 535 (4 535)	0.10 (0.17)	58.97 (38.74)	1.82 (1.54)	3.35 (2.31)	1 475 841 (1 572 458)	113.0 83.0	
Pamour Porcupine Mines, Limited, Pamour Division Timmins	2 720[1] (2 720)[1]	3.19 (3.26)	0.41 (0.00)	- (-)	- (-)	848 806 (933 020)	2 469.0 (2 742.5)	Re-evaluation of ore reserves in progress. Exploration on nearby properties continues.
Pamour Porcupine Mines, Limited, Schumacher Division, Schumacher	2 720[1] (2 720)[1]	2.96 (3.05)	3.43 (3.98)	0.25 (0.23)	- (-)	728 079 (881 357)	1 769.0 (2 276.8)	
Willroy Mines Limited, Macassa Division, Kirkland Lake	320 (320)	17.73 (17.47)	2.67 (3.43)	- (-)	- (-)	95 717 (101 075)	1 637.4 (1 691.7)	Exploration program on adjacent claim blocks.
MANITOBA - SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited Flin Flon Mill	7 250 (7 260)	1.22 (1.22)	20.86 (20.57)	1.99 (2.26)	2.89 (3.21)	1 253 875 (1 679 000)	959.6 (1 339.5)	
Snow Lake Mill	3 450	0.95	12.29	2.87	3.69	446 947	234.0	Snow Lake concentrator completed in March 1979.
Inco Limited Thompson	12 700 (12 700)	0.10 (...)	2.74 (...)	0.14 (0.14)	... (...)	2 269 680 (2 139 911)	142.4 n.a.	
Sherritt Gordon Mines Limited Fox mine, Lynn Lake	2 700 (2 700)	0.17 (0.15)	4.69 (4.80)	1.19 (1.24)	1.82 (1.73)	772 500 (874 933)	121.0 (127.8)	
Sherritt Gordon Mines Limited Ruttan Mine Leaf Rapids	9 100 (9 100)	0.21 (0.22)	5.60 (5.69)	1.39 (1.15)	1.17 (1.53)	2 094 159 (2 307 069)	408.7 (507.7)	

BRITISH COLUMBIA

Afton Mines Ltd. Kamloops	7 700 (7 260)	0.79 (0.72)	4.90 (4.97)	1.06 (1.01)	- (-)	2 822 528 (2 456 770)	1 744.4 (1 438.7)	
Bethlehem Copper Corporation Highland Valley	17 690 16 060	0.04 (0.03)	2.13 (2.74)	0.41 (0.41)	- (-)	6 536 861 (6 490 760)	135.0 (136.8)	
Brenda Mines Ltd. Peachland	27 220 (22 000)	0.02 (0.02)	1.27 (1.37)	0.14 (0.16)	- (-)	9 075 720 (9 995 801)	103.1 (110.9)	
Dankoe Mines Ltd. Keremeos	400 (400)	0.86 (1.71)	250.29 (286.29)	0.02 (0.02)	0.21 (0.18)	25 536 (28 677)	18.8 (21.5)	
Erickson Gold Mining Corp. Cassiar	135	0.66	0.72	-	-	28 896	590.9	Mine production commenced January 1979.
Zapata Granby Corporation, Phoenix mine, Greenwood	.. (2 600)	.. (0.55)	.. (4.29)	.. (0.44)	- (-)	.. (198 640)	.. (56.8)	
Newmont Mines Limited, Granduc Operating Division, Stewart	.. (7 260)	.. (0.14)	.. (8.73)	(1.43)	- (-)	.. (740 119)	.. (96.7)	Closed June 30, 1978. Scheduled to be reopened by Esso Minerals Canada in 1980.
Newmont Mines Limited, Similkameen Division, Princeton	20 000 (20 000)	0.17 (0.34)	0.62 (1.37)	0.44 (0.41)	- (-)	7 034 952 (6 826 464)	1 178.3 (1 140.0)	Developing Copper Mountain orebodies.
Noranda Mines Limited, Babine Division, Bell Copper Mine	9 100 (9 100)	0.27 (0.34)	.. (0.69)	0.35 (0.44)	- (-)	5 073 909 (4 470 094)	727.8 (733.9)	Mill expansion to be completed by 1981.
Granisle Mine Babine Lake	12 700 (13 000)	0.24 (0.21)	2.40 (2.26)	0.45 (0.41)	- (-)	4 382 909 (4 549 288)	498.2 (500.8)	
Northair Mines Ltd., Brandywine Mine	300 (270)	11.35 (12.14)	26.33 (70.63)	0.50 (0.20)	2.41 (3.26)	91 587 (93 397)	923.5 (1 050.0)	
Utah Mines Ltd., Island Copper Mine, Coal Harbour, Vancouver Island	37 200 (37 200)	0.24 (0.21)	1.68 (1.37)	0.45 (0.40)	- (-)	13 339 997 (14 200 278)	1 674.0 (1 385.4)	
Wesfrob Mines Limited Tasu	7 250 (7 250)	0.10 (0.10)	4.46 (4.11)	0.37 (0.35)	- (-)	1 009 247 (889 933)	84.5 (68.5)	
Western Mines Limited, Buttle Lake, Vancouver Island	900 (900)	2.91 (2.85)	131.31 (139.89)	1.32 (1.25)	9.82 (9.57)	266 877 (269 035)	638.7 (685.7)	

TABLE 4. (CONT'D.)

Company and Location	Mill or Mine Capacity (tonnes of ore/day)	Grade of Ore Treated: Gold (grams/ tonne)	Silver (grams/ tonne)	Copper %	Combined Lead and Zinc %	Ore Treated (tonnes)	Gold contained in Concentrate (kilograms)	Remarks
YUKON TERRITORY								
Hudson Bay Mining and Smelting Co., Limited Whitehorse	2 350 (2 375)	0.69 (0.86)	7.20 (7.82)	1.12 (1.40)	- (-)	829 221 (782 984)	493.6 (598.0)	
NORTHWEST TERRITORIES								
Cominco Ltd., Con and Rycon mines, Yellowknife	590 (590)	15.77 (18.69)	3.67 (4.46)	- (-)	- (-)	196 469 (199 563)	2 955.1 (3 561.1)	
Giant Yellowknife Mines Limited, Yellowknife	1 100 (1 100)[1]	7.06 (9.29)	2.06 (2.85)	- (-)	- (-)	377 621 (359 841)	2 336.1 (2 960.8)	
Lolar Mines Limited, Yellowknife	26[1] (19)[1]	11.07 (10.80)	.. (..)	- (-)	- (-)	Included with Giant		Ore treated at Giant mill.
Supercrest Mines Limited, Yellowknife	53[1] (113)[1]	13.41 (14.02)	.. (..)	- (-)	- (-)	Included with Giant		Ore treated at Giant mill.

Source: Federal-Provincial questionnaire survey of companies with producing mines in Canada. This data is supplied on a calendar year basis. In previous annual reviews most of the data was obtained from company annual reports based on the corporate fiscal year. Thus there are some discrepancies between the above statistics and those reported in the 1978 annual review.

[1] Average daily tonnage milled.
- Nil; .. Not available.

mining areas in China place production in the range of 30-60 t, similar to the level of production in Canada and the United States. Estimates of Brazilian production have recently been revised upward giving more weight to the output of the thousands of individual alluvial miners or garimpeiros which is not accurately measurable.

Gold production for 1979 in the Republic of South Africa was estimated to be 703.3 t, 73 per cent of the non-communist world total. Comparable figures for 1978 were 706.4 t and 72.9 per cent. Although Canada is officially the world's third ranking gold producer, it accounted for only 5.1 per cent of the non-communist world's 1979 gold production.

Consolidated Gold Fields Limited, in its report "Gold 1980", estimated non-communist world total gold production in 1979 to be 962.4 t compared with 980.3 t in 1978.

The world's major centres for gold distribution are: London, where gold sales are handled largely through members of the London Gold Market, the group that sets the morning and afternoon London Gold Market fixing prices; and Zurich, where sales are handled through banks. Hong Kong is becoming an increasingly active gold trading centre. The Republic of South Africa is a major supplier of gold to these markets. The U.S.S.R has also been a substantial gold supplier, especially to the Swiss market.

According to "Gold 1980", the world market supply of 1 765 t of gold in 1979 was only slightly above the 1 752 t of the previous year. Sales by the communist countries in 1979 were estimated at 229 t, far below sales of 410 t in 1978. Gold supplied from official government sources or agencies increased sharply in 1979 to 574 t from 362 t in 1978. Most of the gold from official government sources or agencies came from the IMF and U.S. Treasury auctions which together accounted for 535 t in 1979.

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 t 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 t 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 t near the end of each year in which gold is auctioned.

TABLE 5. INTERNATIONAL MONETARY FUND GOLD AUCTIONS, 1979

Date of Sale	Quantity Sold	Average Price Received
	(troy ounces)	($U.S. per troy ounce)
January 3	470,000	219.34
February 7	470,000	252.53
March 7	470,000	241.68
April 4	470,000	239.21
May 2	470,000	246.18
June 6	444,000	280.39
July 3	444,000	281.52
August 1	444,000	289.59
September 5	444,000	333.24
October 10	444,000	412.78
November 7	444,000	393.55
December 5	444,000	426.37
Total IMF Gold Auction Sales in 1979	5,458,000 (169.76 t)	
Quantity remaining to be sold in 1980	2,220,000 (69.05 t)	

Source: IMF Survey (International Monetary Fund Publication) and International Monetary Fund.

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 Special Drawing Rights (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.

In May 1978 the IMF announced a modification to the format of its gold sales. 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. Arrangements were made for developing nations to submit non-competitive 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 non-competitive bids at the gold auctions. These countries held 14.76 per cent of the IMF quotas and were eligible for 3.7 million ounces of the total 25 million ounces of gold. The third of four annual restitutions of 194.4 t of gold to member countries was completed early in 1979. A total of 5,458,000 fine troy ounces of gold (169.76 t) were sold in IMF public auctions during the year.

UNITED STATES TREASURY - GOLD AUCTIONS

The United States Treasury continued with its gold auctions, the last regular monthly auction being held on October 17, 1979. On October 16 the Treasury announced that it would change its gold auction procedures by selling the metal on various days and in various amounts, with the details of such sales to be announced a few days in advance. Under the new procedures, the amount of gold to actually be sold was set only after the Treasury had opened and examined all bids. On October 25 the Treasury announced it would sell up to 1.25 million ounces (38.879 t) on November 1, and after examining the bids received sold the entire amount. The November 1 auction was the last U.S. Treasury Auction held during 1979. Total U.S. Treasury sales of gold during the year were 11,750,000 troy ounces (365.48 t).

TABLE 6. GOLD AUCTIONS BY THE U.S. TREASURY DEPARTMENT, 1979

Date of Sale	Quantity Sold	Average Price Received
	(troy ounces)	($U.S. per troy ounce)
January 16	1,500,100	219.21
February 22	1,500,100	252.06
March 20	1,500,100	240.09
April 17	1,500,100	230.68
May 15	750,000	254.92
June 19	750,000	279.02
July 17	750,000	296.44
August 21	750,000	301.08
September 18	750,000	377.78
October 17	750,000	391.98
November 1	1,250,000	372.20
Total U.S. Treasury Sales in 1979	11,750,000 (365.48 t)	

Source: IMF Survey (International Monetary Fund Publication) and International Monetary Fund.

CANADA - GOLD SALES

In his December 11 budget speech, the Minister of Finance, Hon. John Crosbie, announced that Canada would sell up to one million ounces (31.103 t) of gold from the country's official monetary gold reserves of 22 million troy ounces (684.3 t). Sales were to be made "in the relatively near future if the market continues to be firm". It was stated that part of the one million ounces might be sold to the Royal Canadian Mint for its "Maple Leaf" gold coin program.

WORLD PRODUCTION

Production was lower in 1979 than in 1978 due to depletion at some mines and treatment of lower-grade ores (because of higher gold prices) at others. Production increases from new capacity now being developed in response to the new price levels will not be sufficient to offset the decline before 1981 and world production is unlikely to show a substantial increase before 1982. Estimates of Soviet production made by different sources vary so widely that comparison of total annual world gold production in 1978 and 1979 is somewhat unrealistic.

TABLE 7. WORLD GOLD PRODUCTION, 1977-79

	1977	1978[p]	1979[e]
		(grams)	
North America			
Canada	53 920 440	53 966 100	49 174 247
U.S.A.	34 224 093	31 066 672	28 608 010
Dominican Republic	10 838 555	10 452 878	10 263 990
Mexico	6 615 888	6 282 899	5 847 364
Other countries	2 569 139	2 731 434	2 534 895
Total	108 168 115	104 499 983	96 428 506
South America			
Brazil[1]	8 693 910	9 458 733	10 581 240
Colombia	8 193 681	8 013 128	9 019 870
Peru	3 246 935	3 205 755	3 804 923
Chile	3 619 642	3 185 445	3 265 815
Other countries	2 237 425	2 044 805	2 143 370
Total	25 991 593	25 907 866	28 815 218
Europe			
U.S.S.R.[e]	244 158 550	248 824 000	253 800 480
Spain	3 663 933	4 665 450	4 820 965
Yugoslavia	5 107 921	5 131 995	4 354 420
Sweden	2 112 951	2 372 972	2 177 210
Other countries	8 368 511	6 955 253	7 042 683
Total	263 411 866	267 949 670	272 195 758
Asia			
Philippines	17 362 783	18 244 958	16 998 909
People's Republic of China[e]	3 110 300	4 665 450	6 220 600
North Korea[e]	4 976 480	4 976 480	4 976 480
Japan	4 634 906	4 516 933	4 132 935
India	3 013 943	2 723 970	2 635 948
Other countries	3 875 092	4 017 730	3 563 342
Total	36 973 504	39 145 521	38 528 214
Africa			
Republic of South Africa	699 876 160	704 438 099	703 445 851
Zimbabwe[e] (Rhodesia)	18 661 800	19 905 920	21 772 100
Ghana	14 956 935	12 504 463	15 000 977
Zaire	2 501 241	2 366 223	2 332 725
Other countries	1 872 805	1 134 295	831 259
Total	737 868 941	740 349 000	743 382 912
Oceania			
Papua-New Guinea	23 007 822	23 366 595	21 772 100
Australia	19 599 711	20 141 681	18 299 730
Other countries	1 760 648	1 104 436	1 007 737
Total	44 368 181	44 612 712	41 079 567
World total	1 216 782 200	1 222 464 752	1 220 430 175

Source: U.S. Bureau of Mines Minerals Yearbook 1978-79 Preprint **Gold**.

[1] Series revised to include an estimate of unregistered output by small producers.
[p] Preliminary; [e] Estimated.

Republic of South Africa. Gold production in in the Republic of South Africa for 1979 was estimated by Consolidated Gold Fields Limited to be 703.3 t compared with 706.4 t in 1978. South African gold production peaked at 1,000.4 t in 1970, then declined steadily until 1978. The grade of ore treated in 1979 was slightly lower than the previous year, at 8.2 g per t compared with 9.4 g per t in 1978.

Of prime importance to the gold mining industry was the greater percentage of African employees working for longer periods and returning to the industry after a specific leave period. The return of experienced workers reduces the costs involved in training programs and the added costs of low productivity until the required skills are developed. An increasing number of workers from the Republic of South Africa are entering the gold mining industry, reportedly as high as 75 per cent for some mines. 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 increased from $U.S. 117 per troy ounce in December 1978 to $141 in December 1979. Productivity has declined over the past few years. This can partly be attributed to the 11-shift fortnight arrangement, to problems related to mining at greater depths, and to pillar recovery. South African mine operators are investigating possibilities for increased mechanization to increase output, but physical characteristics of the ore deposits make mechanization difficult.

South African gold production is expected to remain stable at around 700 tpy until 1987 and then fall gradually to 350 t by the turn of the century. Mining of lower grade ores in the older mines is being partially offset by expansion of production capacity. Three new gold mines came on stream; Elandsrand Gold Mining Co. Ltd. was officially opened, Unisel Gold Mines Ltd. started production in October and Deelkraal Gold Mining Co. Ltd. began milling in December. Consideration is being given to re-opening some of the old mines and exploration is very active, although results are often shrouded in secrecy.

The strong gold price has contributed to the strengthening of the South African economy and establishment of a very favourable balance of payments position. The gold placed with foreign banks under 'swap' agreements in 1976-77, when foreign exchange was urgently needed, is now being redeemed. It may soon become possible for South Africa to exert a stabilizing effect on the price of gold by withholding part of its output from the market at times when the price appears to be weakening.

U.S.S.R. Western observers have very little direct evidence on which to base estimates of Soviet gold production. An estimate by the CIA in 1964 of 135-155 tpy was sharply lower than any previous estimate. During the 1970s Consolidated Gold Fields conducted three separate studies of Soviet production, utilizing press reports and technical papers. The third study, which is still in progress, incorporates detailed study of satellite photographs of gold producing areas of the Soviet Union and further refinements of techniques used in the earlier studies. Estimated production capability for 1979 was in the 280-350 t range, somewhat below estimates for previous years but higher than estimates by other Soviet-watchers who placed output at about 250 tpy. Despite the differences in production estimates, it seems clear that the Soviet Union is the world's second leading gold producer, well behind the Republic of South Africa but far ahead of the third producer, Canada.

Most Soviet gold sales have been made through Zurich. Soviet sales policy is not stated but gold sales are an important source of foreign exchange. Sales in 1979 from the communist bloc were estimated at 229 t, well below the levels of the three previous years. The higher gold prices during 1979 may have enabled the Soviets to meet their foreign exchange requirements through smaller sales, or the heavy selling of the previous years may have somewhat depleted Soviet gold stocks.

United States. The United States Bureau of Mines estimated gold production in the United States in 1979 to be 28 600 kg compared with 31 000 kg in 1978. About 43 per cent of the United States domestic gold production was a byproduct of base-metal mining, mainly from the copper ores in the western states compared to 40 per cent in 1978. 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 operator in Nevada, were the major lode gold producers in the United States. Kennecott Copper Corporation, a large copper producer, was in fact the leading U.S. gold producer in 1979 through byproduct gold output from its Bingham Canyon mine in Utah. These three mines accounted for approximately two-thirds of U.S. gold output. There was increased activity in gold exploration in the western United States, especially in Nevada in search of the Carlin-type deposits, and in California. A number of interesting finds have been announced and several properties are being developed for production. The most important appears to be the Freeport Minerals Company and FMC Corporation Jerritt Canyon deposit in Elko County, Nevada. Similar in type and size to the nearby Carlin deposit, Jerritt Canyon is expected to achieve production in 1982. Recovery of gold from low grade deposits by the heap leaching process continues to be important in the western United States.

The United States is a major consumer of gold imported mainly from Canada, the U.S.S.R. and Switzerland. Most of the gold imported from Switzerland originates from the Republic of South Africa. The United States is also a major market for the South African krugerrand and the Gold Maple Leaf. In 1979 the United States was a major exporter of gold; 16.5 million ounces was sent abroad, 43 per cent to the United Kingdom and most of the remainder to Switzerland and Canada.

Papua-New Guinea. Papua-New Guinea is a substantial producer of gold, mainly as a byproduct of open-pit copper ore by Bougainville Copper Limited. Gold production from this property was 19 703 kg in 1979. In late 1979 a feasibility study on the Ok Tedi deposit was submitted to the PNG government which gave approval for the project in March 1980. The consortium, consisting of Dampier Mining Company Limited, Mount Fubilan Development, Kupferexploration GmbH and the PNG government which is taking up a 20 per cent development share, will spend about $U.S. 520 million to bring the property into production. It will operate for the first two years as a gold mine while milling the gold rich overburden that lies above the main copper-gold orebody. It is estimated that about 15 t of gold per year will be produced for five years.

Australia. Australian gold output in 1979 was estimated by the Australian Bureau of Mineral Resources to be 18 300 kg compared with 20 142 kg in 1978. The 9 per cent decline is attributed to strikes at two major producers, Telfer Project and Central Norseman Gold Corp. N.L. early in the year. Domestic consumption was 8 000 kg and exports were 6 500 kg. The partners in the Telfer mine announced that in view of the high gold price, they would defer development of a high grade underground zone and instead would expand the open cut and continue mining lower grade surface zones.

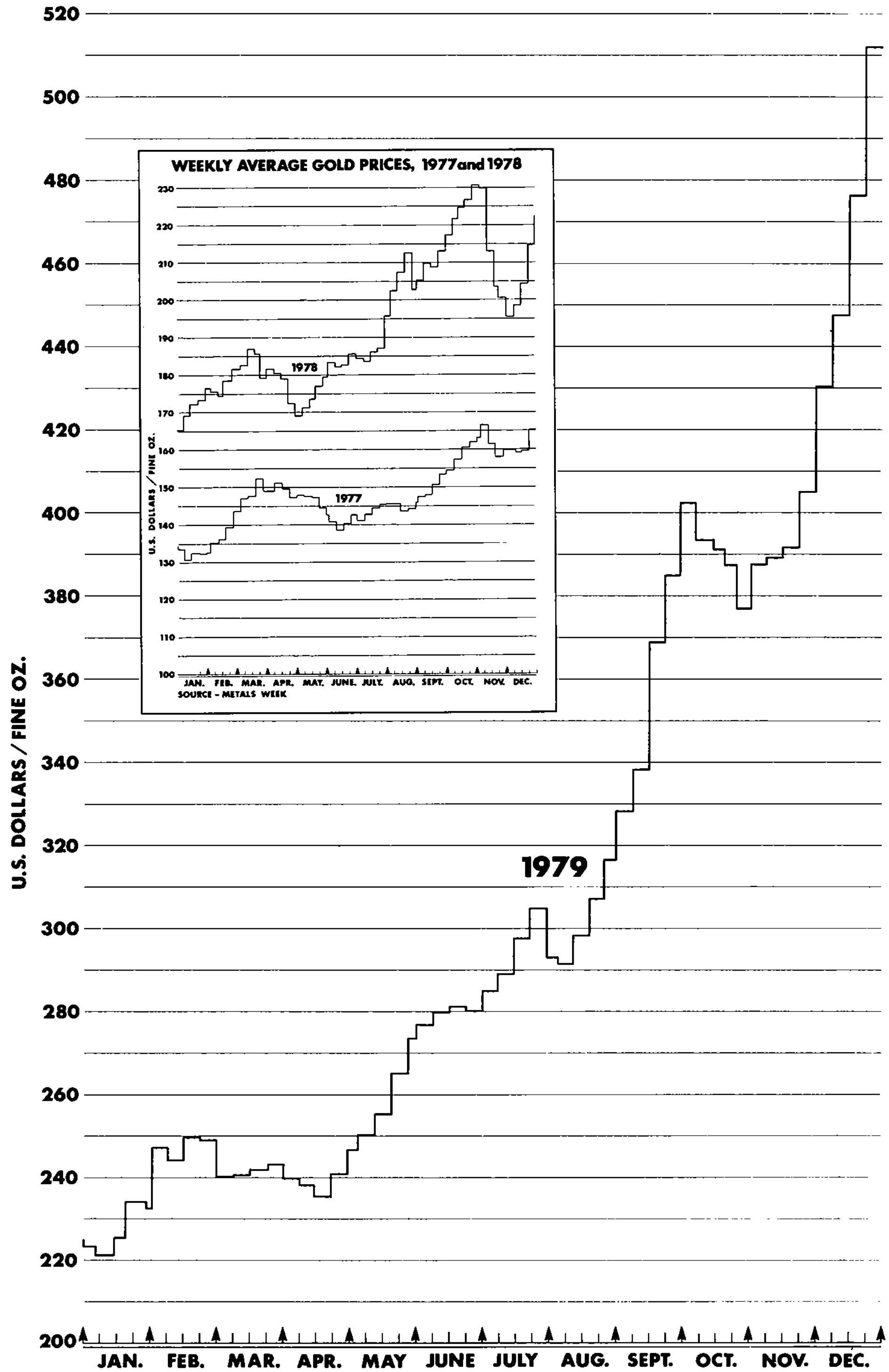
Kalgoorlie Mining Associates have completed an upgrading and renewal program at Mount Charlotte and the Oraya concentrator and have begun to develop the Lake View leases at Fimiston. Spargo's Exploration N.L. has been redeveloping the Mount Ida gold mine which closed in 1947.

Philippines. Gold production in the Philippines in 1979 was approximately 17 000 kg compared to 18 245 kg in 1978. Atlas Consolidated Mining & Development Corp. proceeded with its Masbate gold project, the first open-pit gold mine in the Philippines. Production is expected to be 2 800 kg of gold and 2 740 kg of silver per year. The first bullion was poured in January 1980. The company's Cebu copper operations produced 3 073 kg of byproduct gold. Benguet Consolidated Inc., commissioned its 17 000 tpd Dizon open-pit copper-gold operation which is expected to produce 3 110 kg of byproduct gold and 6 850 kg of silver. Benguet's gold operations produced 2 740 kg of gold. Productivity was reduced by an abnormally high turnover of underground workers. Lepanto Consolidated Mining Co. implemented plans to bring into production the Placer Project of Manila Mining Corp., a lode gold deposit with reserves of 457 000 t grading 14.9 g/t gold.

PRICES

The price of gold on the London Gold Market (in US dollars) was $227.15 an ounce on January 2, 1979. The low for the year was $US 216.55 on January 15. Subsequently the gold price rose sharply, reaching record highs on many days from June to October, and again in December. A then all-time record high gold price of $524.00 an ounce was set in the morning fixing on December 31, 1979, which was the final fixing of the year, and the average price for

WEEKLY AVERAGE GOLD PRICES
LONDON-2nd FIXING
(IN U.S. DOLLARS)



SOURCE-METALS WEEK

December was $455.06 an ounce. The average price for 1979 was $306.70 an ounce compared with $193.23 an ounce in 1978. The equivalent Canadian dollar gold price based on the average currency exchange differential for 1979 was $Cdn.359.25 an ounce compared with $Cdn.220.40 an ounce in 1978.

The unprecedented activity in international gold markets was at first attributable to the ratcheting upward of political tension in the Middle East, affecting what J. Aron & Company Inc. in its recent analysis of the international gold market refers to as the "World Anxiety Quotient". Oil price increases by OPEC nations, the revolution in Iran culminating in the overthrow of the Shah and the seizure of the U.S. embassy staff, and finally the occupation of Afghanistan by Soviet troops, made the world very anxious indeed. However the run-up that took place in December 1979 and January 1980, culminating in the record price on January 21 of $U.S.850 per ounce can be more correctly attributed to a bandwagon effect that drew in uninformed small investors and would-be speculators and drove the price to a level where more experienced traders who had bought at much lower prices could sell and take massive profits.

Although gold prices of recent years appear to be much higher than the $U.S.35.00 an ounce fixed price that prevailed from 1934 to 1968, and the earlier $U.S.20.67 an ounce price, this picture changes when inflation is taken into account and historical gold prices are converted into their equivalent prices expressed in 1979 constant dollars. On this basis, it was only in 1979 that gold prices rose above the former record prices that prevailed around 1900 and during the 1930s.

Current gold prices indicate continuing strong world demand for gold. Consumption for electronics, dental, and other industrial uses (only a fraction of which is ultimately recovered for re-use) amounts to 10 to 15 per cent of total world gold production. Much of the remaining demand is for carat jewellery, coins, medals, medallions and private sector bullion purchases. High-carat jewellery, gold coins, gold wafers and the like have been much in demand in recent years and, although this "investment" gold could be returned to circulation, much of it is purchased by individuals who have no serious intention of reselling it in the short term. Repeal of laws in the United States restricting ownership of gold by private individuals, together with today's relative affluence and the ready availability of gold wafers and gold coins at prices affordable by small investors, have resulted in a popular demand for gold that may well continue to absorb large quantities of the metal. Also, gold bullion is one of the vehicles for the investment of surplus "petrodollars" accumulated by some of the OPEC nations.

For some years the shortfall between non-communist world demand for, and production of, gold has been met from gold sales by the Soviet Union, the United States Treasury and the International Monetary Fund. Investment and speculative demand for gold seems likely to continue to exert pressure on the available gold supply for the next few years, and there may be a shortfall in the amount of gold readily available to meet world demand. Therefore, although the actions of gold speculators may cause considerable price fluctuations, it seems likely that the price of gold will continue to climb in constant dollar terms.

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 convertibility of the U.S. dollar into gold was suspended, it has not been officially used for this purpose. With the ratification of the Second Amendment of the 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 and Canada being exceptions, are maintaining or increasing the amount of gold held in their reserves.

Because it is an excellent conductor, gold has many uses in the rapidly expanding electronics industry. A thin film of gold also improves the thermal properties of glass, used for architectural purposes and the cockpit windows in airliners. Research has been directed toward 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 substitute for gold in many applications.

Consolidated Gold Fields estimated non-communist world consumption of gold for fabrication purposes to be 1 315 t in 1979, a substantial decrease from 1 596 t in 1978. The jewellery industry in the non-communist world consumed 737 t of gold in 1979, about 56 per cent of the total consumption. In 1978 the jewellery industry used 1 007 t. The jewellery manufacturing industry is experiencing difficulties as consumers demonstrate considerable resistance to sharp price increases. Manufacturers are increasing the use of lower carat metal and of gold fill, gold roll and gold plate. Gold used in the minting of official gold coins in 1979 was 290 t, which was 22 per cent of total gold consumed, compared with 288 t in 1978.

Interest in numismatic and bullion gold coins continued during 1979. Such coins are popular with small investors wishing to acquire gold but unfamiliar with bullion trading procedures. The Gold Institute/ l'Institut de l'Or reported that in 1979, 80 countries issued a total of 230 gold coins of varying gold content. The krugerrand, the one-ounce legal tender bullion gold coin of the Republic of South Africa, accounted for about 47.5 per cent of the gold thus consumed. One million ounces were consumed in the minting of the Gold Maple Leaf, Canada's entry in the bullion coin market.

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 possibility of 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, complicating efforts to estimate future gold prices. Another major problem encountered in forecasting gold prices is that gold has proved to be one of the few investments to retain its value in the face of rapidly increasing inflation and depreciating currencies, especially in the case of the U.S. dollar.

The record gold price achieved in January 1980 was not sustainable. From the January peak of $U.S. 850, the price dropped back into the $U.S. 450 range during April and May. Analysts suggest that, despite political tensions in the Middle East, there was substantial dishoarding from that quarter. Gold bought when the price was $U.S. 200 or less an ounce is being sold to realize profits. This could help to explain the relative price weakness, rather surprising given that the IMF sales ended in May 1980, the U.S. Treasury has not held a gold auction since November 1979, and no sales of Soviet gold have been reported since January 1980. The only country known to be selling gold from official reserves is Canada which in December 1979 decided to reduce the gold proportion of the foreign exchange account by 1 million ounces. Some of this is being absorbed by the Gold Maple Leaf bullion coin program.

World mine production of gold in 1980 may be slightly higher than in 1979. Output from established mines may be slightly lower as higher prices make it economic to put lower grade feed through the mill. Expansion plans will not likely contribute much to increased gold output before 1981 and possibly 1982. Mines on the verge of closing in 1978-79 may continue to salvage formerly sub-economic ore. Increased gold production will come mainly from new mines. Higher gold prices are now being reflected in increased gold exploration and mine development activity worldwide. The impact on 1980 production can come from three sources: major gold mines in the Republic of South Africa that were being developed prior to the outbreak in gold prices and that came on stream at the end of 1979; mines that were developed almost to production in the early 1970s only to be mothballed when gold prices declined and that can be brought up

TABLE 8. AVERAGE ANNUAL PRICE OF GOLD, 1970 AND 1975-79

	London Gold Market[1] $ U.S.	equiv. $ Cdn. (per troy ounce)
1970	35.97	37.55
1975	161.018	163.781
1976	124.836	123.107
1977	147.718	157.089
1978	193.228	220.407
1979P	306.686	359.289

[1] Annual average of London Gold Market afternoon fixing price, as reported by Sharpes Pixley Ltd.
P Preliminary.

to production fairly quickly; mines that had closed because reserves at prevailing prices were exhausted but which can be returned to production fairly quickly, particularly if mill and headframe remain intact. Exploration is beginning to turn up numerous deposits that may now be economic but there is almost no possibility that these will produce before 1982, and 1983 is a more likely date. If the price of gold continues to hold (or increase) there is a strong possibility that gold production in 1985 will be substantially higher than at present.

The increase in the price of gold has also had an impact on the economics of base-metal production, particularly on copper. World copper prices have been weak through the late 1970s and profitability of a number of producing copper mines depends on by-product gold recovery. Gold may be attaining the status of coproduct in some cases. The gold content, particularly of the upper weathered portions of the orebody, is a critical factor in the development of the Dizon Mine in the Philippines and the Ok Tedi deposit in Papua-New Guinea.

Investment demand for gold during the 1980s is difficult to predict. At least temporarily, the demand triggered by the increase in the "World Anxiety Quotient" appears to have been satisfied. Tension-creating geopolitical developments have not triggered dramatic or sustained price movements. In fabrication, attempts will undoubtedly be made to use less gold or to substitute for gold. It may be that, temporarily a new demand-supply ratio has become established within the recent price range of $U.S. 500-700 per ounce.

Gypsum and Anhydrite

D.H. STONEHOUSE

CANADIAN PRODUCTION

Production of gypsum in Canada in 1979 was a record 8.1 million tonnes (t) up only slightly from the previous record established in 1978. Exports too were at a record level of nearly 5.5 million t, principally to the United States. Gypsum production and shipments normally have related closely to activity in the building construction industry in both Canada and the United States. In recent years increased amounts of gypsum wallboard have been used in nonresidential building construction, offsetting reduced consumption in the residential sector caused by fewer housing starts and completions. Larger amounts are being used in retrofit applications accounting for the increased consumption of gypsum during a period of reduced housing starts.

The principal gypsum products manufactured in Canada are wallboard, lath and sheathing. Minor tonnages of plaster of paris and joint-filling compounds are also produced. Statistics relative to Canadian production of wallboard and other gypsum products are not available from Statistics Canada for 1979. Imports of wallboard were reduced greatly during 1979 as western board plants increased capabilities to cope with regional demand. Ontario imported nearly 4 million square feet of board in 1979, down from about 27 million square feet in 1978, and constituting about 50 per cent of total board imports.

Atlantic Canada is the principal gypsum producing region, particularly the Province of Nova Scotia, from which close to 70 per cent of shipments are to United States wallboard plants. Other producers mainly supply Canadian demand. In Ontario an expansion program at Caledonia by Domtar Inc. progressed on schedule during 1979. The project will include a complete new board plant, probably operative early in 1980, and a new mine development some five years from now. Additional capacity at the Canadian Gypsum Company, Limited, Hagersville plant was made operative during the year. Because of water problems in their new shaft at Drumbo, Ontario, Westroc Industries Limited experienced production difficulties during the year. Their new quarry operation at Amaranth, Manitoba provided crude gypsum to prairie board plants operated by Westroc.

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

TABLE 1. CANADA, GYPSUM PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	5 548 931	24 635 028	5 639 000	26 446 000
British Columbia	742 800	3 115 450	717 000	5 197 000
Newfoundland	809 290	4 942 700	802 000	5 085 000
Ontario	741 115	4 358 005	767 000	4 693 000
Manitoba	182 710	1 125 376	128 000	963 000
New Brunswick	49 595	447 958	52 000	424 000
Total	8 074 441	38 624 517	8 105 000	42 808 000
Imports				
Crude gypsum				
Mexico	58 358	1 313 000	134 149	2 494 000
United States	12 436	344 000	18 154	464 000
United Kingdom	201	4 000	40	2 000
Hong Kong	-	-	120	1 000
Total	70 995	1 661 000	152 463	2 960 000
Plaster of paris and wall plaster				
United States	20 847	2 668 000	17 796	2 569 000
France	-	-	103	92 000
United Kingdom	385	59 000	195	50 000
Italy	35	24 000	30	16 000
Other countries	110	11 000	106	18 000
Total	21 377	2 762 000	18 230	2 745 000
	(square metres)		(square metres)	
Gypsum lath, wallboard and basic products				
United States	4 176 847	3 308 000	697 894	911 000
United Kingdom	-	-	15 812	26 000
Total	4 176 847	3 308 000	713 706	937 000
Total imports gypsum and gypsum products		7 731 000		6 642 000
	(tonnes)		(tonnes)	
Exports				
Crude gypsum				
United States	5 142 451	22 837 000	5 437 504	25 703 000
Bahamas	36 180	193 000	37 232	196 000
Total	5 178 631	23 030 000	5 474 736	25 899 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.

p Preliminary; - Nil.

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.

Between the closure of the Westroc Industries Limited mine at Silver Plains, Manitoba, and the start up of its open-pit mine at Amaranth, Manitoba, gypsum from Windermere, British Columbia was rail-hauled abnormally long distances to supply the needs of cement producers and the gypsum products industry in the prairie provinces. Crude gypsum is imported on the west coast from Mexico, mainly for cement manufacture. Minor amounts of crude gypsum have been

TABLE 2. CANADA, SUMMARY OF GYPSUM MINING OPERATIONS, 1979

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: Energy, Mines and Resources Canada.

shipped to the mid-United States for agricultural use, and quantities have been exported to the northwestern United States from British Columbia, mainly for use by cement manufacturers.

Gypsum products are not shipped great distances because freight and handling costs represent a major part of the price to the consumer for items that are relatively low-priced and readily available at many locations.

Building construction expenditures were over $24 billion in 1979 and are expected to increase by about 6 per cent to nearly $26 billion in 1980. Total construction will likely reach $46.5 billion in 1980 from just over $42

TABLE 3. CANADA, SUMMARY OF GYPSUM PRODUCTS OPERATIONS, 1979

Company	Location	Remarks
Newfoundland		
Atlantic Gypsum Ltd.	Corner Brook	Gypsum products manufacture
Nova Scotia		
Domtar Inc.	Windsor	Gypsum plaster manufacture
New Brunswick		
Canadian Gypsum Company, Limited	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 Company, Limited	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.	Galgary	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: Energy, Mines and Resources Canada.

billion in 1979. Principal construction projects will be in the energy, municipal transportation and environmental protection fields. 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.

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, 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 t. 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.

TABLE 4. WORLD PRODUCTION OF GYPSUM, 1978 AND 1979

	1978	1979[e]
	(000 tonnes)	
United States	13 509	12 973
Canada	8 074	8 105
France	5 800	5 715
Iran	7 000	5 443
Spain	4 500	4 536
Italy	4 180	4 173
United Kingdom	3 217	3 175
West Germany	2 238	2 268
Mexico	1 758	1 814
Other Free World	11 213	12 610
Communist Countries	8 787	9 980
World total	70 276	70 792

Sources: United States Bureau of Mines, Commodity Data Summaries, January 1980; Energy, Mines and Resources Canada.

[e] Estimated.

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, 1970, 1975-79

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
	(tonnes)			
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	8 074 441	70 995	5 178 631	2 966 805
1979[p]	8 105 000	152 463	5 474 736	2 782 727

Sources: Statistics Canada; Energy, Mines and Resources 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 1979 was 280 922 t. 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, 1978 AND 1979

	Starts			Completions			Under Construction		
	1978	1979	% Diff.	1978	1979	% Diff.	1978	1979	% Diff.
Newfoundland	2,865	2,999	+ 5	3,561	2,611	-27	3,483	2,850	-18
Prince Edward Island	1,210	1,068	-12	1,036	1,173	+13	528	403	-24
Nova Scotia	4,853	4,538	- 6	5,745	6,132	+ 7	5,463	3,634	-33
New Brunswick	5,167	5,021	- 3	5,896	5,090	-14	1,888	1,951	- 3
Total (Atlantic Provinces)	14,095	13,626	- 3	16,238	15,006	- 8	11,362	8,838	-22
Quebec	43,671	41,730	- 4	54,129	44,288	-18	24,053	20,413	-15
Ontario	71,710	56,887	-21	80,429	76,570	- 5	66,106	44,851	-32
Manitoba	12,121	5,772	-52	10,550	8,410	-20	8,048	4,992	-38
Saskatchewan	9,527	11,742	+23	11,383	10,865	- 5	8,138	8,640	+ 6
Alberta	47,925	39,947	-17	43,025	44,492	+ 3	31,323	25,454	-19
Total (Prairie Provinces)	69,573	57,461	-17	64,958	63,767	- 2	47,509	39,086	-18
British Columbia	28,618	27,345	- 4	30,779	26,858	-13	15,672	15,413	- 2
Total Canada	227,667	197,049	-13	246,533	226,489	- 8	164,702	128,601	-22

Source: Statistics Canada.

TABLE 7. CANADA, VALUE OF CONSTRUCTION BY TYPE, 1978-80

	1978	1979p	1980f
		($ million)	
Building construction			
Residential	13 780	14 153	14 540
Industrial	1 563	1 945	2 178
Commercial	3 856	4 825	5 357
Institutional	1 682	1 966	2 137
Other building	1 353	1 549	1 705
Total	22 234	24 438	25 917
Engineering construction			
Marine	223	250	310
Highways, airport runways	3 035	3 428	3 484
Waterworks, sewage systems	1 804	1 956	2 091
Dams, irrigation	148	189	220
Electric power	3 855	4 073	4 358
Railway, telephones	1 442	1 663	1 913
Gas and oil facilities	3 336	4 197	5 606
Other engineering	2 113	2 177	2 519
Total	15 956	17 933	20 501
Total construction	38 190	42 371	46 418

Source: Statistics Canada.
p Preliminary; f Forecast.

TARIFFS

CANADA

Item No.		British Preferential	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¢	12¢	free
29400-1	Gypsum, ground, not calcined	free	free	15%	free
28410-1	Gypsum tile	15%	15%	25%	10%

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
29300-1	6¢	5.8¢	5.5¢	5.3¢	5.0¢	4.8¢	4.5¢	4.3¢	4.0¢
28410-1	15.0%	14.3%	13.6%	12.8%	12.1%	11.4%	10.7%	9.9%	9.2%

UNITED STATES

Item No.		
512.21	Gypsum, crude	Free

		1979	1980	1981	1982	1983	1984	1985	1986	1987
512.24	Gypsum, ground calcined, per ton	59¢	57¢	55¢	53¢	50¢	48¢	46¢	44¢	42¢
245.70	Gypsum or plastic building boards and lath, ad valorem	6.0%	5.6%	5.1%	4.7%	4.2%	3.8%	3.3%	2.9%	2.4%

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated 1978, USITC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Indium

J.J. HOGAN

Indium occurs as a minor constituent of certain ores of zinc, lead, tin, tungsten and iron. It is commonly associated with sphalerite, one of the major zinc minerals. Commercial indium is recovered, mainly from flue dusts and residues of the zinc smelting operations but some indium is also recovered from lead smelting. It is recovered at only a few of the world's zinc and lead smelters.

Canadian output of indium in 1979 was 4 512.9 kilograms (kg) compared with 3 847.7 kg in 1978. Cominco Ltd. is the only Canadian producer of indium and one of the world's largest producers of the metal.

Other major producers of indium are located in the United States, Japan, West Germany, Australia, Peru and Belgium. Statistical data on output and consumption of indium in these countries are not generally available, although the United States Bureau of Mines estimated 1979 world production at 42 300 kg compared with 44 480 kg in 1978. Indium output has been affected by closures and cutbacks in production at some zinc smelters. The content of indium in zinc ores can vary widely and at this time it appears that zinc ores being mined have a low indium content.

PRODUCTION

In Canada, indium was first recovered from the smelting operations of Cominco at Trail, British Columbia. The presence of indium in the lead-zinc-silver silver ores of Cominco's Sullivan mine at Kimberley, British Columbia, had been known for many years. In 1942, 13.6 kg were produced by laboratory methods. After a decade of intensive research and development, commercial production began in 1952. At present, the potential annual production at Trail is 31 100 kg.

Cominco produces both a standard grade (99.97 per cent) and a high-purity grade (approximately 99.999 to 99.9999 per cent indium). The metal is cast into ingots varying in size from 0.3 kg to 10 kg and some is processed further into fabricated forms such as discs, wire, ribbon, foil, sheet, powder and spherical pellets. Alloys and chemical compounds of indium, such as indium antimonide, are also produced.

PROPERTIES AND USES

Indium is a silver-white metal that resembles tin in its physical and chemical properties. Its chief characteristics are extreme softness, low melting point and high boiling point. The metal has a melting point of 156°C, boiling point of 2 000°C and atomic weight of 114.8. Its specific gravity at 20°C is 7.31 which is about the same as that of iron.

Indium forms alloys with precious metals and many base metals. A major application is low-melting alloys which can be designed to fit a particular melting point requirement by varying the indium content in the alloy. Indium alloys are widely used as solders.

The electronic industry is an important consumer of indium, especially in germanium transistors, diodes and rectifiers. Growth in this field is limited by the increased use of substitutes. Indium is used as coatings or plating for aluminum wire junctions, bearings, dental alloys and for protective finishes on jewellery and silverware. A silver-cadmium-indium alloy is used in nuclear reactor control rods. Alloys of indium are used as holding parts in the machining, grinding and polishing of glass lenses and ceramics. A relatively large quantity of indium is consumed in research and development for new applications.

The United States Bureau of Mines estimated that in 1979 the uses of the metal in that country were distributed as follows: electrical and electronic components 50 per cent; solders, alloys and coatings 40 per cent; and research and other uses 10 per cent.

FOREIGN TRADE

Detailed statistics on foreign trade are not available for indium. United States imports of the metal in 1979 were estimated by the United States Bureau of Mines at 8 398 kg compared with 6 438 kg in 1978. The source of imports for 1975-78 were: Peru 26 per cent, United Kingdom 21 per cent, Canada 17 per cent, Japan 12 per cent and others 24 per cent.

PRICES

The price of indium as quoted by **Metals Week** increased sharply in 1979, from an opening price for the year of $U.S. 337.58 per kg ($10.50 per ounce) to a closing price of $594.79 per kg ($18.50 per ounce) for metal having a minimum purity of 99.7 per cent. Three United States suppliers, Indium Corp. of America, ASARCO Incorporated and Cominco American Inc., normally established the producer price for indium, with Indium Corp. taking the lead in 1979.

A steadily rising consumer demand was the main reason for the price rise in 1979. World consumption of indium is small but the metal is used in a wide variety of fields. Growth in most fields has been upwards but at a low rate.

The following table shows indium price changes during the years 1977 to 1979.

Indium prices as quoted by Metals Week, 1977-79

Effective date	Ingots $U.S. per kilogram[1]
August 31, 1977	273.28,321.51[2]
March 28, 1978	249.17,273.28
September 26	260.42,273.28
October 6	265.24,273.28
October 24	273.28,281.32
November 10	273.28,305.43
November 20	305.43
November 27	337.58
December 1	337.58
February 21, 1979	337.58,342.14
April 3	342.14,377.77
April 18	337.77
May 4	401.88
June 11	434.04
August 2	466.19
October 4	530.49
December 18	594.79

[1] 1 kilogram is equivalent to 32.1507 troy ounces. [2] Two prices for any period indicate quotes of different producers.

Iron Ore

C.J. CAJKA

Canadian mine shipments of iron ore reached an all-time record of 60.2 million tonnes (t) in 1979, a 40 per cent increase over 1978 when strikes in the Quebec-Labrador region limited Canadian shipments to 42.9 million t, and 8.6 per cent higher than the previous record of 55.4 million t in 1976. This record output was achieved despite the closure of three Ontario iron ore mines. At the same time imports of iron ore, almost entirely from the United States, also reached an all-time high of 5.9 million t.

The recession in the United States during 1979 proved less severe than had been forecast, and indeed, the country's economy showed modest growth for the year. Other industrialized countries also recorded modest economic growth in 1979, although there was evidence of tailing-off by year-end. Along with this growth in world economies, a record 750 million t of steel were produced worldwide, which in turn created a steady demand for iron ore. Nevertheless, concern with oversupply of iron ore, brought about by recent capacity increases, overshadowed the iron ore market. In the United States alone, pellet capacity has been increased by 22 million t since 1976 and another 2.5 million t will be added in 1980.

The Lake Erie base price for iron ore products increased by about 11 per cent during 1979, reflecting the rising cost of energy, labour and materials. The offshore prices for iron ore products showed modest improvements, although this was in relation to depressed 1978 prices.

CANADIAN DEVELOPMENTS

Following settlement of the 1978 labour disputes, the Quebec-Labrador mines returned to near-capacity production rates and continued at this pace throughout 1979. Mine shipments rose to record levels, in part due to new production from the Sidbec-Normines Inc. iron ore and pelletizing facilities. Sidbec-Normines 6 million tpy pellet plant at Port Cartier began operating in November, 1978 and within a few months was able to bring production to two-thirds of its rated capacity.

1979 marked the 25th anniversary of iron ore production from Schefferville by the Iron Ore Company of Canada.

Quebec Cartier Mining Company undertook a major extension of the dock loading facilities at Port Cartier in 1979. When completed in 1980, the port will have a loading capability of more than 26 million tpy of bulk commodities.

Iron ore production from northwestern Ontario continued to decline as three more iron mines were closed during 1979. The Moose Mountain mine, concentrator and pellet plant near Capreol, owned by National Steel Corporation, was closed in May. Annual capacity at the plant was some 600 000 t of pellets.

Caland Ore Company Limited, a subsidiary of Inland Steel Company, closed its mine at Atikokan in November, 1979 and the associated concentrator-pellet plant in

TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979P	
	(tonnes)[1]	($)	(tonnes)[1]	($)
Production (mine shipments)				
Newfoundland	18 782 158	564,113,772	29 968 000	949,449,000
Quebec	13 933 074	337,521,218	21 377 000	639,881,000
Ontario	9 600 001	308,366,931	8 164 000	286,012,000
British Columbia	615 569	11,597,462	676 000	13,473,000
Total[2]	42 930 803	1,221,599,383	60 185 000	1,888,815,000
Imports				
Iron ore				
United States	3 860 949	142,761,000	5 051 080	199,716,000
Brazil	365 022	10,654,000	791 677	25,482,000
Sweden	418 738	12,915,000	45 477	1,509,000
Norway	41 159	1,320,000	23 970	673,000
Bolivia	-	-	346	11,000
Total	4 685 868	167,650,000	5 912 550	227,391,000
Exports				
Iron ore, direct shipping				
United States	2 517 412	27,711,000	3 413 119	48,539,000
Italy	283 512	3,069,000	447 516	6,379,000
Belgium-Luxembourg	117 304	1,270,000	194 349	2,774,000
West Germany	-	-	36 596	522,000
Total	2 918 228	32,050,000	4 091 580	58,214,000
Iron ore concentrates				
United States	3 631 249	89,627,000	3 918 335	102,735,000
Netherlands	2 704 207	40,010,000	4 985 124	85,574,000
United Kingdom	2 232 067	34,915,000	4 188 547	77,625,000
Japan	2 247 465	26,375,000	4 721 487	72,682,000
Italy	919 148	14,032,000	1 762 763	30,150,000
West Germany	544 383	9,039,000	1 703 392	29,732,000
France	751 930	11,508,000	1 322 043	21,941,000
Belgium-Luxembourg	501 885	10,158,000	539 215	12,311,000
Spain	42 742	844,000	300 628	5,101,000
Philippines	121 662	1,245,000	309 476	4,024,000
Yugoslavia	224 016	3,855,000	200 403	3,679,000
Portugal	48 279	1,148,000	120 479	2,979,000
Other countries	33 012	918,000	87 847	2,049,000
Total	14 002 045	243,674,000	24 159 739	450,582,000
Iron ore, agglomerated				
United States	12 439 700	419,024,000	15 460 445	629,077,000
United Kingdom	616 803	22,310,000	1 995 224	85,552,000
Netherlands	883 094	29,996,000	1 555 774	65,060,000
Spain	128 499	4,652,000	582 527	24,715,000
West Germany	152 499	4,767,000	478 871	21,143,000
Italy	315 959	10,862,000	263 508	9,633,000
Other countries	183 021	5,251,000	196 701	8,370,000
Total	14 719 575	496,862,000	20 533 050	843,550,000
Iron ore, nes				
United States	289 246	10,207,000	64 295	1,686,000
United Kingdom	-	-	63	28,000
Argentina	-	-	288	26,000
Total	289 246	10,207,000	64 646	1,739,000

TABLE 1. (Cont'd.)

	1978		1979P	
	(tonnes)[1]	($)	(tonnes)[1]	($)
Total exports, all classes				
United States	18 877 607	546,569,000	22 856 194	782,037,000
United Kingdom	2 848 870	57,225,000	6 183 834	163,205,000
Netherlands	3 587 301	70,006,000	6 540 898	150,634,000
Japan	2 295 353	27,380,000	4 721 487	72,682,000
West Germany	696 882	13,806,000	2 218 859	51,397,000
Italy	1 518 619	27,963,000	2 473 787	46,162,000
Spain	171 241	5,496,000	883 155	29,816,000
Belgium-Luxembourg	702 539	13,779,000	901 761	22,238,000
France	751 930	11,508,000	1 322 043	21,941,000
Yugoslavia	224 016	3,855,000	228 907	4,893,000
Other countries	254 736	5,206,000	518 090	9,080,000
Total	31 929 094	782,793,000	48 849 015	1,354,085,000
Consumption of iron ore at Canadian iron and steel plants	15 282 779	..	17 189 502	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.
[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.

April, 1980. The plant had a nominal production capacity of 1 016 000 t of pellets per year.

Both of these mining companies were closed for a number of factors, the major ones being depleting ore reserves, an oversupply of iron ore within North American markets because of the recessionary level of steel production in the United States, and the start up of new iron ore facilities in the U.S. by the integrated steel producers that had operated the closed Ontario mines. The planned mine closing of Steep Rock Iron Mines Limited at Atikokan took place in February and the associated pellet plant in August, 1979. The reason for closing was the depletion of ore reserves. Steep Rock had annual capacity to produce 1.47 million t of pellets. The three mine closures involved about 1,250 jobs: 530 at Steep Rock; 470 at Caland and 250 at Moose Mountain.

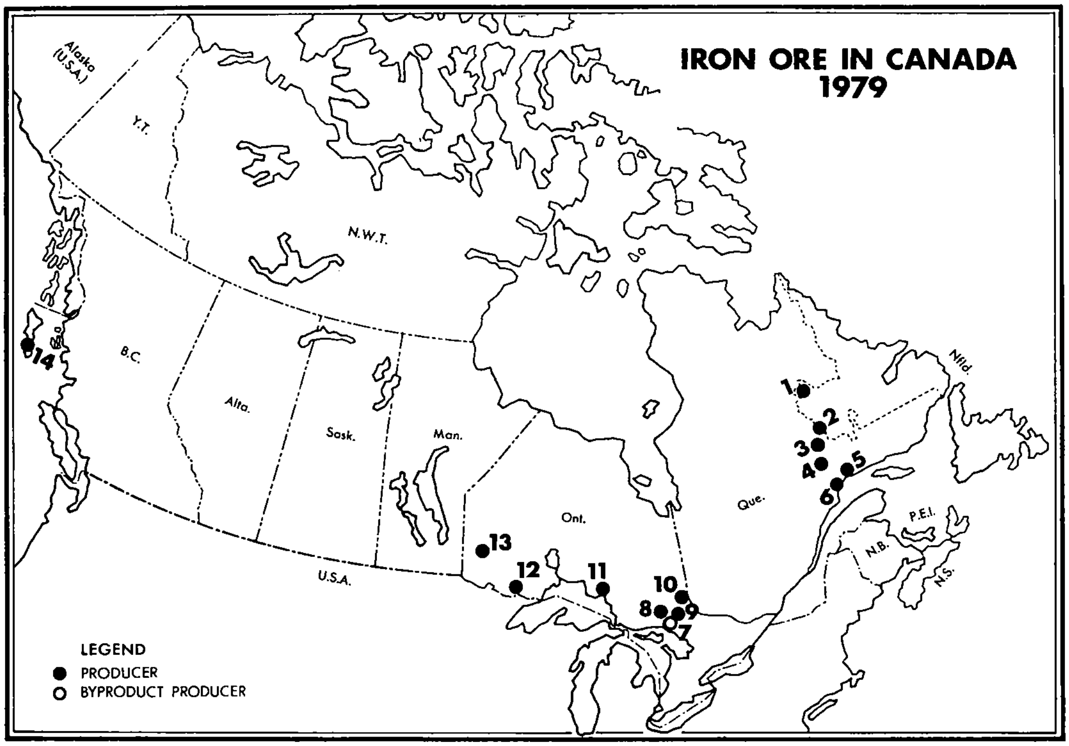
Craigmont Mines Limited, a British Columbia copper producer that recovers a magnetite concentrate as byproduct, announced that it would extend the life of the mine into early 1981. It had earlier been disclosed that the mine would close in July 1979 when ore reserves would be depleted. Higher prices for copper enabled the company to lower the cutoff grade of ore mined and thereby increase reserves. The company produces 40 000 to 50 000 tpy 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 about ten years after the mine closes.

FOREIGN DEVELOPMENTS

Brazilian ore shipments were interrupted following flood damage on the rail link between the Cia Vale do Rio Doce (CVRD) mines and the port of Tubarao. Nevertheless, Brazilian production in 1979 reached a record 87 million t and shipments were made up over the course of the year. The massive Carajas project remained in the news with the first contracts let to build the 900 kilometre (km) railway between Sao Luis and the rich orebody. Current plans call for 15 million t of production in 1984, rising to 25-30 million t in 1986. It is estimated that the total cost, including the railroad, will be about $2.5 billion.

Australian iron ore production in 1979 at 85 million t increased marginally from 1978 in spite of lengthy strikes which hit the

Pilbara region. Production increases were reported at Mount Tom Price, Paraburdoo, Pannawonica and Yampi Sound. Beneficiation plants were started at Mount Whaleback and Mount Tim Price to produce annually 5 million t and 10.8 million t, respectively, of high-grade product. Early in 1979, CSR Ltd. announced the discovery of a high-grade iron ore deposit at Yandicoogina Creek in the Pilbara region, some 80 km northwest of Mt. Newman. Probable ore reserves exceeding 1 billion t of 58.7 per cent iron are reported. Also during 1979, the Australian government decided to



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. Quebec Cartier Mining Company and Sidbec Normines Inc. (Port Cartier)
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)

TABLE 2. CANADA, IRON ORE PRODUCTION (SHIPMENTS), 1977-79

Company and Location	Ore Mined	Product Shipped	1977	1978	1979
			(000 tonnes, natural wt.)		
Adams Mine, Kirkland Lake, Ont.	Magnetite	Pellets	1 218	1 250	1 242
Algoma Ore Division of The Algoma Steel Corp. Ltd., Wawa, Ont.	Siderite	Sinter	1 771	1 732	1 711
Caland Ore Co. Ltd., Atikokan, Ont.	Hematite and goethite	Pellets	1 027	957	832
		Concentrates	477	546	303
Griffith Mine, Bruce Lake, Ont.	Magnetite	Pellets	1 565	1 553	1 530
Hilton Mines Ltd., Shawville, Que.	Magnetite	Pellets	177	-	-
Iron Ore Company of Canada, Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	3 069	3 007	4 087
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	6 435	3 898	8 363
		Pellets	11 158	6 755	10 649
Sept Iles, Que.	Schefferville "treat ore"	Pellets	4 552	3 597	4 731
Marmoraton Mining Co. Ltd., Marmora, Ont.	Magnetite	Pellets	611	137	-
National Steel Corporation, Capreol, Ont.	Magnetite	Pellets	582	655	231
Quebec Cartier Mining Company, Mount Wright, Que.	Specular hematite	Concentrate	13 169	9 911	14 809
Sidbec-Normines Inc., Fire Lake and Lac Jeannine, and Port Cartier, Que.	Specular hematite	Concentrate	297	248	100
		Pellets (standard)	-	1 164	3 358
		Pellets (low silica)	-	344	731
Sherman Mine, Temagami, Ont.	Magnetite	Pellets	1 109	1 155	947
Steep Rock Iron Mines Ltd., Atikokan, Ont.	Hematite	Pellets	1 433	1 302	985
Texada Mines Ltd., Texado Island, B.C.	Magnetite	Concentrate	100	-	-
Wabush Mines, Wabush, Labrador and Pointe Noire, Que.	Specular hematite and magnetite	Pellets	5 640	4 419	5 539

TABLE 2. (Cont'd.)

Company and Location	Ore Mined	Product Shipped	1977	1978	1979
			(000 tonnes, natural wt.)		
Wesfrob Mines Limited, Queen Charlotte Islands, B.C.	Magnetite	Pellet concentrate	366	610	588
Byproduct producer					
Inco Limited, Sudbury, Ont.	Pyrrhotite	Pellets	649	361	135
Total			55 405	43 601	60 871

Source: Energy, Mines and Resources Canada.
- Nil.

TABLE 3. PRODUCTION AND CAPACITY OF PIG IRON AND CRUDE STEEL AT CANADIAN IRON AND STEEL PLANTS, 1978 AND 1979

	1978	1979P
	(tonnes)	
Pig iron		
Production	10 338 266	10 905 660
Capacity at December 31[1]	11 807 009	11 730 000
Steel ingots and castings		
Production	14 898 449	16 078 041
Capacity at December 31	18 607 629	18 890 040

Source: Statistics Canada.
[1] In blast or in use.
P Preliminary.

suspend iron ore export controls, an action that was introduced in 1978 in response to a growing government concern with unsatisfactory export prices.

During the year Brazil and Australia signed a trade agreement involving exchange of information and discussions on each country's general perception of the iron ore market, including supply and demand, and plans for new projects.

TABLE 4. RECEIPTS, CONSUMPTION AND STOCKS OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, 1978 AND 1979

	1978	1979P
	(tonnes)	
Receipts imported	5 236 968[1]	5 988 042[2]
Receipts from domestic sources	10 690 677[3]	12 260 251[4]
Total receipts at iron and steel plants	15 927 645	18 248 293
Consumption of iron ore	15 282 779[5]	17 189 502[6]
Stocks of ore at iron and steel plants, December 31	4 597 982	5 709 137
Change from previous year	+657 426	+1 111 155

Source: American Iron Ore Association.
[1] Compared with 4 685 868 t in Table 1.
[2] Compared with 5 912 550 t in Table 1.
[3] Compared with domestic shipments of 10 273 037 t compiled by Statistics Canada.
[4] Compared with 12 230 187 t compiled by Statistics Canada. [5] Compared with 14 847 867 t compiled by Statistics Canada for blast furnace consumption. [6] Compared with 16 410 124 t compiled by Statistics Canada for blast furnace consumption.
P Preliminary.

TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1979

Material Consumed	Sinter Plants at Steel Mill	Direct Reduction Plants	Consumed In Iron and Steel Furnaces: Production of Pig Iron	Steel Furnaces	Total in Furnaces
			(tonnes)		
Iron ore					
Crude and concentrate	210 077	-	58 857	3 789	62 646
Pellets	104 037	1 384 183	13 420 007	87 317	13 507 324
Sinter	95 300	-	1 609 437	-	1 609 437
Sinter produced at steel plant	-	-	1 117 886	-	1 117 886
Direct-reduced iron	-	-	-	734 439	734 439
Other iron-bearing materials					
Flue dust	68 896	-	-	-	-
Mill scale, cinder, slag	549 239	-	401 267	1 387	402 654

Source: Company data.
[1] Dominion Foundries and Steel, Limited; Sidbec-Dosco Limited; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; The Steel Company of Canada, Limited.
- Nil.

In China, earlier ambitious programs to rapidly expand iron ore and steel production were scaled down as the problems of finding adequate exchange earnings became evident. United States Steel Corporation, which had earlier signed a protocol agreement with China in regards to the construction of a $1 billion iron ore pelletization project near Anshan, announced that the project would be delayed by at least 5 to 12 months, and that it might be smaller than the annual 17 million t of pellet product that was originally planned.

A net increase of 3.9 million t of annual pellet capacity was added in the United States in 1979 even though two pellet plants and one underground mine were closed. An additional 2.5 million t of pellet capacity will be placed in production in 1980.

The United Nations Conference on Trade and Development (UNCTAD) held no international meetings on iron ore during 1979. However, the Secretariat of UNCTAD distributed a report to members on questions relating to a possible study of the problems of the iron ore industry and market from a longer-term perspective. Very few governments had responded to the questions by early 1980. A Third Preparatory Meeting on iron ore had been anticipated for the purpose of taking further steps regarding: a study in the light of the UNCTAD secretariat note; responses by governments; and an outline, prepared by the UNCTAD secretariat.

PRICES

The Lake Erie base price for iron ore increased moderately during 1979. The price for Mesabi Non-Bessemer ore[1] was in the range of $U.S. 20.85 to $21.95 per t at the beginning of 1979, rising to $U.S. 24.21[2] at year-end. Pellet prices[3] were raised twice during 1979, from U.S. 59.9 cents per iron natural metric unit at the beginning of 1979 to U.S. 64.5 cents in April, and to U.S. 66.7 cents in August.

Off-shore market prices for iron ore products are normally determined through

[1] 51.50 per cent iron natural at rail of vessel, lower lake port.
[2] Equivalent to U.S. 47.01 cents per iron natural metric unit.
[3] Per iron natural metric unit at rail of vessel, lower lake port.

annual supplier-purchaser negotiations, refer to dry products and are paid f.o.b. supplier port. Based upon a sample of press reports, price increases in 1979 were 10 to 12 per cent in most cases. The prices per iron metric unit for ore fines were reported to be U.S. 21-23 cents for Japanese markets and about U.S. 23.5 cents for European markets. Although there were few reports on contracted prices for acid iron ore pellets, those that appeared indicated that the price for European markets was about U.S. 40 cents per iron metric unit and for the Japanese market about U.S. 35 cents.

TABLE 6. WORLD IRON ORE PRODUCTION, 1977-79

	1977	1978p	1979e
	(000 tonnes)		
U.S.S.R.	239 716	240 800	244 000
Brazil	82 001	85 000	87 000
Australia	96 098	83 189	85 000
United States	56 646	82 784	85 000
People's Republic of China[e]	60 000	70 000	70 000
Canada (mine shipments)	53 621	42 931	60 000
India	42 307	38 155	41 000
France	36 630	33 458	33 000
Republic of South Africa	26 481	24 206	..
Sweden	24 839	21 486	24 000
Liberia	18 136	18 800[e]	20 000
Venezuela	13 683	13 600	13 000
Chile	7 896	9 666	..
North Korea[e]	9 500	9 500	..
Spain	7 899	8 100	..
Mauritania	9 794	6 934	..
Mexico	5 381	5 334	..
Peru	6 284	4 921	..
Other countries	50 114	48 908	121 000
Total	847 026	847 772	883 000

Sources: Energy, Mines and Resources Canada; Statistics Canada; for remaining countries, U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 9 and U.S. Mineral Commodity Summaries, January 1980.
p Preliminary; e Estimated; .. Not available.

SEAWAY TOLLS

The year 1979 marked the second phase of a three-phase increase in seaway charges to reduce operating deficits on the St. Lawrence Seaway system. Toll charges on the Montreal to Lake Ontario segment were increased from 50 to 62 cents per t of bulk cargo, and on the Welland Canal from 20 to 24 cents per t.

The Gross Registered Tonnage (GRT) rate remained unchanged from 1978 at 70 cents per t on each of these two segments of the Seaway. In 1980 the toll rates will rise to 68 cents per t on the Montreal-Lake Ontario segment and to 31 cents per t on the Welland Canal.

Prior to 1978 the Montreal-Lake Ontario toll was 44.1 cents per t, and $100 was charged for each of the eight locks in the Welland Canal. The toll increases to 1980 are substantial and will have a significant effect on the competitiveness of Quebec-Labrador ores in the Lower Lakes market. Iron ore traffic on the St. Lawrence Seaway decreased from 19.4 million t in 1977 to 13.5 million t in 1979, although Seaway tolls are not necessarily the main, and certainly not the sole, cause of this decline.

OUTLOOK

There were indications late in 1979 of substantial improvements in iron ore prices. For example, the Brazilians (CVRD) had negotiated a contract with a West German purchaser who agreed to a 19.6 per cent increase in the price of ore, and Malmexport AB of Sweden was seeking a 30 per cent price increase for its iron ore fines in the European market. Nevertheless, the long-forecast recession seemed to be taking hold in the United States by late 1979 and a parallel economic decline can be anticipated in other industrialized countries in 1980. For this reason, and particularly in the U.S. market where mine capacity has been substantially expanded, iron ore production capacity is expected to exceed requirements by a considerable margin. This surplus capacity in the world iron ore industry will probably last until about 1985. In the meantime, competition for export markets will undoubtedly be severe.

In the longer term, much depends upon structural changes that are taking place in the iron ore and steel industries. In this regard, the iron ore industry is being reorganized in several countries including India, Sweden and France; steel production is growing rapidly in the developing countries, and major adjustments will have to be instituted in the U.S. and by some European steel industries. Furthermore, all these factors are being influenced by the escalating cost of energy. When and where Canadian iron ore expansion can take place in the context of these major world adjustments is largely conjectural, but it does seem improbable that new capacity will be introduced before the late 1980s.

TABLE 7. CANADA, IMPORTS OF STEEL SCRAP BY PROVINCE, 1977-79

		1977		1978		1979P	
		World	U.S.	World	U.S.	World	U.S.
Nova Scotia	tonne	-	-	152	152	-	-
	$000	-	-	9	9	-	-
New Brunswick	tonne	331	331	434	434	1 442	1 442
	$000	15	15	43	43	116	116
Quebec	tonne	44 866	44 866	64 267	64 263	52 313	52 309
	$000	2,538	2,538	3,336	3,296	5,187	5,187
Ontario	tonne	180 064	179 876	277 606	277 399	343 721	343 099
	$000	8,762	8,729	17,857	17,792	31,862	31,814
Manitoba	tonne	7 287	7 287	85 981	85 981	90 222	90 222
	$000	174	174	4,730	4,730	8,271	8,271
Saskatchewan	tonne	112 734	112 734	155 407	155 407	177 626	177 626
	$000	6,717	6,717	9,690	9,690	16,950	16,950
Alberta	tonne	1 433	1 433	81 864	81 864	69 510	69 510
	$000	47	47	3,722	3,722	6,096	6,096
British Columbia	tonne	868	830	2 272	2 249	2 677	1 908
	$000	98	98	158	156	256	204
Canada total	tonne	347 583	347 357	667 983	667 749	737 511	736 116
	$000	18,351	18,318	39,545	39,438	68,738	68,638

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 8. CANADA, EXPORTS OF STEEL SCRAP, BY PROVINCE OF LADING, 1977-79

		1977		1978		1979P	
		World	U.S.	World	U.S.	World	U.S.
Newfoundland	tonnes	3 802	-	168	168	-	-
	$000	168	-	16	16	-	-
Nova Scotia	tonnes	388	388	940	486	133	64
	$000	46	46	196	107	64	17
New Brunswick	tonnes	56	56	118	118	46	3
	$000	6	6	13	13	10	...
Quebec	tonnes	135 019	18 370	225 949	18 195	299 499	14 543
	$000	10,151	1,769	16,479	1,480	38,830	1,713
Ontario	tonnes	347 195	325 975	381 756	349 908	402 257	378 022
	$000	19,075	17,040	28,334	23,874	35,594	32,587
Manitoba	tonnes	3 310	3 310	2 761	2 761	9 940	9 866
	$000	350	350	346	346	1,412	1,399
Saskatchewan	tonnes	377	377	18	18	699	699
	$000	45	45	8	8	154	153
Alberta	tonnes	1 094	880	1 524	1 504	5 317	5 153
	$000	59	40	121	118	581	537
British Columbia	tonnes	79 696	79 381	94 930	92 282	139 354	134 532
	$000	4,429	4,321	6,889	6,487	12,210	11,570
Yukon	tonnes	204	204	-	-	-	-
	$000	18	18	-	-	-	-
Canada total	tonnes	571 141	428 941	708 164	465 440	857 245	542 882
	$000	34,347	23,635	52,402	32,449	88,855	47,976

Source: Statistics Canada.
P Preliminary; - Nil; ... Less than $500.

TABLE 9. LAKE ERIE BASE PRICE OF SELECTED ORES[1] AT YEAR-END, 1971-79

	1971	1972	1973	1974	1975	1976	1977	1978	1979
	($U.S. per tonne)								
Mesabi Non-Bessemer	10.99	10.99	11.72	15.50	18.21	19.94	20.84	21.95	24.21
Old Range Non-Bessemer	11.24	11.24	11.97	15.75	18.45	20.19	21.09	22.19	24.46
Pellets (per tonne natural iron unit)[2]	0.275	0.275	0.289	0.399	0.464	0.523	0.546	0.599	0.667

Sources: **Skillings Mining Review; Iron Age.**
[1] 51.5 per cent of iron natural, at rail of vessel, lower lake ports. [2] One iron unit equals 1 per cent of a tonne. A 60 per cent iron ore, therefore, has 60 units.

Iron and Steel

JAMES C. POPE

Production of crude steel in Canada increased 7.9 per cent in 1979 to 16.1 million tonnes (t). Steel producer shipments increased from 11.7 million t to 12.2 million t, an increase of about 4.5 per cent, due to a 7.6 per cent increase in deliveries in Canada.

The lower demand of the domestic motor vehicle industry, which was down 7.2 per cent, was off-set by a 10.2 per cent increase in demand by the steel service centres and the energy sector where pipe and tube consumption increased 11.8 per cent. Most steel products were in strong demand, particularly for rail cars and equipment for the natural resources, construction and agricultural industries. Demand by the steel fabricators increased slightly.

Total exports were down 12 per cent, principally due to a 9.3 per cent drop in exports to the United States which accounted for approximately 80 per cent of total export markets. Exports to other countries decreased by 22 per cent, reflecting the recession being experienced in western economies.

The effects of the Trigger Price Mechanism and the Basic Price Systems on the steel markets of the United States and the European Economic Community (EEC), respectively, were a reduction of imports and a higher price for imported steel in these two market areas, which tended to stabilize the market. Prices of steel being exported by Japan and major exporters of western Europe also rose and remained strong for the first half of 1979. As domestic markets in western Europe and the United States softened in late 1979, export prices tended to decrease.

PRODUCTION, SHIPMENTS AND CONSUMPTION

Crude steel production increased 7.9 per cent from 14.9 million t in 1978 to 16.1 million t in 1979. Basic oxygen furnace production accounted for about 57 per cent, with production up some 702 000 t. Open hearth furnace production increased 266 000 t to 3.3 million t, the second year in succession that production by open hearths increased after a 7-year period of continuing decline in production. Electric furnace production increased 4.8 per cent to 3.4 million t. Output of steel castings, mainly produced by electric furnaces, increased from 170 493 t in 1978 to 223 353 t in 1979.

Steelmaking capacity, which was 18.0 million t at January 1, 1978, increased to 18.6 million t due to the marginal expansion in basic oxygen furnace capacity. Average steel furnace capacity utilization increased to 86.4 per cent from 82.8 per cent in 1978. Basic oxygen furnaces had the highest capacity utilization rate at 89.5 per cent while capacity utilization of steel castings furnaces increased to 49.5 per cent from 37.9 per cent in 1978.

TABLE 1. CANADA, GENERAL STATISTICS OF THE DOMESTIC PRIMARY IRON AND STEEL INDUSTRY, 1977-79

		1977	1978	1979P
Production				
Volume indexes				
Total industrial production	1971=100	125.2	132.4	137.7
Iron and steel mills[1]	1971=100	121.0	136.5	145.4
		($ million)	($ million)	($ million)
Value of shipments, iron and steel mills[1]		3,843.6	5,068.6	6,059.9
Value of unfilled orders, year-end, iron and steel mills		574.8	840.0	981.5
Value of inventory owned, year-end, iron and steel mills		1,084.5	1,155.7	1,496.5
		(number)	(number)	(number)
Employment, iron and steel mills[1]				
Administrative		10,981	11,159	11,799
Hourly rated		38,769	41,549	44,084
Total		49,750	52,708	55,883
Employment index, all employees	1961=100	144.5	152.8	161.9
Average hours per week, hourly rated		39.4	39.9	40.1
		($)	($)	($)
Average earnings per week, hourly rated		305.32	333.89	365.5
Average salaries and wages per week, all employees		322.58	350.81	383.7
		($ million)	($ million)	($ million)
Expenditures, iron and steel mills[1]				
Capital: on construction		78.5	52.5	56.3
on machinery		313.7	257.0	296.8
Total		392.2	309.5	353.1
Repair: on construction		46.8	36.3	41.8
on machinery		394.3	471.3	571.8
Total		441.1	507.6	613.6
Total capital and repair		833.3	817.1	966.7
Trade, primary iron and steel[2]				
Exports		898.3	1,270.7	1,446.6
Imports		756.1	973.0	1,482.8

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 Energy, Mines and Resources, Canada.
P Preliminary.

Total pig iron production increased 5.5 per cent to 10.9 million t. Basic iron (hot metal) production increased 9.3 per cent to 10.4 million t while foundry iron production decreased 38.8 per cent to 505 000 t. Shipments of foundry pig iron correspondingly decreased 40.8 per cent.

Consumption of pig iron in steelmaking furnaces increased to 10.3 million t, a 9.9 per cent increase over 1978, while ferrous scrap consumption in steelmaking furnaces increased 6.1 per cent to 8.2 million t. Apparent domestic consumption of foundry pig iron increased to 160 000 t from 142 000 t in 1978.

Producer shipments of rolled steel in 1979 amounted to 12.2 million t, an increase of 4.6 per cent compared with 1978. Shipments were up for most groups including increases of: 31.1 per cent to 345 565 t for rails; 20.0 per cent to 118 580 t for cold-finished bars; 14.6 per cent to 1 700 685 t for plate; 14.3 per cent to 141 137 t for wire rod and 12.4 per cent to 71 687 t for track material. Ingots and semis shipments declined 17.9 per cent to 500 176 t and concrete reinforcing bar shipments declined 7.8 per cent to 529 874 t.

Domestic consumption of rolled steel products increased by 7.7 per cent to 10.6

TABLE 2. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1977-79

	1977	1978	1979P
		(tonnes)	
Furnace capacity January 1[1]			
Blast	10 495 000	10 304 000	11 240 019
Electric	612 350	567 000	566 990
Total	11 107 350	10 871 000	11 807 009
Production			
Basic iron	9 099 156	9 512 985	10 400 732
Foundry iron[2]	561 769	825 281	504 928
Total	9 660 925	10 338 266	10 905 660
Shipments			
Basic iron	91 441	(3)	(3)
Foundry iron[2]	611 898	684 439	405 384
Total	703 339	684 439	405 384
Imports			
Tonnes	11 913	2 556	9 913
Value ($000)	2 268	521	2 130
Exports			
Tonnes	505 277	544 713	255 522
Value ($000)	83 649	92 150	47 874
Consumption of pig iron			
Steel furnaces	8 896 744	9 346 645	10 275 058
Consumption of iron and steel scrap			
Steel furnaces	6 846 788	7 698 640	8 167 315

Sources: Statistics Canada; **Primary Iron and Steel** (monthly); **Iron and Steel Mills** (annual).
[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. (3) Included with "Foundry".
P Preliminary.

million t. The only sectors showing a decline in consumption over that of 1978 were: automotive, down 7.1 per cent to 1 685 991 t; contractors' products, down 2.4 per cent to 87 472 t; and appliances, down 0.8 per cent to 19 878 t. Slow sales in these sectors reflected the decline in automobile production and the soft market in the housing industry.

Warehouses and steel service centres received the largest share of rolled steel shipments in 1979. These outlets took delivery of 2.0 million t, an increase of 10.2 per cent over 1978. Deliveries to the pipe and tube industry increased 11.9 per cent to 1.6 million t due to strong activity in oil and gas exploration in western Canada. Increased production of railroad cars and improvements of railroad track resulted in deliveries of 275 494 t (46.5 per cent increase) and 228 260 t (86.4 per cent increase), respectively, to the railway operating, and railroad cars and locomotive

TABLE 3. CANADA, CRUDE STEEL PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1977-79

	1977	1978	1979P
		(tonnes)	
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	3 742 137	3 742 137	3 742 137
Basic oxygen converter	9 523 626	9 568 985	10 185 870
Electric	3 745 767	4 222 038	4 228 388
Total	17 011 530	17 533 160	18 156 395
Steel castings	445 973	450 327	451 234
Total furnace capacity	17 457 503	17 983 487	18 607 629
Production			
Steel ingot			
Basic open-hearth	2 879 758	3 029 062	3 295 093
Basic oxygen	7 952 828	8 413 641	9 115 530
Electric	2 649 558	3 285 253	3 444 065
Total	13 482 144	14 727 956	15 854 688
Continuously cast, included in total above	2 169 047	3 011 054	3 192 286
Steel castings[2]	149 099	170 493	223 353
Total steel production	13 631 243	14 898 449	16 078 041
Alloy steel in total	1 691 581	1 850 088	2 184 057
Shipments from plants			
Steel castings	133 870	157 231	199 746
Rolled steel products	10 327 360	11 692 504	12 229 716
Total	10 461 230	11 849 735	12 429 462
Steel ingots included with rolled steel products above	587 658	609 555	500 176
		(000 tonnes)	
Exports, equivalent steel ingots	2 231.8	2 883.7	2 748.0
Imports, equivalent steel ingots	1 520.0	1 624.6	2 322.4
Indicated consumption, equivalent steel ingots	12 895.2	13 588.6	15 507.7

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.

sectors. Deliveries to the natural resources and extractive industries sectors increased 23 per cent, reflecting increased activity in the mining industry.

INVESTMENT AND CORPORATE DEVELOPMENTS

Expenditures by the Canadian steel industry for capital and repair increased by 18.3 per cent to $966.7 million. Repair expenditures in 1979 of $613.6 million increased by 20.9 per cent, while capital expenditures increased 14.1 per cent to $353.1 million.

The Steel Company of Canada, Limited (Stelco) continued work on the first phase of its Nanticoke project, estimated to cost $1.2 billion. The project will include a 4 770 tpd blast furnace, two 225 t basic oxygen furnaces and a continuous slab caster capable of making slabs up to 250 mm thick, 1 880 mm wide and 9.75 m long. Initially, slabs will be transported to its Hamilton Works for further processing, but eventually they will be finished at Nanticoke.

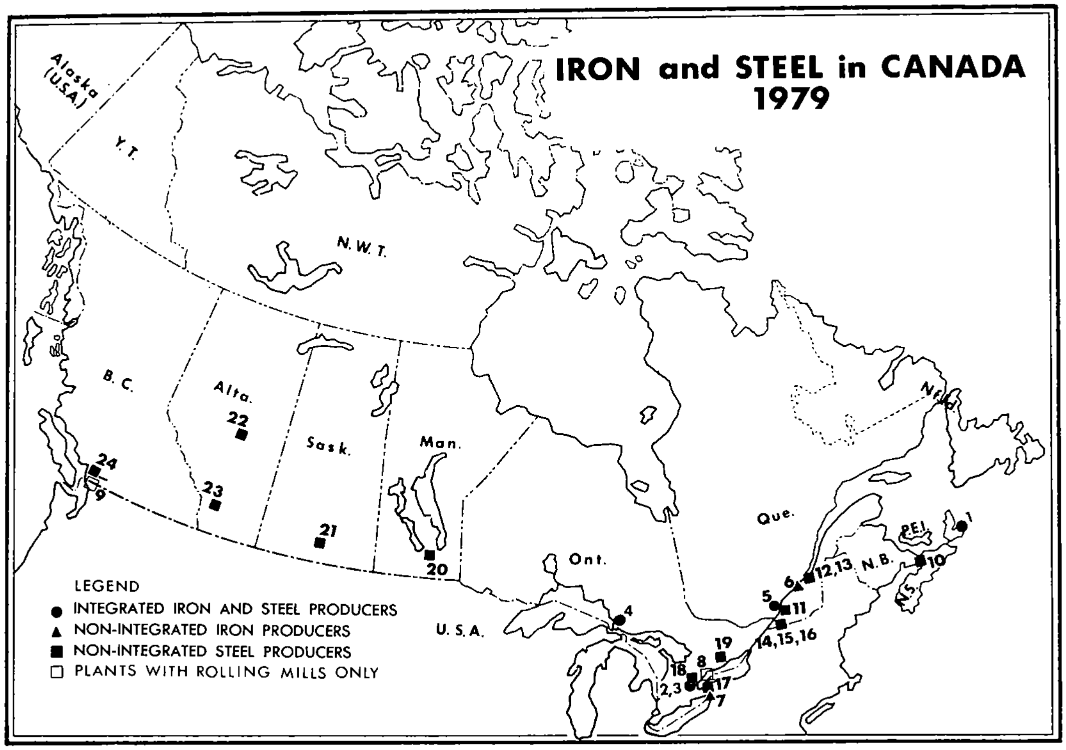
Initial production at Nanticoke is planned for April 1980 and output is expected to reach 1.2 million tpy by mid-1981, bringing Stelco's annual steel capacity to 7.3 million t. Stelco's management has also approved in principle an expenditure of $365 million for a program to include the following undertakings: completion of a new 203-mm hot strip mill at Nanticoke with an annual capacity of 1.2 million t, installation of a fourth sheet galvanizing line at Hilton Works with annual capacity of 200 000 t, major modifications to the No. 1 bar mill at Hilton Works, modifying the No. 3 electrolytic trimming line that will permit the production of tin-free steel for use in the manufacture of food and beverage containers, and installation of additional equipment for manufacturing bolts, nuts and cold-drawn bars as well as for cleaning and annealing steel rods.

Dominion Foundries and Steel, Limited (Dofasco) is installing a fourth sheet-galvanizing line at its Hamilton plant. The new facilities will cost $45 million and start-up is expected in mid-1981. An expenditure of $350 million was approved for a second hot strip mill in Hamilton. The new mill is expected to be completed in 1983 but its annual capacity of 4.0 million t will not be fully utilized until the company expands its iron-making capacity. A major expansion project to include a fifth blast furnace is under consideration by Dofasco.

TABLE 4. PRODUCER SHIPMENTS[1] OF ROLLED STEEL[2], 1978 AND 1979

	1978	1979	Growth
	(tonnes)		(%)
Ingots and semis	609.6	500.2	-17.9
Rails	263.7	345.6	+31.1
Wire rods	998.0	1 141.1	+14.3
Structural shapes	1 004.0	1 043.3	+3.9
Concrete reinforcing bar	574.6	529.9	-7.8
Other hot-rolled bars	1 143.3	1 219.0	+6.6
Track material	63.8	71.7	+12.4
Plate	1 484.3	1 700.7	+14.6
Hot-rolled sheet and strip	2 579.9	2 640.7	+2.4
Cold finished bars	98.8	118.6	+20.0
Cold reduced sheet, strip, other and coated	1 809.6	1 853.7	+2.4
Galvanized sheet and strip	1 062.9	1 065.2	+0.2
Total	11 692.5	12 229.7	+4.6
Alloy steel in total shipments	947.8	1 062.5	+12.1

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.



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)

Non-integrated 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)

Non-integrated 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)

The Algoma Steel Corporation, Limited (Algoma) of Sault Ste. Marie, Ontario, completed construction in 1979 of a new $57 million slab-casting facility at the main works and a $19 million expansion of heat-treating facilities at its tube division. Work was under way at year-end on a new $24 million heat treating line to produce quenched, tempered, and normalized plate. A total of $49 million will be spent to upgrade the company's 267-mm wide mill to increase production of both plate and hot rolled sheet steel. The rail and structural mills are being upgraded and the capacity to produce wide flange beams and other heavy structurals is being increased by 20 per cent.

Interprovincial Steel and Pipe Corporation Ltd. (Ipsco) is completing a $45 million expansion of its rolling mill at Regina, Saskatchewan that will increase annual rolling capacity from 480 000 t to 750 000 t. Ipsco intends to spend another $35 million to increase melting capacity from 540 000 tpy to 750 000 tpy. Also, the company has made modifications at its spiral pipe-making facilities. The building of the Alaska pipeline and increased activity in the oil and gas industry are expected to lead to new orders for both line pipe and gathering lines.

The Government of Quebec announced a $150 million program for Sidbec-Dosco Limited (Sidbec). Some $30 million will be spent to pay back the Province's Department of Finance for advances toward the purchase of QSP Ltd. (Questeel) assets; $85 million for restarting the second steelmaking furnace at Questeel, and for repairs at its Contrecoeur hot rolling mill and Montreal tube mill; and $35 million to cover the deficit on operations expected for 1979. The long-term development plans at Sidbec have been shelved temporarily because of forecasts of a recession for the United States in 1980.

Lake Ontario Steel Company Limited (Lasco) of Whitby, Ontario plans to double annual steel capacity to 700 000 t by late 1980. The company is also expanding its product line of light structurals and bars to include both larger and smaller sizes.

TABLE 5. DISPOSITION OF ROLLED STEEL PRODUCTS[1], 1978 AND 1979

	1978	1979	Growth 1978/1979
	(tonnes)		(%)
Wholesalers, warehouses and steel service centres	1 809 125	1 994 139	+10.2
Automotive vehicles and parts	1 815 714	1 685 991	-7.1
Agricultural equipment	163 182	223 803	+37.1
Contractors products	616 712	601 888	-2.4
Metal building systems	76 473	87 472	+14.4
Structural steel fabricators	1 002 854	1 029 588	+2.7
Containers	592 824	627 030	+5.8
Machinery and tools	350 932	381 434	+8.7
Wire, wire products and fasteners	763 575	859 332	+12.5
Natural resources and extractive industries	206 433	253 907	+23.0
Appliances and utensils	158 682	157 359	-0.8
Stamping, pressing and coating	479 836	532 945	+11.1
Railway operating	188 012	275 494	+46.5
Railroad cars and locomotives	122 431	228 260	+86.4
Shipbuilding	27 660	29 020	+4.9
Pipes and tubes	1 435 110	1 605 259	+11.9
Miscellaneous	54 215	47 697	-12.0
Total domestic shipments	9 863 770	10 620 618	+7.7
Producer exports[2]	1 828 733	1 609 098	-12.0
Total producer shipments	11 692 503	12 229 716	+4.6

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 2.267 and 2.117 million t in 1978 and 1979, respectively.

Burlington Steel Division of Slater Steel Industries Limited of Hamilton concluded a $4 million program to upgrade its bar mill facilities for the production of special bar quality products.

There was no major investment at Sydney Steel Corporation (Sysco) of Sydney, Nova Scotia during 1979. However, rationalization plans are being studied by both the federal and Nova Scotia governments because of the continuing need to replace old and outmoded facilities. Proposals put forward include: the closure of Sysco; a two-blast-furnace operation with new Q-BOPS; renovation of one blast furnace and the existing open hearth furnaces; and an electric furnace and rail mill operation.

Steel imports continued to be monitored by the federal government. However, strong domestic demand and the low value of the Canadian dollar largely eliminated concerns of injurious dumping for many steel products and the emphasis has since been placed on improving the quality of import documentation. Various measures are under consideration to ensure that importers and brokers provide customs officials with accurate documents.

PRICES

The demand for most steel products was strong and as the result of increased costs of materials, labour and energy, prices increased. At year-end some typical mill product prices per t fob steel plant were: hot-rolled sheet, $350 ($330 at year-end 1978); cold-rolled sheet, $420 ($380); galvanized sheet, $485 ($440); tinplate, $590 ($560); steel plate, $380 ($340); large structurals, $360 ($310) and basic pig iron, $235 ($205).

Scrap prices were very volatile in 1979. The composite price for No. 1 heavy melting steel scrap in the United States increased steadily from $U.S. 88 per t in January to $U.S. 126 in March, declined steadily to a level of $94 in May, and moved up again to $108 in June. For the last six months of 1979 scrap prices ranged from $108 to $86.

Prices for iron ore and coal both increased during 1979. As a result of higher costs for labour, energy and transportation, the Lake Erie base price of iron ore pellets increased 11.3 per cent from ¢U.S. 59.9 a natural iron unit to ¢U.S. 66.7. United States medium-volatile bituminous coal was selling on a long-term contract basis at $68 per t cif Ontario steel mills at the end of 1979 compared with $66 at the end of 1978.

TRADE

Total exports of rolled steel declined 6.6 per cent to 2.12 million t, reflecting the 9.2 per cent decrease to 1 298 838 t (by producers of rolled steel) to the U.S. and the 22 per cent decrease to 310 260 t to other countries. The values of exports increased 18.5 per cent to $1.40 billion. Semi finished steel exports (castings, ingots, blooms, billets and slabs) decreased 48.7 per cent to 155 400 t from 302 900 t in 1978. Finished steel exports (hot and cold rolled products) increased slightly by 0.4 per cent to 1 996 300 t; steel castings, rails, wire rods, structurals, bars and plate exports increased, while ingots, semis, leach material, hot rolled sheet and strip, cold rolled bars, sheet and strip, and galvanized product exports decreased. Fabricated steel product exports increased 12.6 per cent to 545 400 t.

Imports of rolled steel rose by 45.3 per cent to 1.82 million t with value increasing to $1.48 billion. Imports from the United States increased 49.3 per cent to 914 600 t, from the EEC by 40.8 per cent to 621 300 t, while imports from Japan decreased 4.1 per cent to 364 600 t. Most product line imports showed increases with only rails, wire rods and pipe showing decreases.

WORLD REVIEW

In 1979 crude steel production in the world increased 4.2 per cent to the record level of 746 million t. In the developing countries of Latin America, Africa, the Middle East and Asia, the production of crude steel increased more than 10 per cent over that of 1978. In the United States crude steel production decreased by 0.6 per cent. Production increased 9.4 per cent in Japan and 5.5 per cent in the EEC countries while it decreased slightly, 0.7 per cent, in the socialist countries of eastern Europe.

The EEC anti-crisis measures during the Davignon Plan were in effect during 1979. These measures included bilateral arrangements with most of the third country trading partners for steel imports into the European community. The guide-line minimum prices that were established for the European community remained unchanged until late 1979 and the list prices of the steel companies changed very little. The prices for reinforcing bars and merchant bars remained strong while the prices for flat products were weaker, reflecting the over-supply of these products.

The Trigger Price Mechanism was in effect in the United States during 1979 and had a bearing on the decrease in imports, which dropped 17.1 per cent to 15.9 million t. In the last half of the year demand for steel softened, especially for flat products, and pricing became more competitive in the shrinking market.

TABLE 6. CANADA, TRADE IN STEEL BY PRODUCT[1], 1977-79

	Imports			Exports		
	1977	1978	1979P	1977	1978	1979P
	(000 tonnes)					
1. Steel castings (including grinding balls)	21.6	16.1	16.0	16.9	23.4	34.7
2. Ingots	52.2	37.4	72.2	88.8	34.2	20.0
3. Semi-finished steel blooms, billets, slabs	9.2	17.2	108.0	151.0	245.3	100.7
4. Total (1+2+3)	83.0	70.7	196.2	256.7	302.9	155.4
5. Finished steel						
A) Hot-rolled						
Rails	19.8	22.6	15.9	122.5	178.0	221.5
Wire rods	176.4	190.3	166.3	195.3	312.9	354.0
Structurals	225.9	151.5	275.9	207.0	323.9	334.0
Bars	106.1	109.1	113.9	83.8	137.4	154.8
Track material	6.5	5.1	4.7	15.1	17.5	11.6
Plate	229.0	283.8	438.7	226.6	275.2	303.5
Sheet and strip	117.7	182.6	283.7	269.9	259.8	218.9
Total hot-rolled	881.4	945.0	1 299.1	1 120.2	1 504.7	1 598.3
B) Cold-rolled						
Bars	19.0	19.5	20.5	11.3	13.6	11.4
Sheet and strip	52.1	66.8	76.1	55.5	86.1	49.5
Galvanized	42.4	53.1	89.2	154.0	192.4	148.7
Other[1]	111.3	112.0	152.3	179.8	190.4	188.4
Total cold-rolled	224.8	251.4	338.1	400.6	482.5	398.0
6. Total finished steel (A+B)	1 106.2	1 196.4	1 637.2	1 520.8	1 987.2	1 996.3
7. Total rolled steel (2+3+6)	1 167.6	1 251.0	1 817.4	1 760.6	2 266.7	2 117.0
8. Total steel (4+6)	1 189.2	1 267.1	1 833.4	1 777.5	2 290.1	2 151.7
9. Total steel (raw steel equivalent)[2]	1 520.0	1 624.6	2 322.4	2 231.8	2 883.7	2 748.0
10. Fabricated steel products						
Steel forgings	7.6	9.3	9.5	42.2	40.7	45.8
Pipe	203.9	317.1	284.4	263.1	359.0	415.5
Wire	88.7	72.4	82.1	63.6	84.5	84.1
11. Total fabricated	300.2	398.8	376.0	368.9	484.2	545.4
12. Total castings, rolled steel and fabricated (8+11)	1 489.4	1 665.9	2 209.4	2 146.4	2 774.3	2 697.1

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).
P Preliminary.

TABLE 7. CANADA, VALUE[1] OF TRADE IN STEEL CASTINGS, INGOTS, ROLLED AND FABRICATED PRODUCTS, 1977-79

	Imports			Exports		
	1977	1978	1979P	1977	1978	1979P
			($000)			
Steel castings	21,833	18,465	33,627	13,724	19,714	32,685
Steel forgings	17,459	20,749	33,146	56,960	60,681	75,200
Steel ingots	8,643	7,190	19,200	11,871	5,862	4,562
Rolled products						
Semis	4,455	8,913	39,562	26,852	52,024	26,145
Other	460,596	589,557	962,170	515,060	763,323	903,736
Fabricated						
Pipe and tube	169,802	267,540	310,334	146,778	215,783	283,777
Wire	71,002	60,100	82,627	43,453	61,204	70,584
Total steel	753,790	972,514	1,480,666	814,698	1,178,591	1,396,689

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, 1977-79

	Imports			Exports		
	1977	1978	1979P	1977	1978	1979P
			(000 tonnes)			
United States	492.0	612.5	914.6	1 781.8	2 212.6	2 240.4
ECSC[2] countries	382.2	441.3	621.3	98.6	110.3	136.2
Japan	393.0	380.1	364.6	0.1	0.2	6.1
Other	222.2	232.0	308.9	265.9	451.2	314.4
Total	1 489.4	1 665.9	2 209.4	2 146.4	2 774.3	2 697.1

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, West Germany).
P Preliminary.

OUTLOOK

Steel demand is expected to decline in 1980 in the United States, Japan and western Europe. For this reason world steel prices will not fully reflect the sharp increases in energy, labour and raw material costs. Scrap prices also are forecast to decline.

In Canada, the short-term outlook depends in large measure on the depth and duration of the recession now under way in the U.S., which is a large export market for Canadian steel and steel-containing products. The consumption of steel by the auto parts industry will be particularly affected by the recession because the Canadian and U.S. auto industries are interlocked, and the decrease in car and truck sales in the United States will affect Canadian steel sales. If interest rates decline in Canada during the first quarter of 1980 and if investment plans are not delayed or postponed, the effects of the recession in the United States should be cushioned by increased investments in Canada.

In the longer-term, steel-intensive energy developments in Canada (oil and gas pipelines, oil sands plants, hydro projects, etc.) should keep domestic demand for steel strong.

As the Canadian dollar is expected to remain below parity with the U.S. dollar during the early part of the 1980s, exports should continue strong. However, some measures are expected to be undertaken by the United States to protect its steel industry.

Although steel production is increasing sharply in Latin America, Africa, the Middle East and Asia, consumption is also increasing at an equal rate. For this reason, steel trade from the developing countries is not expected to increase substantially in the near future.

TABLE 9. WORLD RAW STEEL PRODUCTION 1978 AND 1979

	1978	1979P
	(million tonnes)	
U.S.S.R.	151.4	149.5
United States	124.0	122.9
Japan	102.1	111.6
West Germany	41.3	46.3
People's Republic of China	31.8	34.0
Italy	24.3	24.1
France	22.8	23.4
United Kingdom	20.3	21.6
Poland	19.3	19.4
Canada	14.9	16.2
Czechoslovakia	15.3	15.1
Brazil	12.2	13.9
Belgium	12.6	13.3
Romania	11.8	12.7
Spain	11.3	12.1
India	10.1	9.4
South Africa	7.9	8.9
Australia	7.6	8.1
Republic of Korea	5.0	7.6
Mexico	6.7	7.0
German Democratic Republic (East Germany)	7.0	7.0
Netherlands	5.6	5.8
Democratic Republic of Korea (North Korea)	5.1	5.3
Luxembourg	4.8	5.0
Austria	4.3	4.9
Sweden	4.3	4.7
Taiwan	3.4	4.3
Hungary	3.9	3.8
Yugoslavia	3.5	3.5
Argentina	2.8	3.2
Bulgaria	2.5	2.5
Finland	2.3	2.4
Turkey	2.2	2.4
Others	10.9	13.3
Total	715.3	745.3

Source: International Iron and Steel Institute.
P Preliminary.

TABLE 10. CANADIAN CRUDE STEEL SUPPLY AND DEMAND, 1965, 1970, 1975-79

	Crude steel production	Imports[1]		Exports[1]		Indicated consumption[2]	
		A[3]	B[4]	A[3]	B[4]	A	B
				(000 tonnes)			
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	1 520	2 031	2 232	2 767	12 919	12 895
1978	14 898	1 625	2 271	2 884	3 581	13 639	13 588
1979p	16 078	2 322	2 963	2 748	3 534	15 652	15 507

Source: Statistics Canada.
[1] Trade of Canada, adjusted to equivalent crude steel by Energy, Mines and Resources, Canada. [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, 1977-79

		1977		1978		1979p	
		World	U.S.	World	U.S.	World	U.S.
Newfoundland	tonnes	3 802	-	168	168	-	-
	$000	168	-	16	16	-	-
Nova Scotia	tonnes	388	388	940	486	133	64
	$000	46	46	196	107	64	17
New Brunswick	tonnes	56	56	118	118	46	3
	$000	6	6	13	13	10	...
Quebec	tonnes	135 019	18 370	225 949	18 195	299 499	14 543
	$000	10,151	1,769	16,479	1,480	38,830	1,713
Ontario	tonnes	347 195	325 975	381 756	349 908	402 257	378 022
	$000	19,075	17,040	28,334	23,874	35,594	32,587
Manitoba	tonnes	3 310	3 310	2 761	2 761	9 940	9 866
	$000	350	350	346	346	1,412	1,399
Saskatchewan	tonnes	377	377	18	18	699	699
	$000	45	45	8	8	153	153
Alberta	tonnes	1 094	880	1 524	1 504	5 317	5 153
	$ 000	59	40	121	118	581	537
British Columbia	tonnes	79 696	79 381	94 930	92 282	139 354	134 532
	$000	4,429	4,321	6,889	6,487	12,210	11,570
Yukon	tonnes	204	204	-	-	-	-
	$000	18	18	-	-	-	-
Canada Total	tonnes	571 141	428 941	708 164	465 440	857 244	542 882
	$000	34,347	23,635	52,402	32,449	88,855	47,976

Source: Statistics Canada.
p Preliminary; - Nil; ... Less than $500.

TABLE 12. CANADA, IMPORTS OF STEEL SCRAP BY PROVINCE, 1977-79

		1977		1978		1979P	
		World	U.S.	World	U.S.	World	U.S.
Nova Scotia	tonnes	-	-	152	152	-	-
	$000	-	-	9	9	-	-
New Brunswick	tonnes	331	331	434	434	1 442	1 442
	$000	15	15	43	43	116	116
Quebec	tonnes	44 866	44 866	64 267	64 263	52 313	52 309
	$000	2,538	2,538	3,336	3,296	5,187	5,187
Ontario	tonnes	180 064	179 876	277 606	277 399	343 721	343 099
	$000	8,762	8,729	17,857	17,792	31,862	31,814
Manitoba	tonnes	7 287	7 287	85 981	85 981	90 222	90 222
	$000	174	174	4,730	4,730	8,271	8,271
Saskatchewan	tonnes	112 734	112 734	155 407	155 407	177 626	177 626
	$000	6,717	6,717	9,690	9,690	16,950	16,950
Alberta	tonnes	1 433	1 433	81 864	81 864	69 510	69 510
	$ 000	47	47	3,722	3,722	6,096	6,096
British Columbia	tonnes	868	830	2 272	2 249	2 677	1 908
	$000	98	98	158	156	256	204
Canada Total	tonnes	347 583	347 357	667 983	667 749	737 511	736 116
	$000	18,351	18,318	39,545	39,438	68,738	68,638

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 13. CANADA, EXPORTS OF STAINLESS STEEL SCRAP BY PROVINCE OF LADING, 1977-79

		1977		1978		1979P	
		World	U.S.	World	U.S.	World	U.S.
Nova Scotia	tonnes	97	65	678	480	243	14
	$000	48	30	281	131	178	10
Prince Edward	tonnes	-	-	17	17	-	-
Island	$000	-	-	13	13	-	-
New Brunswick	tonnes	170	19	233	115	618	-
	$000	88	14	136	62	260	-
Quebec	tonnes	4 955	3 267	6 497	4 300	6 693	3 211
	$000	2,987	1,993	2,415	1,452	5,400	2,296
Ontario	tonnes	11 714	9 704	10 463	9 087	15 539	10 264
	$000	5,864	4,779	4,779	4,120	7,638	4,946
Manitoba	tonnes	241	241	202	202	30	30
	$000	136	136	70	70	23	23
Saskatchewan	tonnes	72	72	-	-	-	-
	$000	42	42	-	-	-	-
Alberta	tonnes	123	123	74	74	215	215
	$ 000	59	59	76	76	145	145
British Columbia	tonnes	1 187	679	2 743	2 375	4 082	3 601
	$000	461	182	1,118	860	1,332	998
Canada Total	tonnes	18 559	14 170	20 907	16 650	27 420	17 335
	$000	9,685	7,235	8,888	6,784	14,976	8,418

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 14. CANADA, ROLLED STEEL SUPPLY AND DEMAND, 1976-79

	Producer or Mill Shipments[1]	Exports[2]	Imports[3]	Apparent Rolled Steel Consumption[4]	Raw Steel Production[5]
			(000 tonnes)		
1976	9 821	1 448	1 052	9 425	13 290
1977	10 327	1 761	1 168	9 734	13 631
1978	11 693	2 267	1 251	10 677	14 898
1979P	12 230	2 117	1 817	11 930	16 078
% change 1979/1978	+4.6	-6.6	+45.2	+11.7	+7.9

Source: Statistics 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 157 000 t in 1976, 134 000 t in 1977, 157 000 t in 1978, and 200 000 t in 1979. [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 166 526 t in 1976, 149 099 t in 1977, 170 493 t in 1978 and 223 353 t in 1979.
P Preliminary.

Lead

J.J. HOGAN AND M.J. GAUVIN

The lead market was strong for most of 1979, weakening somewhat in the final two months of the year. Lead supply was affected by shortage of concentrates, cut-backs in zinc production which affected lead-zinc mines, and sales of metal and concentrates to the U.S.S.R. The price reacted to these factors and established new highs.

CANADIAN DEVELOPMENTS

Canada's production of lead in all forms was 315 751 tonnes (t) in 1979, slightly below the 319 809 t produced in 1978. The value of production was $414,416,000, up by more than 59 per cent over the 1978 value. Mine production decreased 6.7 per cent to 341 115 t and primary refined production decreased 5.3 per cent to 183 769 t. Capacity utilization in the smelting and refining sector was 84.7 per cent.

Exports of lead contained in ores and concentrates increased 6.2 per cent to 151 487 t in 1979. Shipments to Japan by weight amounted to 48 per cent of the total, to the United States, 24 per cent, and to West Germany, 12 per cent. Exports of refined metal, which totalled 117 994 t, fell 10.6 per cent from those in 1978, with 52 per cent going to the United States and 32 per cent to the United Kingdom. Scrap exports increased 24 per cent to 21 864 t, with 26 per cent of the total going to the United States market, 27 per cent to West Germany and 19 per cent to Sweden.

Data on imports of lead in concentrates have not been available since 1977. Imports of lead pigs, blocks and shot were 2 133 t in 1979 compared with 1 715 t in 1978.

Lead consumption in Canada, including primary and secondary metal, was 100 762 t in 1979, 5.8 per cent lower than in the previous year. Batteries and battery oxides consumed over 51 per cent of the total.

MINE PRODUCTION

Canada

Newfoundland. ASARCO Incorporated operates the province's sole lead producer, the Buchans Mine, located in central Newfoundland. Output in 1979 was 32 per cent lower than the previous year. Remaining ore reserves at the mine are limited.

Nova Scotia. Two new lead producers commenced production in Nova Scotia, the first in the province to be opened solely for metals since 1951.

The Yava lead mine of Barymin Explorations Limited, near Sydney on Cape Breton Island, came into production in May. In 1979 the mill operated well below its capacity of 550 tpd. Production is coming from the west zone which contains an estimated 1.1 million t averaging 5.4 per cent lead. It is expected that the mill will be operating at full capacity in 1980. The

Gays River zinc-lead mine of Esso Minerals Canada, 48 kilometres (km) northeast of Halifax, began operations in November. Cost to bring the 1 350 tpd mine into production was approximately $28 million. Reserves are estimated to be 10.8 million t averaging 2.78 per cent lead and 4.23 per cent zinc.

New Brunswick. Lead production in New Brunswick was about 4 per cent higher in 1979 than in the previous year. The $53 million expansion program at the No. 12 mine of Brunswick Mining and Smelting Corporation Limited to increase mine and mill capacity to 10 000 tpd is expected to be completed in 1981. Proven ore reserves at No. 12 at the end of 1979 were 69 million t averaging 9.1 per cent zinc, 3.7 per cent lead, 0.3 per cent copper and 96 grams per tonne (g/t) silver. Reserves at the No. 6 mine are limited and should be exhausted in 1981 or 1982.

On October 1, 1979 Noranda Mines Limited acquired all of the shares of Heath Steele Mines Limited in exchange for all of the stock of Noranda Phosphate, Inc., owner of undeveloped phosphate land in Florida. Heath Steele had a 75 per cent interest in the Little River Joint Venture which operates a lead-zinc-copper-silver mine near Newcastle, New Brunswick. ASARCO acquired the remaining 25 per cent interest in the Little River property held by Inco Limited. Production at this mine in 1979 was slightly higher than in 1978. Proven ore reserves at the end of 1979 were 25 million t averaging 1.18 per cent copper, 1.53 per cent lead, 4.43 per cent zinc and 61 g/t silver.

Quebec. Quebec has been a minor producer of lead. The only lead producer, the Manitou-Barvue division mine of Louvem Mining Company Inc., exhausted its ore reserves and closed in 1979.

Ontario. Ontario is also a minor producer of lead, all production being a byproduct of copper and zinc production. Output increased at two producers, the Sturgeon Lake Joint Venture of Falconbridge Copper Limited and the Geco division of Noranda Mines Limited, and declined at two producers; Mattabi Mines Limited and Texasgulf Canada Ltd. Lead production was 8 619 t in 1979 compared with 7 060 t in 1978.

Reserves of Ontario producers at year-end: were Falconbridge Copper, 0.29 million t grading 1.71 per cent copper, 1.04 per cent lead, 7.17 per cent zinc and 130 g/t silver; Geco 20.3 million t grading 1.86 per cent copper, 0.11 per cent lead, 3.80 per cent zinc and 52 g/t silver; Mattabi, 3.4 million t grading 0.57 per cent copper, 0.77 per cent lead, 6.97 per cent zinc and 100 g/t silver; and Texasgulf, 91.6 million t grading 2.82 per cent copper, 0.18 per cent lead, 5.13 per cent zinc and 66 g/t silver.

The Sturgeon Lake Joint Venture managed by Falconbridge Copper carried out an extensive exploration program on its property with little success. Ore reserves are limited and are expected to be exhausted in late 1980 or early 1981. Mattabi Mines, in which Noranda has a 60 per cent interest, expects to complete its open-pit operation in early 1981 and mill feed will come from underground operations. Noranda's Lyon Lake property is expected to be in operation in the latter part of 1980 and its ore will be treated at the Mattabi mill. Reserves at Lyon Lake are 3.6 million t grading 1.24 per cent copper, 0.63 per cent lead, 6.53 per cent zinc and 117 g/t silver.

Manitoba and Saskatchewan. A small amount of byproduct lead was produced by Hudson Bay Mining and Smelting Co., Limited. Hudson Bay operated nine ore sources in 1979 and only two reported lead concentrate production - Ghost Lake and Chisel Lake. Production was 307 t in 1979 compared with 532 t in 1978.

British Columbia. British Columbia was the largest producer of lead in 1979, based mainly on the lead output from the Sullivan mine of Cominco Ltd., which accounted for over 95 per cent of the total. Lead production in the province was 87 653 t in 1979 compared with 81 065 t in 1978.

Ore reserves at the Sullivan mine at year-end were 49 million t averaging 4.5 per cent lead, 5.9 per cent zinc and 38 g/t silver. Ore reserves at the property of Western Mines Limited were 1.04 million t grading 1.1 per cent copper, 1.0 per cent lead, 8.0 per cent zinc, 116 g/t silver and 2.7 g/t gold. Ore reserves at Northair Mines Ltd. at year-end were 101 742 t grading 2.75 per cent lead, 3.97 per cent zinc, 26.1 g/t silver and 8.1 g/t gold.

TABLE 1. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production				
All forms[1]				
British Columbia	81 965	65,809,200	87 653	115,042,000
Yukon	79 234	64,322,403	82 232	107,928,000
New Brunswick	72 693	59,013,175	75 673	99,319,000
Northwest Territories	70 089	56,898,673	55 191	72,437,000
Ontario	7 060	5,731,508	8 619	11,312,000
Newfoundland	8 887	7,214,909	5 860	7,692,000
Manitoba	532	431,687	307	403,000
Quebec	249	202,286	216	283,000
Total	319 809	259,623,841	315 751	414,416,000
Mine output[2]	365 782		341 115	
Refined production[3]	194 054		183 769	
Exports				
Lead contained in ores and concentrates				
Japan	89 711	35,229,000	72 614	69,730,000
West Germany	14 522	3,950,000	18 955	13,559,000
U.S.S.R.	196	111,000	10 835	10,648,000
United States	22 208	8,087,000	35 981	8,787,000
Italy	3 174	1,138,000	5 521	2,763,000
Other countries	12 872	4,264,000	7 581	4,284,000
Total	142 683	52,779,000	151 487	109,771,000
Lead pigs, blocks and shot				
United States	65 412	50,024,000	61 184	74,963,000
United Kingdom	38 106	27,257,000	38 233	47,621,000
Italy	7 733	4,071,000	6 682	6,407,000
Netherlands	2 166	1,321,000	4 147	5,217,000
Pakistan	1 698	865,000	1 699	1,596,000
Japan	874	632,000	1 164	1,471,000
Other countries	15 962	10,715,000	4 885	5,459,000
Total	131 951	94,885,000	117 994	142,734,000
Lead and alloy scrap (gross weight)				
United States	4 731	2,468,000	5 621	3,946,000
Sweden	3 535	1,554,000	4 235	3,146,000
West Germany	426	100,000	5 878	3,083,000
United Kingdom	141	140,000	772	749,000
South Korea	2 035	588,000	1 639	638,000
Belgium-Luxembourg	49	18,000	814	554,000
Taiwan	1 246	330,000	1 166	470,000
Other countries	5 443	1,876,000	1 739	825,000
Total	17 606	7,074,000	21 864	13,411,000

TABLE 1. (cont'd)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Materials, nes lead-fabricated				
United States	8 375	7,350,000	8 678	10,848,000
United Kingdom	199	163,000	729	917,000
Netherlands	88	22,000	55	84,000
Bangladesh	-	-	47	56,000
Other countries	97	71,000	142	138,000
Total	8 759	7,606,000	9 651	12,043,000
Imports				
Lead pigs, blocks and shot	1 715	1,413,000	2 133	2,655,000
Lead oxide, dioxide and tetroxide	322	402,000	331	525,000
Lead fabricated materials not elsewhere specified	2 270	3,020,000	500	892,000
Lead in concentrates	..	..	..	..
Lead in dross, skimmings and sludge	..	..	..	..
Lead and lead alloy scrap	..	..	..	..

	1978			1979P		
	Primary	Secondary[4]	Total	Primary	Secondary	Total
			(tonnes)			
Consumption						
Lead used for, or in the production of:						
Antimonial lead	1 501r	x	x	1 209	x	x
Battery and battery oxides	45 689	5 990	51 679	44 509	4 729	49 238
Cable covering	x	x	x	x	x	
Chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	15 838	5 912	21 750	14 612	6 556	21 168
Copper alloys; brass, bronze, etc.	119	196	315	302	70	372
Lead alloys:						
solders	1 441	4 411	5 852	1 765	5 780	7 545
others (including babbitt, type metals, etc.)	488	3 407	3 895	306	2 548	2 854
Semi-finished products: pipe, sheet, traps, bends, blocks for caulking, ammunition etc.	2 808r	x	x	2 172	x	x
Other lead products	3 819	9 143	17 271	3 696	9 764	16 841
Total, all categories	71 703	29 059	100 762	68 571	29 447	98 018

Sources: Statistics Canada; Energy, Mines and Resources 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; r Revised; x Confidential but included in "other"; nes Not elsewhere specified.

TABLE 2. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970, 1975-79

	Production		Exports			Imports	
	All forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Refined[3]	Consumption[4]
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	322 791	1 962	89 193
1976	256 324	175 720	140 933	114 421	255 354	1 941	107 654
1977	280 955	187 457	137 820	130 819	268 639	821	106 962
1978	319 809	194 054	142 683	131 951	274 634	1 715	100 762
1979P	315 751	183 769	151 487	117 994	269 481	2 133	..

Sources: Statistics Canada; Energy, Mines and Resources 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; .. Not available.

Yukon Territory. The Yukon Territory was the second-largest lead producer in Canada in 1979, production being 82 232 t compard with 79 234 t in 1978.

In 1979 the Foreign Investment Review Agency approved the November 1978 purchase by Cyprus Anvil Mining Corporation of the Grum, Vangorda and Swim Lake properties from Kerr Addison Mines Limited, Canadian Natural Resources Limited and Vangorda Mines Limited, a 70 per cent-owned subsidiary of Kerr Addision. The purchase price, including buying out the minority Vangorda shareholders, was about $21.7 million. This purchase added considerably to the reserves of Cyprus in the Faro district. Indicated reserves are: Grum, 26.1 million t grading 4.1 per cent lead, 6.4 per cent zinc and 65 g/t silver; Swim Lake, 4.5 million t grading 4.0 per cent lead, 5.5 per cent zinc and 51 g/t silver; and Vangorda, 8.5 million t grading 3.18 per cent lead, 4.96 per cent zinc, 0.27 per cent copper and 60 g/t silver. A feasibility study is under way on the development of these properties and a plan could be decided upon by mid-1980. United Keno Hill Mines Limited produced 2 549 t of lead in 1979 compared with 3 412 t in 1978.

Northwest Territories. Production at Nanisivik Mines Ltd. met targets in 1979 and was slightly higher than the previous year. Lead production at Pine Point Mines Limited declined in 1979 compared to the previous year because lower-grade ore was treated.

In November 1979, Cominco Ltd., the operator for Arvik Mines Ltd., announced its intention to bring the Polaris zinc-lead mine, on Little Cornwallis Island in the Canadian high Arctic, into production at a cost of approximately $150 million. Production is scheduled to begin in 1982 and its 2 000 tpd mill is expected to produce about 30 000 t of lead in concentrates and 100 000 t of zinc in concentrates annually. Estimated ore reserves are 22.7 million t grading 4.3 per cent lead and 14.1 per cent zinc.

Cominco acquired the remaining 25 per cent of the outstanding shares of Arvik Mines Ltd. from Bankeno Mines Limited for $5 million in October, 1979. Under the arrangement, Bankeno has the option to acquire, for $7.5 million, a royalty interest of 25 per cent of the net proceeds of production from the Polaris mine and any other mines on the Arvik properties which are brought into production.

METAL PRODUCTION

Refined lead production in 1979 was 183 769 t, a decline of 5.3 per cent from the previous year.

TABLE 3. (cont'd.)

Company and Location	Mill Capacity (tonnes/ day)	Copper (%)	Lead (%)	Zinc (%)	Silver (grams/ tonne)	Gold (grams/ tonne)	Ore Milled (tonnes)	Lead Concentrates Produced (tonnes)	Lead Concentrates Grade (%)	Lead Concentrates Content (tonnes)	Lead Content All[1] Concentrates (tonnes)	Destination[2] of Concentrates
Ontario (cont'd)												
Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	0.55 (0.83)	0.77 (0.67)	6.91 (6.49)	97.71 (93.26)	0.38 (0.41)	945 015 (871 675)	15 046 (9 696)	27.83 (31.76)	4 187 (3 079)	5 453 (4 333)	2 (3)
Noranda Mines Limited, Geco, Manitouwadge	4 550 (4 550)	1.82 (1.54)	0.11 (0.12)	3.24 (2.19)	58.97 (38.74)	0.10 (0.17)	1 475 841 (1 572 458)	918 (1 003)	56.00 (51.14)	514 (513)	1 485 (1 240)	2 (2,3)
Texasgulf Canada Ltd., Kidd Creek Mine, Timmins	9 050 (9 050)	1.95 (1.62)	0.15 (0.22)	5.47 (6.12)	76.0 (78.9)	- (-)	3 680 858 (3 002 148)	12 460 (18 319)	12.29 (11.37)	1 531 (2 083)	3 649 (4 179)	3 (3)
Manitoba-Saskatchewan												
Hudson Bay Mining and Smelting Co., Limited, Flin Flon concentrator	7 250 (7 250)	2.00 (2.26)	0.17 (0.13)	2.73 (3.16)	19.0 (20.57)	.. (..)	1 253 875 (1 679 001)	463 (942)	56.60 (56.41)	262 (531)	383 (778)	2 (2)
Snow Lake concentrator[4]	3 400	2.87	0.14	3.55	12.3	..	446 947	295	59.32	175	354	2
British Columbia												
Cominco Ltd., Sullivan mine, Kimberley	9 050 (9 050)	- (-)	5.33 (4.64)	3.73 (3.31)	63.77 (62.06)	- (-)	2 047 726 (2 107 876)	155 477 (136 270)	60.98 (62.40)	94 810 (85 033)	100 156 (90 061)	2 (2)
Northair Mines Ltd., Alta Lake	250 (250)	0.50 (0.20)	0.91 (1.30)	1.50 (1.96)	26.33 (70.63)	11.35 (12.14)	91 587 (93 397)	1 759 (2 781)	39.65 (37.49)	697 (1 043)	738 (1 120)	2 (2,3)
Silvana Mines Inc., Silmonac mine, Sandon	100 (100)	- (-)	4.89 (5.81)	4.51 (4.34)	478.63 (508.80)	- (-)	19 625 (15 966)	1 500 (1 460)	60.64 (60.45)	910 (882)	923 (896)	2 (2)
Teck Corporation, Beaverdell	100 (100)	- (-)	0.28 (0.35)	0.63 (0.60)	320.23 (323.66)	- (0.17)	33 662 (35 280)	317 (439)	22.74 (20.46)	72 (90)	92 (112)	2 (2)

Western Mines Limited,	900	1.32	1.37	8.45	131.31	2.91	266 877	6 635	43.04	2 856	3 398	2
Lynx and Myra Falls mines, Buttle Lake	(900)	(1.25)	(1.33)	(8.24)	(139.89)	(2.85)	(269 035)	(6 635)	(43.05)	(2 856)	(3 417)	(2)
Yukon Territory												
Cyprus Anvil Mining	9 050	-	3.26	5.28	25.03	0.10	2 823 031	146 120	52.72	77 034	81 032	4,5,8
Corporation, Faro	(9 050)	(0.20)	(3.17)	(5.14)	(19.89)	(0.14)	(3 280 660)	(167 258)	(52.48)	(87 773)	(92 454)	(3,4,5,7,8)
United Keno Hill	450	-	3.00	-	818.40	-	112 783	5 715	45.00	2 572	2 572	3
Mines Limited, Elsa	(450)	(-)	(5.50)	(0.79)	(1224.69)	(-)	(81 721)	(6 931)	(49.76)	(3 449)	(3 449)	(3)
Northwest Territories												
Nanisivik Mines Ltd.,	2 200	-	1.39	12.92	66.17	-	615 459	12 591	60.73	7 646	8 206	5,8
Baffin Island	(2 200)	(-)	(1.44)	(13.24)	(61.71)	(-)	(574 314)	(11 507)	(62.91)	(7 239)	(7 868)	(5,6)
Pine Point Mines	9 050	-	1.91	5.48	-	-	2 985 536	67 014	73.67	49 369	53 965	2,3,4,8
Limited, Pine Point	(9 050)	(-)	(2.62)	(5.91)	(-)	(-)	(2 985 072)	(90 673)	(76.50)	(69 365)	(74 237)	(2,3,4,5,8)

Source: Data provided by companies to Energy, Mines and Resources Canada.

[1] Includes lead in zinc, copper, silver and bulk concentrates. [2] Destination: (1) Brunswick Mining and Smelting Corporation Limited, (2) Cominco Ltd., (3) U.S., (4) Japan, (5) Germany, (6) Belgium, (7) United Kingdom, (8) others. [3] Came into production in 1979. [4] Began operating in 1979 to treat ores from mines in Snow Lake area.
- Nil; .. Not available.

TABLE 4. PROSPECTIVE CANADIAN LEAD PRODUCING MINES

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Zinc	Lead	Copper	Silver	Remarks
Ontario								
Noranda Mines Limited, Lyon Lake Division, Sturgeon Lake	1980	900	3 579 000	6.53	0.63	1.24	117.2	Ore to be treated at Mattabi mill.
Noranda Mines Limited, "F" Group mine, Sturgeon Lake	1981	..	572 000	8.10	0.49	0.98	61.70	Ore to be treated at Mattabi mill.
Yukon Territory								
Hudson Bay Mining and Smelting Co., Limited, Tom claims, MacMillan Pass, Canol Road	..	..	7 800 000	8.4	8.2	-	94.0	Further exploratory work being done.
Northwest Territories								
Arvik Mines Ltd., Little Cornwallis Island	1985	2 000	22 700 000	14.10	4.10	-	..	Controlled by Cominco Ltd. Decision on mining under discussion with federal government.

Source: Company reports and technical papers.
- Nil; .. Not available.

Lead recovered by domestic secondary lead smelters is a significant portion of total Canadian lead production. Statistical data on lead output from this source are not available but it is believed to amount to about 35 to 40 per cent of primary production.

The 40 000 tpy secondary lead smelter of Ballast Metals Canada Inc. near Montreal came into operation late in 1979. This company is jointly owned by Preussag AG of West Germany and the Singerman Group. Including this plant, the capacity of secondary lead smelters in Canada is approximately 126 000 t.

DOMESTIC CONSUMPTION

Consumption of both primary and secondary lead in 1979 was estimated at 68 571 t and 29 447 t, respectively, for a total consumption of 98 018 t. Consumption in 1978 was 100 762 t.

Canadian consumption of lead has doubled since 1950. The most spectacular growth has been in battery production and in chemical uses. However, the use of lead in batteries was down in 1979 because of reduced demand by the auto industry. The production of nonleaded gas for use in automobiles equipped with emission control devices has sharply reduced the use of tetraethyl lead in gasoline. Little published data are available on lead consumption in Canada but trends are similar to those in the United States and most other industrial countries.

WORLD INDUSTRY

World lead mine production over the past three years has been stable. According to the International Lead and Zinc Study Group (ILZSG) mine production was 2.510 million t in 1979 and 2.513 million t in 1978. Metal production was 3.970 million t in 1979 compared with 3.922 million t in 1978. Lead consumption was 3.936 million t in 1979 compared with 3.961 million t in 1978. With net trade of refined metal with socialist countries totalling 207 000 t, the balance betweeen production and consumption shows a statistical shortfall of 99 000 t. Producers stocks at the end of 1979 were 178 200 t, compared with 148 000 at the end of 1978. Stocks on the London Metal Exchange at the end of 1979 were 17 500 t, an increase of 1 500 t over the previous year.

TABLE 5. UNITED STATES CONSUMPTION OF LEAD BY END-USE, 1978 AND 1978

	1978	1979P
	(tonnes)	
Storage batteries	879 274	647 243
Gasoline antiknock additives	178 331	186 945
Solder, type metal, terne metal and bearing metals	92 473	60 820
Pigments	91 642	82 789
Ammunition - shot and bullets	55 776	52 882
Sheet and pipe	23 105	9 489
Cable covering	13 851	15 662
Caulking	9 909	4 055
Other uses	88 383	49 418
Total reported[1]	1 432 744	1 109 263
Estimated indistributed consumption	-	194 337
Grand Total	1 432 744	1 303 600

Source: United States Bureau of Mines, Mineral Industry Surveys, **Lead Industry in December 1979.**

[1] Includes lead content of scrap used directly in fabricated products.

P Preliminary; - Nil.

The net addition to world mine capacity for lead was 57 000 tpy in 1979, with five new mines and an expansion at an existing mine, and two closures. The new mines are located in Argentina with 1 000 t annual production; Canada, 22 000 t; Japan, 4 000 t; Spain, 21 000 t and Thailand, 12 000 t. The closures were in Japan, 1 000 t; and the United States, 2 000 t.

Lead smelter annual capacity rose by 105 000 t in 1979, with three new secondary smelters coming on stream and an expansion at another. In the United States a new plant of 30 000 t annual capacity was built, and an expansion at a second plant increased its capacity by 30 000 t. In Canada a 40 000 t secondary smelter was completed in the Province of Quebec, and in Australia a new 12 000 t secondary smelter replaced a 7 000 t smelter.

TABLE 6. NON-COMMUNIST WORLD MINE PRODUCTION OF LEAD, 1978 AND 1979

	1978	1979P
	(000 tonnes)	
United States	542	532
Australia	380	390
Canada	366	341
Peru	183	185
Mexico	164	165
Yugoslavia	110	120
Morocco	110	102
Sweden	82	84
Spain	72	72
Ireland	47	70
Japan	57	48
South Africa, Republic of	38	41
West Germany	32	34
Denmark	31	32
Argentina	31	31
France	33	30
Brazil	26	30
Other countries	209	203
Total	2 513	2 510

Sources: Energy, Mines and Resources Canada; International Lead and Zinc Study Group, Monthly Bulletin, February, 1980.

P Preliminary.

TABLE 7. NON-COMMUNIST WORLD PRODUCTION[1] OF REFINED LEAD, 1978 AND 1979

	1978	1979P
	(000 tonnes)	
United States	1 188	1 175
United Kingdom	346	359
West Germany	305	314
Australia	239	254
Japan	228	221
France	208	215
Mexico	209	209
Canada	194	184
Spain	120	128
Italy	116	122
Yugoslavia	121	120
Belgium	104	92
Brazil	85	88
Peru	74	83
South Africa, Republic of	63	65
Other countries	322	341
Total	3 922	3 970

Sources: Energy, Mines and Resources Canada; International Lead and Zinc Study Group, Monthly Bulletin, February, 1980.

[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.

United States. Mine production of lead in 1979 declined for the fifth successive year to 532 000 t, 1.8 per cent below the 1978 total. This was largely due to a labour strike at Ozark Lead Company in Missouri, a subsidiary of Kennecott Copper Corporation, and curtailment of output at some lead-zinc mines because of high zinc inventories. Metal production and consumption were also lower, the former by 1.8 per cent to 1 180 000 t, and the latter by 7.6 per cent to 1 239 000 t. Reduced consumption was mainly the result of lower demand by the lead storage battery industry. Lead use was also lower in solder, type metal, bearing metals, sheet and pipe.

Lead from secondary sources plays an important role in supplying the United States market. Over 52 per cent of lead production in 1979 was of secondary origin. In 1979 ESB Ray-O-Vac Corporation, a unit of Inco Limited, purchased a plant in Newstead, New York from AMAX Inc. and plans to turn it into a 32 000 tpy secondary lead smelter to supply its battery manufacturing plants. ESB also purchased a 18 000 tpy secondary smelter in Beech Grove, Indiana from N L Industries, Inc. The latter company sold several of its secondary lead smelters in 1979.

Ozark Lead Company will spend $25 million to expand its underground mine and surface facilities in Missouri. The program is scheduled for completion in 1981 and will increase capacity by 30 per cent to approximately 82 000 t of contained lead annually, about 16 per cent of the nation's primary lead production.

TABLE 8. NON-COMMUNIST WORLD CONSUMPTION[1] OF REFINED LEAD, 1978 AND 1979

	1978	1979P
	(000 tonnes)	
United States	1 188	1 169
West Germany	369	382
United Kingdom	346	368
Australia	239	254
Japan	228	221
France	208	215
Mexico	209	209
Canada	194	184
Spain	120	128
Italy	116	122
Yugoslavia	121	111
Brazil	85	88
Other countries	538	485
Total	3 961	3 936

Source: International Lead and Zinc Study Group, Monthly Bulletin, April, 1980.

[1] Consumption of those types of metal as reported under "production" in Table 7.

P Preliminary.

Several regulatory matters in the United States have affected the lead industry in recent years. Late in 1978 the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) introduced stringent regulations regarding lead in air 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. The OSHA regulations limit worker exposure to airborne lead at the workplace to a level of 50 micrograms per m^3 on an eight-hour, time-weighted basis. Industry will have several years in which to meet the new levels. The Lead Industries Association (LIA) challenged the EPA and OSHA standards in the courts but at year-end no decision had been given.

Europe. Mine production in the nine EEC member countries in 1979 was 195 000 t compared with 175 000 t in 1978. Strikes hampered production in Ireland in 1978. Metal production was 1 238 000 t in 1979, an increase of 2.7 per cent over the previous year. Consumption increased by 2.9 per cent to 1 309 000 t.

Japan. Mine production of lead in Japan was 47 000 t in 1979 compared with 57 000 t in 1978, while metal production was 221 000 t compared with 228 000 t in 1978. Lead consumption remained unchanged at 267 000 t. The large supply deficit between mine and metal production was made up largely by imports of concentrates from the Yukon Territory and the Northwest Territories. The Ezuri lead-zinc-copper-silver mine of Dowa Mining Co., Ltd. came into production in October. Annual output has been estimated at about 4 000 t. Reserves are estimated to be 3 million t averaging 3.3 per cent lead, 10.1 per cent zinc, 0.89 per cent copper and 180 g/t silver.

PRICES

The lead price in 1979 was erratic (Table 9). In the United States the lead price opened the year at 38 cents a pound, rose to 40 cents early in January, 42 cents in mid-January, 44 cents in early February, 48 cents in mid-March, 54 cents toward the end of May and to 62 cents early in July. Factors affecting the price were reduced London Metal Exchange (LME) stocks, increased European buying, reduced mine production, higher demand for lead batteries and purchasing by the U.S.S.R. Declining LME prices then forced a reduction in U.S. producer prices in early February to 61 cents and then 58 cents within two days early in July. Subsequent attempts to raise the U.S. price were generally unsuccessful: the price rose to 60 cents in late July, fell to 56 cents in August, rose to 67 cents in late September and then fell steadily to 63 cents on October 1, to 57 cents on October 31 and finally to 55 cents on December 15.

The Canadian lead price followed the U.S. price, the difference being the exchange rate differential. The monthly average LME spot price averaged ¢U.S. 44.97 per pound (£494.4 per t) in January 1979, rose to a high of 62.63 cents per pound (£653.75 per t) in June, and then fell to 53.33 cents per pound (£534.3 per t) in December.

TABLE 9. LEAD METAL PRICES, 1979

Month	London Metal Exchange Spot	United States Domestic Delivered Price	Canada Delivered Carlots
	£ per tonne	¢ per pound	¢ per pound
January	494.8	40.8	46.55
February	526.3	43.3	49.30
March	577.5	45.7	52.45
April	559.7	48.0	54.50
May	601.9	48.8	55.10
June	654.4	56.5	61.71
July	562.9	58.1	66.00
August	542.3	57.9	66.00
September	560.3	58.0	66.00
October	615.2	61.1	71.00
November	572.9	57.3	65.00
December	534.9	55.9	64.21
1979 Average	567.7	52.6	59.79
1978 Average	342.8	33.7	36.80

Source: International Lead and Zinc Study Group, Monthly Bulletin, February 1980.

OUTLOOK

According to the International Lead and Zinc Study Group, annual new lead mine capacity coming on stream in 1980 will be approximately 100 000 t. The major addition will be from the Black Mountain Mineral Development Company Limited mine in the Republic of South Africa. The mine began production in late 1979 but its output will be reflected in 1980 production figures. In 1981 new additions to production capacity will total about 95 000 t, coming mainly from Canada, Mexico, the United States and Australia.

Lead from secondary sources, new production coming on stream in 1980 and 1981, and new mines that are expected to come into production between 1982-84, should ensure an ample lead supply in the short to medium term. No major mine closures are indicated. According to plans, primary and secondary lead smelting capacity will be increased during this period, primary smelters by approximately 116 000 t and secondary smelters by 141 000 t.

Lead use in tetraethyl lead additives to gasoline will continue to decline but the loss in this application should be offset by increased use of lead in batteries, especially in industrial-type batteries for fork-lift trucks, standby power, recreational vehicles, hospital service carts and other conveyances. Supply and demand are expected to remain in approximate balance over the next few years.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	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	Manufacturers of lead not otherwise provided for	17 1/2%	11 1/2%	17 1/2%	30%

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
33800-1	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0
33900-1	17.5	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2

TARIFFS (cont'd)

UNITED STATES (MFN)

		1979	1980	1981	1982	1983	1984	1985	1986	1987
602.10	Lead bearing ores	0.75	-	-	-	-	-	-	-	-
624.02	Lead bullion	5.2	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
624.03	Other	5.1	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
624.04	Lead waste etc.	5.8	3.6	3.4	3.2	3.0	2.8	2.7	2.5	2.3

EUROPEAN ECONOMIC COMMUNITY: (MFN)

		1979	Base Rate	Concession Rate
26.01	Lead ores & concentrates	free	free	free
78.01	Lead unwrought	3.5	3.5	3.5
	Lead waste & scrap	free	free	free

JAPAN (MFN)

			(%)	
26.01	Lead ores & concentrates	free	free	free
78.01	Lead unwrought			
	Unalloyed	7.5	7.5	6.0
	Alloyed	12.0	12.0	6.5
	Other	7.0	7.0	4.7
	Lead waste & scrap	5.0	5.0	3.2

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978. TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20, No. L289, 1977; Customs Tariff Schedules of Japan, 1978; GATT Documents, 1979.

Lime

D.H. STONEHOUSE

CANADIAN INDUSTRY AND DEVELOPMENTS

Lime is a high-bulk, comparatively 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 nearly 85 per cent of Canada's total lime output in 1979, 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 1979 in Nova Scotia, Prince Edward Island, Newfoundland or Saskatchewan. A high calcium limestone deposit at Pinehouse Lake, Saskatchewan, was however, investigated by Missi Island Mines Ltd. with the intention of producing lime for the uranium industry in that region.

During 1979, 18 companies operated a total of 23 lime plants in Canada; one in New Brunswick, four in Quebec, ten in Ontario, two in Manitoba, four in Alberta and two in British Columbia. Steel Brothers Canada Ltd. took their vibratory grate plant at Fort Whyte out of operation during the year leaving a total of 83 kilns available; 30 rotary, 50 vertical, and three rotary grate. Preliminary returns indicate that lime production in 1979 was slightly greater than in 1978 despite poor performance in 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 in recent years the industry could produce between 10 000 and 12 000 tpd or about 3.5 million tpy.

Domlim Inc., which operates a lime plant at Lime Ridge, Quebec, and which has associated plants at St. Bruno and at Longueuil, began construction of a new lime kiln and other plant facilities at St. Adolphe de Dudswell, Quebec, during 1979. The new plant is expected to cost about $6 million and will have a capacity of about 350 tpd. Both domestic and export markets are considered strong enough by company market analysts to warrant the new plant.

Of particular interest during 1979 was the move by three separate Canadian lime producers to obtain production facilities in the United States. Steel Brothers Canada Ltd. began construction of a 500 tpd lime plant at Delta, Utah, during 1979, at a projected cost of $U.S. 7 million. Completion is expected in 1980. Quicklime will be sold in the chemical and industrial markets with particular emphasis on use in industrial flue gas scrubbers. The Lime Division of Domtar Chemicals Group announced a $3.5 million expansion and modernization of its Bellefonte, Pennsylvania lime plant. The

TABLE 1. CANADA, LIME PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979P	
	(tonnes)	($000)	(tonnes)	($000)
Production[1]				
By type				
Quicklime	1 857 580		1 899 000	
Hydrated Lime	176 631		193 000	
Total	2 034 211	76 218	2 092 000	79 151
By province				
Ontario	1 372 470	46 807	1 406 000	49 782
Quebec	355 114	16 181	363 000	16 037
Alberta	140 614	5 099	154 000	6 475
British Columbia	63 503	2 500	73 000	3 047
Manitoba	..	3 300	..	1 905
New Brunswick	..	2 331	..	1 905
Total	2 034 211	76 218	2 092 000	79 151
Imports				
Quick and hydrated				
United States	30 394	1 958	41 095	3 052
West Germany	674	113	304	74
France	62	20	80	40
Total	31 130	2 091	41 479	3 166
Exports				
Quick and hydrated				
United States	478 220	19 052	488 695	22 711
Honduras	-	-	1 270	230
Panama	-	-	307	57
Other countries	332	51	599	55
Total	478 552	19 103	490 871	23 053

Source: Statistics Canada.

[1] Producers' shipments and quantities used by producers.
P Preliminary; - Nil; .. Not available.

TABLE 2. CANADA, LIME PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1965, 1970, 1975-79

	Production[1]					Apparent
	Quick	Hydrated	Total	Imports	Exports	Consumption[2]
	(tonnes)					
1965	1 215 978	254 028	1 470 006	22 983	217 120	1 275 869
1970	1 296 590	224 026	1 520 616	30 649	181 994	1 369 271
1975	1 533 944	199 195	1 733 139	30 099	234 034	1 529 204
1976	1 703 374	227 019	1 930 393	36 882	309 355	1 657 920
1977	1 767 406	232 638	2 000 044	24 480	359 540	1 664 984
1978	1 857 580	176 631	2 034 211	31 130	478 552	1 586 789
1979P	1 899 000	193 000	2 092 000	41 479	490 871	1 642 608

Source: Statistics Canada.

[1] Producers' shipments and quantities used by producers. [2] Production, plus imports, less exports.
P Preliminary.

work was to begin as soon as approval of pollution control equipment was obtained. The program will involve kiln improvements and mine rehabilitation. Steetley Industries Limited announced in September 1979 that its U.S. subsidiary, Steetley Resources Inc. had purchased National Gypsum Company's dolomitic lime plant at Gibsonburg, Ohio, for $U.S. 2.25 million. Production, principally for the steel industry, is expected in early 1980. Steetley also purchased the facilities of the Ohio Lime Co., a wholly owned subsidiary of General Refractories Company, at Woodville, Ohio, also producing dolomitic quicklime for the steel industry and refractory-grade, dead-burned dolomite.

TABLE 3. CANADIAN LIME INDUSTRY, 1979

Company	Plant Location	Type of Quicklime
New Brunswick		
Havelock Processing Ltd.	Havelock	High-calcium
Quebec		
Domlim Inc.	Lime Ridge	High-calcuim[2]
	St. Adolphe de Dudswell	High-calcium[3]
Domtar Inc.	Joliette	High-calcium[2]
Gulf Canada Limited, Shawinigan Chemical Division	Shawinigan	High-calcium[2]
Quebec Sugar Refinery[1]	St.-Hilaire	High-calcium
Ontario		
The Algoma Steel Corporation, Limited[1]	Sault Ste. Marie	High-calcium and dolomitic
Allied Chemical Canada Ltd.[1]	Amherstburg	High-calcium
BeachviLime Limited	Beachville	High-calcium
Guelph DoLime Limited	Guelph	Dolomitic[2]
Chromasco Limited[1]	Haley	Dolomitic
Domtar Inc.	Beachville	High-calcium[2]
	Hespeler	Dolomitic[2]
Reiss Lime Company of Canada, Limited	Spragge	High-calcium
The Steel Company of Canada, Limited (Stelco)	Ingersoll	High-calcium[2]
Steetley Industries Limited	Dundas	Dolomitic
Manitoba		
The Manitoba Sugar Company, Limited[1]	Fort Garry	High-calcium
Steel Brothers Canada Ltd.	Faulkner	High-calcium
Alberta		
Canadian Sugar Factories Limited[1]	Taber	High-calcium
	Picture Butte	High-calcium
Steel Brothers Canada Ltd.	Kananaskis	High-calcium
Summit Lime Works Limited	Hazell	High-calcium and dolomitic
British Columbia		
Steel Brothers Canada Limited	Kamloops	High-calcium
Texada Lime Ltd.	Fort Langley	High-calcium

Source: Energy, Mines and Resources Canada.

[1] Production for captive use. [2] Hydrated lime produced also. [3] Under construction.

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.

Soil stabilization, especially for highways, offers a potential market for lime. However, not all soils have the physical and chemical characteristics to react properly with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to asphalt hot-mix prevents the asphalt from stripping from the aggregate. This could become more important as new technologies relating to asphalt maintenance and repair are adopted and as the sources of good clean aggregate become scarce.

The use of lime-silica bricks, blocks and slabs has not been as popular in Canada as in European countries, although lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

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 $CaO \cdot MgO$) 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.

TABLE 4. CANADA, CONSUMPTION OF LIME, QUICK AND HYDRATED, 1978 AND 1979 (PRODUCERS' SHIPMENTS AND QUANTITIES USED BY PRODUCERS, BY USE)

	1978		1979P	
	(tonnes)	($000)	(tonnes)	($000)
Chemical and metallurgical				
Iron and steel plants	759 283	28 661	894 622	37 156
Pulp mills	268 420	12 042	348 404	17 226
Uranium plants	94 821	3 690	61 533	2 886
Water and sewage treatment	78 480	3 272	42 020	2 103
Nonferrous smelters	66 183	2 649	60 497	2 791
Cyanide and flotation mills	60 614	2 580	53 298	2 433
Sugar refineries	24 485	1 126	24 733	1 657
Other industrial[1]	613 945	18 881	314 729	13 168
Construction				
Finishing lime	12 420	712	14 746	914
Mason's lime[2]	..	..	..	..
Sand-lime brick	12 354	413	4 848	170
Agricultural	13 189	757	13 910	879
Road stabilization	14 767	650	17 756	859
Other uses	15 250	785	8 228	532
Total	2 034 211	76 218	1 859 324	82 774

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes glassworks, fertilizer plants, tanneries and other miscellaneous industrial uses.
[2] Figures are included in "other uses" to ensure confidentiality.
P Preliminary; .. Not available.

Calcining is done in kilns of various types, but essentially those of vertical or rotary design are used. 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 t 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 t of product. The industry is aiming at a 14 per cent improvement in fuel utilization by 1980, over the base year 1973.

TABLE 5. WORLD PRODUCTION OF QUICKLIME AND HYDRATED LIME INCLUDING DEAD-BURNED DOLOMITE SOLD AND USED, 1978-79

Country	1978P	1979e
	(000 tonnes)	
U.S.S.R.	23 500	..
United States	18 546	20 390
Japan	9 058	9 900
West Germany	8 990	9 900
Poland	8 716	..
France	4 600	5 100
Brazil	4 500	5 000
Romania	3 600e	..
East Germany	3 500e	..
Czechoslovakia	3 060e	..
Yugoslavia	2 260e	..
Italy	2 141	2 400
Canada	2 092	2 034
Belgium	1 892	2 100
Other countries	14 902	54 707
Total	111 357	111 531

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, January 1980; U.S. Bureau of Mines, Mineral Trade Notes, Vol. 75, Nos. 10-11 and Statistics Canada.

P Preliminary; e Estimated; .. Included in other countries.

PRICES

Canadian lime prices quoted in Chemical **Processing Newsletter**	
	November, 1979
Lime carloads and truckload lots fob Ontario works	
Ontario quicklime - bulk	$34.98 per ton
Ontario hydrated - bulk	$37.64 per ton

fob Free on board.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
29010-1	Lime	free	free	free	25

UNITED STATES (MFN)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
512.11	Lime hydrated	Remains free								
512.14	Lime other	Remains free								

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, (1979); Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44.

Magnesium

D. PEARSON

Primary magnesium is produced by two basic processes. The first is by electrolysis of magnesium chloride derived from seawater and brines. The second method (Pidgeon process) reduces magnesium from ores such as dolomite or magnesite, with ferrosilicon at high temperatures. Canadian production as well as plants in France, Italy, Japan and one in the United States use the latter method. The other producers use the electrolytic method. The electrolytic process consumes considerably more energy than the ferrosilicon reduction process.

CANADA

Chromasco Limited is the only Canadian producer of primary magnesium. This company has operated a mine and a smelter at Haley, Ontario since 1942. Dolomite of high-purity (98% pure) is mined from a deposit on the company's property and calcined into "dolime". The calcined material is mixed with ferrosilicon and charged into retorts which are heated by natural gas. Under vacuum and at high temperature, magnesium is reduced, volatilizes and accumulates in the water-cooled head sections of the retorts. The production at present is a batch process. The plant has an annual capacity of 10 800 tonnes (t) of magnesium metal. The plant can also produce calcium and strontium in the same equipment.

The following grades of magnesium metal are produced: commercial, 99.90 per cent; high purity, 99.95 per cent; and refined, 99.98 per cent. Magnesium alloys are produced to most 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.

Commercial-grade magnesium represents the major proportion of production. This grade is suitable for general fabrication and alloying. The high-purity grade is mostly used for the formation of Grignard reagents (alkyl-magnesium-halides) which are used to react and form a variety of organic and inorganic compounds. The refined grade is used in the laboratory and as a reducing agent in the production of titanium, zirconium, uranium and beryllium.

In 1979, production of magnesium in Canada was 9 172 t with a value of $25,073,000 compared with 8 309 t valued at $19,825,000 in 1978. Production in 1979 was the highest since 1969 when it reached 9 648 t. Both exports and imports of magnesium metal were higher than the previous year. All but 10 t of the magnesium metal imported came from the United States. Exports of metal increased 26.6 per cent to 6 017 t. West Germany was Canada's best customer, buying 1 805 t, followed by Japan at 1 364 t, United States at 1 079 t and the United Kingdom at 1 019 t. Domestic consumption increased 12.7 per cent over that of 1978 but was only two-thirds that in 1977. This reduction was mainly caused by the reduced demand by the largest Canadian aluminum producer which was affected by a

TABLE 1. CANADA, MAGNESIUM PRODUCTION AND TRADE, 1978 and 1979

	1978		1979P	
	(tonnes)	($ 000)	(tonnes)	($ 000)
Production[1] (metal)	8 309	19 825	9 172	25 073
Imports				
Magnesium metal				
United States	1 829	4 724	2 659	7 860
United Kingdom	31	231	10	82
Norway	82	184	-	-
Total	1 942	5 139	2 669	7 942
Magnesium alloy				
United States	331	1 221	296	1 844
United Kingdom	251	1 827	179	1 622
Denmark	2	17	3	8
Total	584	3 065	478	3 474
Exports				
West Germany	1 292	2 940	1 805	4 807
Japan	1 065	2 419	1 364	3 476
United States	526	1 927	1 079	4 180
United Kingdom	1 194	3 207	1 019	2 988
Switzerland	210	492	296	861
People's Republic of China	-	-	252	575
Australia	28	114	112	421
Israel	27	102	29	112
Denmark	-	-	20	87
Netherlands	-	-	19	51
Uruguay	5	27	9	51
New Zealand	4	16	6	25
Colombia	3	11	5	22
India	9	24	2	7
Other countries	390	969	-	-
Total	4 753	12 248	6 017	17 663

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
P Preliminary; - Nil.

three month strike in 1979. Use of magnesium fell into the traditional categories.

Research is continuing at the University of Sherbrooke on the extraction of magnesium from asbestos tailings. A pilot plant is in operation to recover magnesium compounds.

WORLD REVIEW

World production of primary magnesium in 1979 set a record at 299 945 t compared with 283 116 t in 1978. The United States produced about 49 per cent of the total. The U.S.S.R. and Norway were the next largest producers, with 23.9 and 14.7 per cent respectively.

Four companies in the United States produced magnesium metal in 1979. Total production was 147 229 t or approximately 90 per cent of capacity. The Dow Chemical Company reached its goal of reducing energy requirements by using a modified cell and anodes. The company is expected to increase

TABLE 2. CANADA, MAGNESIUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-1979

	Production[1]	Imports		Exports		Consumption[2]
	Metal	Alloys	Metal	Metal		Metal
	(tonnes)	(tonnes)		(tonnes)	($)	(tonnes)
1970	9 392	232	1 847	6 957	5,562,000	4 477
1975	3 826	886	7 500	3 875	9,480,000	5 404
1976	6 092	684	1 128	3 397	7,450,000	4 230
1977	7 633	720	1 478	4 320	10,497,000	6 222
1978	8 309	584	1 942	4 753	12,248,000	3 607
1979p	9 172	478	2 669	6 017	17,663,000	4 066

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Magnesium metal in all forms and in magnesium alloys produced for shipments, less remelt.
[2] Consumption as reported by consumers.

p Preliminary.

TABLE 3. CANADA, CONSUMPTION OF MAGNESIUM, 1970, 1975-1979

	1970	1975	1976	1977	1978	1979p
	(tonnes)					
Castings and wrought products[1]	1 200	1 301	1 087	879	951	1 447
Aluminum alloys and other uses[2]	3 277	4 103	3 143	5 343	2 656	2 619
Total	4 477	5 404	4 230	6 222	3 607	4 066

Source: Energy, Mines and Resources 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.

its production capacity by about 11 000 t by 1982. Dow is currently building at magnesium granule plant at Freeport, Texas. This product is used in the desulphurization of iron and steel. At yearend N L Industries, Inc. was discussing the sale of its magnesium operations at Rowley, Utah with several prospective purchasers. This plant started operations in 1972 and last year reached full production of approximately 25 000 t for the first time. The two other magnesium producers in the United States, Northwest Alloys, Inc. and American Magnesium Company, had announced in 1977 their intentions of expanding production capacities. During 1979 there was no confirmation in the press that these increases were in effect.

In Norway, Norsk Hydro-Elektrisk Kvaelstofaktieselskab is increasing its production capacity to 50 000 t by using a new cell design. This work and the installation of the necessary pollution control measures are proceeding on schedule.

Two magnesium companies in Japan produced 11 368 t of primary magnesium. In addition, 16 191 t was produced from recycled

TABLE 4. WORLD PRIMARY MAGNESIUM PRODUCTION, 1969, 1978 and 1979

	1969	1978	1979p
	(000 tonnes)		
United States[e]	90.6	135.6	147.2
U.S.S.R.[e]	45.4	71.7	71.7
Norway	31.1	39.2	44.0
Japan	9.4	11.2	11.4
Canada	9.6	8.3	9.2
France	4.4	8.5	9.0
Italy	6.4	7.7	6.5
China[e]	1.0	1.0	1.0
United Kingdom	2.9	-	-
Total	200.8	283.2	299.9

Sources: American Bureau of Metal Statistics Inc.; U.S. Bureau of Mines; Energy, Mines and Resources Canada.

P Preliminary; [e] Estimated.

metal. The Japanese market for magnesium showed a healthy 17 per cent growth in 1979. Insufficient metal was produced for their own use and the shortfall was made up from 12 222 t of imported metal. Canada was a major supplier to this market.

Yugoslavia's plans to construct a magnesium smelter were well advanced at year-end. The company, Magnchrom Oour Bela Stena, with the technical assistance of Pechiney Ugine Kuhlmann, is building the plant at Balgevac Na Ibru in Serbia. It will use the "Magnetherm" process developed by Société Francaise d'Electrometallurgie S.A. (Sofrem).

Brazil's annual consumption of magnesium is reported to be about 13 600 t and growing at a rate of 5 per cent a year. Brazil does not yet produce the metal but as reported in 1978, Brasiliera de Magnesio (Brasmag) is constructing a 5 400 tpy magnesium smelter in Minas Gerrais which is scheduled to come on stream in 1982. This plant will use the ferrosilicon reduction method. A feasibility study has been proposed for a complex of three magnesium smelters and a series of chemical plants in the state of Rio Grande Do Norte. This complex would use local bitterns, (the liquor remaining in saltworks after the salt has crystallized out of solution) as the source of magnesium and related chemicals. Production, if the plan is approved, would be sometime in or after 1985.

India has announced that it will build its first magnesium smelter at Valinokkam in the Ramanathapuram district. It will have a capacity of 600 t and will use technology developed at the Central Electro Chemical Research Institute at Karaikud. India's annual consumption of magnesium is reported to be about 4 500 t.

There is very little information on production and consumption of magnesium in the communist countries. Poland, Russia and China produce the metal. It is estimated that in 1979, Russia produced about 72 000 t while Chinese production is variously estimated to have been between one and five thousand t.

USES

Magnesium's principal use is alloying with other metals. It imparts hardness and strength to aluminum and there is increasing use in the ferrous industry for deoxidizing and desulphurizing. In the production of titanium and other reactive metals, magnesium acts as a reducing agent. In the pure form, magnesium is used for cathodic protection of metal structures such as oil storage tanks. Alloys of magnesium are used extensively in the foundry industry. Magnesium finds many uses in the chemical industry especially in the formation of Grignard reagents.

PRICES

The Canadian price of commercial grade magnesium (99.8 per cent pure) in carload lots fob Haley, Ontario was $1.15 cents a pound at the beginning of 1979. There were two increases during the year, on February 9 to $1.23 and on October 1 to $1.25 cents a pound.

Primary ingot prices in the United States at the beginning of 1979 were $U.S. 1.06 a pound at the beginning of the year and increased on January 10th to $1.09 in 10,000 lb. lots. Die casting alloy AZ91B ingot prices jumped proportionately from $U.S. 1.04 to $1.07 a pound over the same period.

OUTLOOK

Industry estimates suggest that western world magnesium consumption will grow by only about 2 per cent in 1980. Aluminum alloying will continue to be the major use. Desulphurization of steel is considered to be the major growth area. The automobile industry is on a downturn which will affect the use of magnesium in nodular iron, which has grown on average by only 1.7 per cent a year since 1975. Die casting is very price sensitive but is expected to grow at a rate of 10.6 per cent a year up to 1985. Chemical uses have been affected in the United States by that country's restriction on leaded gasoline, thus influencing magnesium used for Grignard lead reactions. The price relationship with aluminum is becoming more favourable for magnesium in structural uses which have shown zero growth since 1977. This use is expected to grow at an annual rate of 5.8 per cent as price differences become narrower.

PRICES

United States magnesium prices, in United States currency, as quoted in **Metals Week.**

	¢/lb
Magnesium metal, in 10,000-lb lots:	
Primary ingot 99.8%	
January 1 to January 9, 1979	105.50
January 10 to December 31, 1979	109.00
Die casting alloy AZ91B ingot	
January 1 to January 9, 1979	103.50
January 10 to December 31, 1979	107.00

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, rods 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

TARIFFS

CANADA (cont'd.)

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
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

MFN Reductions under GATT (effective January 1 of year given)

Item No.		1979	1980	1981	1982	1983 (%)	1984	1985	1986	1987
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	25	25	25	25	25	25	25	25	25
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes	25	25	25	25	25	25	25	25	25

UNITED STATES

Item No.		1979	1980	1981	1982	1983 (%)	1984	1985	1986	1987
628.55	Magnesium, unwrought, other than alloys; and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	20	19	18	16.5	15	13.5	12	10	8
628.57	Magnesium, unwrought alloys, per pound on magnesium content	12.1	7.3	7.2	7.1	7	6.8	6.7	6.6	6.5
628.59	Magesium metal, wrought, per pound on magnesium content	¢ per lb. of magnesium content + %								
		6.5¢ + 3.5%	6.2¢ 3.4%	6.0¢ 3.3%	5.7¢ 3.1%	5.5¢ 3.0%	5.2¢ 2.9%	5.0¢ 2.8%	4.7¢ 2.6%	4.5¢ 2.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Manganese

D.G. LAW-WEST

Manganese is essential in the production of nearly all types of steel and approximately 95 per cent of all manganese produced is consumed by the iron and steel industry. Accordingly, the demand for manganese ores is determined by the world's production of iron and steel. Manganese is often considered to be a strategic commodity because of its critical role in iron- and steel-making, and because currently there are no acceptable substitutes. Although world production of crude steel reached an all-time high in 1979, stocks of manganese ore and ferromanganese remained fairly substantial.

CANADA

Canada has no domestic producers of manganese ore, but several low-grade deposits have been identified in Nova Scotia, New Brunswick and British Columbia. The largest of these deposits, located near Woodstock, N.B. contains an estimated 45 million tonnes (t) of mineralization grading 11 per cent manganese and 14 per cent iron. Although techniques have been developed to utilize such low-grade deposits, commercial production is unlikely to be economic at current 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. Union Carbide had a severe drop in production in 1979 due to a nine-month labour dispute that ended in September. The company had an additional setback when the ferromanganese furnace that was being operated by supervisory personnel exploded after a "mix bridge" formed inside the furnace. The explosion killed five people who were doing visual checks on the furnace at the time.

WORLD DEVELOPMENTS

World manganese production in 1979, virtually unchanged from the previous year, was about 21 million t. This is well below the record production of 25 million t in 1976.

The Soviet Union remained the largest manganese producer in the world with an estimated output of 9.5 million t of marketable ore in 1979. The Nikopol Basin in the Ukraine accounts for some 80 per cent of the country's production. Reports on Soviet manganese indicate that ore exports were in the range of 1.25 million t to 1.4 million t in 1979, most of which went to Comecon countries.

South Africa, the largest non-communist world manganese producer increased manganese production to over 5 million t in 1979. Anglo American Corp. of South Africa Ltd. officially opened the Middleplaats manganese mine, near Kurman in the Northern Cape area. Design capacity at this mine is capable of handling 1.1 million tpy of ore from reserves grading 30-38 per cent manganese, which are sufficient for 30 years of operation. The mine had the distinction of selling its entire 1979 production of 200 000 t before it was officially opened.

TABLE 1. CANADA, MANGANESE, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Imports				
Manganese in ores and concentrates[1]				
French Africa, nes	-	-	18 935	2,970,000
United States	24 636	4,563,000	5 182	1,889,000
Brazil	38 756	6,415,000	10 996	1,832,000
Gabon	39 759	3,718,000	9 552	1,479,000
Other countries	33 295	3,746,000	486	177,000
Total	136 446	18,442,000	45 151	8,347,000
Manganese metal				
South Africa	7 539	6,585,000	7 811	8,326,000
Other countries	400	488,000	464	532,000
Total	7 939	7,073,000	8 275	8,858,000
Ferromanganese, including spiegeleisen[2]				
South Africa	11 803	5,454,000	22 130	12,366,000
United States	5 864	3,300,000	19 480	11,800,000
Brazil	-	-	10 500	5,118,000
Portugal	6 957	4,635,000	8 892	4,445,000
Norway	-	-	5 043	3,307,000
India	-	-	5 726	2,462,000
United Kingdom	-	-	5 041	2,313,000
Netherlands	-	-	5 001	2,199,000
Other countries	2 188	750,000	1 866	1,272,000
Total	26 812	14,139,000	83 679	45,282,000
Silicomanganese, including silicospiegeleisen				
United States	6 309	2,902,000	12 079	7,054,000
Norway	5 779	2,412,000	6 776	3,551,000
Other countries	3 754	1,864,000	3 021	1,741,000
Total	15 842	7,178,000	21 876	12,346,000
Exports				
Ferromanganese[2]				
United States	19 878	5,960,000	11 962	2,767,000
Jamaica	46	27,000	81	63,000
Total	19 924	5,987,000	12 043	2,830,000
Consumption				
Manganese ore				
Metallurgical grade	198 560	..	58 587	..
Battery and chemical grade	2 760	..	3 056	..
Total	201 320	..	61 643	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Mn content; [2] Gross weight.
p Preliminary; - Nil; .. Not available.

Manganese ore production from Groote Eylandt Mining Company Proprietary Ltd. in the Northern Territory of Australia increased to 1.5 million t from 1.2 million t during the year. However, with lower prices and higher costs the increased production did not prevent operating profits from falling.

Gabon, the third largest manganese producer, increased ore production to 2.0 million t, which exceeded production of the previous two years but was lower than the 2.2 million t produced in 1976. Manganese production in Gabon is expected to nearly double when the Trans-Gabon railway is completed in 1983-84. Currently, there are tentative plans for the construction of ferromanganese facilities in Gabon, details of which have not been announced.

Cia Minera Autlan S.A. de C.V. of Mexico is the only vertically integrated manganese mining company with ferromanganese production facilities in the United States. In 1979 the company bought the ferroalloy operation of Airco, Inc. located at Mobile, Alabama. Annual production at the U.S. plant will be increased to 45 000 t of standard ferromanganese and silicomanganese. Minera Autlan mines some 600 000 to 700 000 t of manganese ore at Tampico, Mexico and produces about 450 000 t of concentrate in nodule form. One-half of the nodule production is exported and the remainder is consumed by the company's ferromanganese plants at Vera Cruz and Tampico. Autlan has plans to increase both nodule and ferromanganese production at its Mexican facilities.

Sinai Manganese Co. of Egypt has commissioned a feasibility study on potential manganese mining and ferromanganese smelting operations in the Sinai. Should results prove favourable, this would be the first major project in the area since it was returned to Egypt.

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 which 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 use about 5.8 kilograms (kg) of manganese per t 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 and impurities content.

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

TABLE 2. CANADA, MANGANESE IMPORTS, EXPORTS AND CONSUMPTION, 1965, 1970, 1975-79

	Imports			Exports	Consumption	
	Manganese Ore[1]	Ferro-Manganese	Silico-Manganese	Ferro-Manganese	Ore	Ferromanganese and Silicomanganese
	(gross weight, tonnes)					
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	12 056	9 861	238 629	83 687
1977	57 644	29 404	4 835	23 104	182 157	82 467
1978	136 446	26 812	15 842	19 924	201 320	69 349
1979p	45 151	83 679	21 876	12 043	61 643	73 774

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Mn content.
p Preliminary.

such applications as rock crusher parts and teeth in earth-moving machinery.

Iron used for castings is desulphurized with manganese. Otherwise, the sulphur causes surface imperfections and makes precision casting very difficult.

Also, manganese can 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 have properties desirable in specific applications such as ship propellers.

Manganese also has many nonmetallurgical applications such as in dry-cell batteries. In this role manganese dioxide provides oxygen to combine with hydrogen, which permits 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. Very few natural manganese dioxide ores can meet these specifications, and thus most batteries contain a blend of natural ore and synthetic manganese dioxide.

A common classification of manganese ore gives rise to the following ore types: (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, these ores must contain no less than 85 per cent manganese dioxide. (2) Ferruginous manganese ores containing 10 to 35 per cent manganese used in the manufacture of spiegeleisen. (3) Manganiferous iron ores containing 5 to 10 per cent manganese used to produce manganiferous pig iron.

All types of manganese ores can be employed in the production of manganese chemicals such as: potassium permanganate, a powerful oxidant used in the purification of public water supplies; manganese oxide, an important addition to welding rods and fluxes and an organometallic form of manganese, which inhibits smoke formation and improves the combustion of fuel oil.

Various manganese chemicals are employed to produce colour effects in face bricks and, to a lesser extent, to colour or decolour glass and ceramics. They are also

TABLE 3. WORLD PRODUCTION OF MANGANESE ORES, 1976-78

	Mn	1976	1977	1978p
	(%)		(000 tonnes)	
U.S.S.R.	35	8 636	8 591	8 600
Republic of South Africa	30-48+	5 452	5 048	4 317
Gabon	50-53	2 217	1 851	1 710
India	10-54	1 738r	1 940	1 567
Australia	37-53	2 154	1 387	1 290
Brazil	38-50	1 696	1 516	998e
People's Republic of China[e]	30+	998	998	998
Mexico	35+	453	487	523
Ghana	30-50	384r	343	321
Hungary	18-28	165	161	156
Japan	26-28	142	126	107
Zaire[1]	30-57	182	150	100r
Morocco	53-50	117	114	100e
Argentina	25-30	53	82	91
Thailand	46-50	50	77	72
Turkey	35-46	34	35	56
Yugoslavia	30+	19	25	32
Iran	33+	40	40	30
Other countries[2]		152	138	114
Total		24 682r	23 109	21 182

Source: U.S. Bureau of Mines, **Mineral Industry Surveys,** October 1979.
[1] Production for Zaire is from **World Mining Yearbook, Catalogue and Survey Directory,** 1979.
[2] Includes 13 countries, each producing less than 30 000 tpy.
p Preliminary; e Estimated; r Revised.

used in paint and varnish driers, and in the production of dyes, fungicides and pharmaceuticals.

PRICES

The 1979 contract price for manganese ore remained virtually unchanged from the previous year's price of $1.36 to $1.40 per metric t unit of manganese contained. It is expected, however, that ore producers will be asking for substantially higher prices in 1980 due to increased freight rates and production costs.

OUTLOOK

The short-term demand forecast for manganese shows little change because of the slow recovery expected in the world steel industry. Furthermore, the downward trend in ore prices (in constant currency) will probably continue until 1981 and then stabilize.

There is a growing trend in expanding ferroalloy production capacity in ore-producing countries because oil price increases deter the shipping of low value-to-bulk cargoes, particularly to countries which are also dependent on oil for the electrical power used in their ferroalloy industries.

In the longer term, technological improvements may reduce the amount of manganese consumed in steelmaking. However, the rising consumption of coals with higher sulphur content may offset these improvements.

PRICES

United States prices in U.S. currency, published by **Metals Week,** December 1978 and December 1979

	December 1978	December 1979
	(cents)	(cents)
Manganese ore, per long ton unit (22.4 lb) cif U.S. ports, Mn content		
Min. 48% Mn (low impurities)	138.00-142.00	138.00-142.00
Ferromanganese, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk	($)	($)
Standard 78% Mn, per long ton	425.00-440.00	430.00-440.00
	(cents)	(cents)
Medium-carbon, per lb. Mn	42.00	46.00
Silicomanganese, per lb. of alloy, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
16-16½% Si, 2% C	20.00-21.50	24.50
Manganese metal, electrolytic metal, 99.99% per lb. Mn, boxed fob shipping point		
Regular	58.00	62.00
6% N	61.00	63.25-65.00

Note: fob Free on board; cif Cost, insurance and freight.

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, on the Mn content, per lb.	free	0.5¢	1.25¢	free
37502-1	Silicomanganese, silicospiegel and other alloys of manganese and iron more than 1% Si, on the Mn content, per lb.	free	0.75¢	1.75¢	free

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(cents)				
37501-1	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
37502-1	0.75	0.75	0.75	0.74	0.73	0.74	0.72	0.71	0.70

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
				per cent, unless otherwise specified						
601.27	Manganese ore, including ferruginous manganese ore and manganiferous iron ore, all the foregoing containing over 10 per cent by weight of manganese	0.12¢/ lb	free	free	free	free	free	free	free	free
606.26	Ferromanganese, not containing over 1% C	0.3¢/ lb + 2%	0.3¢/ lb + 2%	0.3¢/ lb + 2%	2.6	2.6	2.5	2.4	2.4	2.3
606.28	Ferromanganese containing 1 to 4% C, per lb. manganese content	0.46¢	0.46¢	0.46¢	1.4	1.4	1.4	1.4	1.4	1.4
606.30	Ferromanganese containing over 4% C, per lb. manganese content	0.3¢	0.3¢	0.3¢	1.6	1.6	1.6	1.5	1.5	1.5
632.28	Manganese metal waste and scrap	1.5¢/ lb + 10%[1]	13.0[1]	11.9[1]	10.9	9.8	8.8	7.7	6.7	5.6
632.30	Manganese metal, unwrought	1.5¢/ lb + 10%	14.0		remains free					

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.
[1] Duty temporarily suspended.

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 1979 of 50 711 kilograms (kg) (1,471 flasks) were significantly greater than the 43 046 kg (1,249 flasks) imported in 1978. Statistics on consumption of mercury metal in Canada are incomplete but usage by those companies reporting consumption totalled 26 249 kg (761 flasks) in 1979 compared with 29 904 kg (867 flasks) in 1978.

WORLD REVIEW

The United States Bureau of Mines (USBM) estimated world production at 6 705 700 kg (194,520 flasks) in 1979 compared with 7 209 444 kg (209,133 flasks) in 1978. The U.S.S.R. is by far the world's largest mine producer of mercury, and its production in 1979 is believed to have been about the same as the 1978 level which has been estimated at 2 459 959 kg (71,359 flasks). Spain, the world's second largest mercury producer, produced 1 206 600 kg (35,000 flasks) in 1979 compared with 1 271 571 kg (36,886 flasks) in 1978. Other major producers in 1979 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 pending market improvement.

The Almaden mine of Minas de Almaden y Arrayanes, in Spain, is the largest producer of mercury in the noncommunist world. Its output has been curtailed, reportedly to about 60 to 70 per cent of normal plant capacity of approximately 60,000 flasks per year. The company is preparing a new mine, El Entredicho, located about 17 km from the present plant, for production in 1980. The ore is reported to be higher grade than that at the Almaden mine and will be mined by open-pit methods and treated in existing furnaces. Tentative plans call for an annual production of about 1 725 000 kg (50,000 flasks) from all properties by 1982; 1 034 190 kg (30,000 flasks) from open-pit ore, 344 730 kg (10,000 flasks) from the present mine and 344 730 kg (10,000 flasks) from a nearby subsidiary mine. By 1985 it is expected that most of the ore will come from the new open-pit mine.

United States production of mercury increased in 1979 because of a significant increase in output at the 635-tonne-per-day open-pit McDermitt mine in Nevada. Mercury production came from two U.S. mines in 1979 but the McDermitt mine accounted for most of that country's production of

1 017 608 kg in 1979 and 990 961 kg in 1978. The McDermitt operation is a joint venture in which Placer Amex Inc., a wholly owned subsidiary of the Canadian company, Placer Development Limited, has a 51 per cent interest and Minerals Exploration Company of New Jersey the remaining 49 per cent.

Yugoslavia plans to reopen the Idrija mercury mine in 1980. Rising mercury prices and the discovery of a new deposit estimated to have sufficient reserves for 25 years operation are major factors in the decision. Reports indicate that the Italian government is considering reopening the Monte Amiata mercury mine in 1980.

The United States is believed to be the world's largest consumer of mercury but in recent years has produced less than its requirements. The USBM reported total mercury consumption by the United States at 1 566 522 kg in 1979 compared with 1 651 773 kg in 1978. A large portion of U.S. requirements was derived from imports, which totalled 993 443 kg in 1979, a drop of 33 per cent from the 1 477 995 kg imported in 1978. Japan and Spain were the major suppliers of mercury to the United States in 1979, accounting for 296 847 and 288 056 kg respectively. Canada was also a significant supplier to the U.S. market from secondary sources or by re-exports. Japan at present is not a primary producer of mercury but has a large stock of mercury, reported to be over 2 068 380 kg, obtained from caustic soda plants following a change in techniques away from the use of mercury.

Data on world consumption of mercury are not available for 1978 or 1979. Unofficial sources estimated consumption in 1977 at 8 273 500 kg and consumption is believed to have increased slightly in 1978 and again in 1979. Besides the United States, other countries that consume significant quantities of mercury are the Federal Republic of Germany, the United Kingdom, France, India, Italy and Japan. The first four named countries import their mercury requirements. In the past, Japan imported much of its mercury requirements but at present its needs can be met from stocks.

In 1975 many of the world's major producers (i.e., Spain, Italy, Turkey, Yugoslavia, Algeria and Peru) established the International Association of Mercury Producers (ASSIMER) with headquarters in Geneva. At that time, member countries accounted for about 90 per cent of non-communist exports of mercury. Canada and the United States did not become members of the organization.

TABLE 1. CANADIAN MERCURY PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Mine Production	-	-	-	-
Imports (metal)				
Spain	3 992	36 000	23 269	261 000
United States	17 282	100 000	21 410	190 000
Puerto Rico	-	-	5 080	41 000
Netherlands	21 727	89 000	907	10 000
United Kingdom	45	...	45	...
Total	43 046	225 000	50 711	502 000
Consumption[1] (metal)				
Heavy chemicals	5 385	..	3 237	..
Electrical apparatus	13 415	..	15 834	..
Gold recovery	265	..	379	..
Miscellaneous	10 839	..	6 799	..
Total	29 904	..	26 249	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Available data, as reported by consumers.
P Preliminary; - Nil; .. Not available; ... Less than $500.

The major objectives of the Association are to stabilize prices by controlling production or by withholding supplies from the market during periods of low demand, to develop new uses for mercury, and to improve the environmental image of mercury. Meetings are held at least once a year to discuss the world's mercury situation and to determine what action is necessary to ensure a viable market. At a meeting in Geneva in January 1979 members of ASSIMER decided not to set a high minimum selling price but to adopt a selective sales policy based on prevailing merchant market prices.

At the end of 1979, the United States strategic and critical materials stockpile contained a total of 6 697 758 kg (194,290 flasks). The stockpile goal is 1 861 679 kg (54,004 flasks). The declared surplus stocks cannot be released without authorization by the United States Congress. Surplus mercury released by other government agencies was auctioned on a monthly basis in 1979 by the General Services Administration and totalled 389 545 kg (11,300 flasks). Stocks held by United States producers, consumers and dealers on December 31, 1978 were 950 834 kg (27,582 flasks).

In 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 waste water 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. In 1975, EPA proposed National Interim Primary Drinking Water Regulations and held hearings on them. Comments and information were received from representatives of state agencies, public interest groups and others. The regulations proposed maximum contaminant levels in public drinking water and set the mercury level at 0.002 milligrams per litre.

TABLE 2. CANADIAN MERCURY PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970, 1975-79

	Production, metal	Imports, metal	Consumption, metal
		(kilograms)	
1965	689	486 200	188 692
1970	841 141	69 536	154 474
1975	413 676	73 527	32 869[1]
1976	-	62 641	26 039[1]
1977	-	21 908	30 447[1]
1978	-	43 046	29 904[1]
1979P	-	50 711	26 249[1]

Sources: Energy, Mines and Resources Canada; Statistics Canada; metal production 1970 is obtained directly from Cominco Ltd. and represents output from Pinchi Lake mine in British Columbia.
[1] As reported by consumers, but coverage is incomplete.
P Preliminary; - Nil.

In March 1974, the EPA promulgated its final effluent limitation guidelines for existing and new sources in the inorganic chemicals manufacturing category. The daily limitation is 0.000 28 g of mercury per 1 000 g of effluent for mercury-cell plants in existence in operation prior to March 1974. The limitation is 0.000 14 g of mercury per 1 000 g of effluent for new 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 proposed 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. EPA also reinstated the use of mercury compounds in latex (water-based) paints, but continued the ban on their use in nonwaterbased paints. The agency also requested a review of the uses of mercury in other pesticides.

In Canada, the federal "Chlor-Alkali Mercury Regulations", which became effective in May 1972, restricts the quantity of mercury that may be discharged in the effluent from any chlor-alkali plant using the mercury-cell process. It stipulates that

TABLE 3. WORLD PRODUCTION OF MERCURY, 1975, 1978 AND 1979

	1975	1978p	1979e
	(kilograms)		
U.S.S.R.e	1 896 015	2 459 959	..
Spain	1 517 157	1 271 571	1 206 600
United States	253 929	990 961	1 017 600
Algeria	965 244	1 228 790e	861 800
People's Republic of China	896 298	713 040	..
Czechoslovakia	203 391	213 905e	..
West Germany	110 004	99 834	..
Mexico	490 000	90 320	517 100
Turkey	186 879	70 118	..
Finland	10 653	46 918	..
Italy	1 092 000	3 103	-
Yugoslavia	584 007	-	-
Canada	413 676	-	-
Other countries	79 285	20 925	3 102 600
Total	8 698 538	7 209 442	6 705 700

Sources: Preprint from the 1977 U.S. Bureau of Mines, Minerals Yearbook for 1975 statistics; U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 6 for 1978 statistics; U.S. Bureau of Mines, Mineral Commodity Summaries, 1980 for 1979 statistics.
p Preliminary; e Estimated; .. Not available, but estimate included in figure for other countries.

TABLE 4. UNITED STATES MERCURY CONSUMPTION BY USES, 1975, 1978 AND 1979

	1975	1978	1979p
	(kilograms)		
Agriculture[1]	20 684	..	..
Catalysts	28 889	..	20 029
Dental preparations	80 667	17 651	30 440
Electrical apparatus[2]	585 042	618 894	266 097[2]
Electrical preparation of chlorine and caustic soda	524 748	384 926	420 950
General laboratory use	11 549	14 479	6 240
Industrial and control instruments	158 507	120 277	124 172
Paint	238 829	308 741	227 212
Pharmaceuticals	15 341	..	..
Other uses	88 286	216 146	352 383
Total consumption	1 752 539	1 681 111	1 447 522

Sources: Preprint from the 1977 U.S. Bureau of Mines, Minerals Yearbook for 1975 statistics; U.S. Bureau of Mines, Mineral Industry Surveys, "Mercury in the Third Quarter of 1979" for 1978 statistics; U.S. Bureau of Mines, Mineral Industry Surveys, "Mercury in the Fourth Quarter 1979" for 1979 statistics.
1 Includes fungicides and bactericides for industrial purposes. 2 Does not include electric lighting, which is included in "Other uses".
p Preliminary; .. Not available.

mercury in liquid effluent 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 federal Food and Drugs Act 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 not object 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 the mercury market has been erratic. It appears that the producers association (ASSIMER) has brought a certain degree of stability to the market through better regulation of production, sales and prices, without excessively encouraging resumed production at inactive mercury mines. Environmental considerations have placed constraints on the use of mercury in some of its applications, especially in the production of chlorine and caustic soda. However, a doubling of prices during 1979 (see below) has encouraged some of the former producers to consider reopening their mines. Prospects of mine reopenings or new mines coming into production should constrain price increases in 1980.

With ample mercury stocks in the hands of producers, consumers and dealers and with many of the recently closed mines on a standby basis, adequate supplies should be assured in the short to medium term. No problems are envisaged in meeting the demand for mercury in the longer term. Consumption is not expected to change greatly from the present level but should show a small upward trend. Declining demand for mercury in the chlor-alkali industry should be more than offset by increased demand for mercury in electrical apparatus and industrial control instruments, applications which are not expected to be affected to any degree by substitutes. Recycled mercury will continue to play an important role in supply. Also available is surplus mercury in the United States strategic stockpile but, when approval for disposal of the mercury is given, it is expected sales will be conducted in such a manner as to not significantly effect normal market operations.

TABLE 5. AVERAGE MONTHLY PRICES OF MERCURY IN 1979 AT NEW YORK AND CIF MAIN EUROPEAN PORT

	New York[1]	cif main European port[2] Low	cif main European port[2] High
		($U.S./flask)	
January	187.500	191.250	201.000
February	200.000	213.625	223.250
March	218.909	237.444	245.556
April	255.476	258.286	266.286
May	296.591	293.750	303.625
June	334.762	335.556	352.222
July	299.355	286.667	315.333
August	289.130	291.250	312.000
September	303.947	302.375	318.750
October	315.000	316.667	332.222
November	328.579	322.778	343.889
December	355.000	357.857	370.714

Sources: Metals Week for New York prices; Metal Bulletin (London) for cif main European port prices.
[1] Consensus of fixed price for prompt sales of 20 or more flasks of prime virgin metal in the United States. Price includes delivery, United States import duty, and any applicable surcharges. [2] Prices are cif main European port, minimum 99.99 per cent.
cif: cost, insurance and freight.

USES

Mercury's two major uses in recent years have been in the manufacture of electrical apparatus and in 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 1979. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches, including "silent" switches for use in residences. Because mercury lamps are more adaptable to higher voltage supply lines than are incandescent lamps, they are widely used for industrial and street lighting purposes. The mercury battery, invented in 1944, has a relatively long shelf life and can withstand high temperatures and high humidity. It is widely used in portable metering and communication devices where reliability is important.

Other applications of mercury 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 governments. Several mercury compounds, especially the chloride, oxide and sulphate, are good catalysts for certain 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.

PRICES

Many of the world's mercury producers have withheld supplies from the market or made it available on a controlled basis and these actions were a major contributing factor in the price of mercury more than doubling during the year. Minas de Almaden played a major role in determining the price structure throughout 1979. This company raised its export price to $U.S. 5.22 per kg early in January and again to $5.80 in mid-January. In the first week of 1979 **Metals Week** quoted mercury at $U.S. 5.08-5.37 per kg. At an ASSIMER meeting in Geneva in the latter part of January, the mercury producers agreed that mercury sales would be based on the free market price and not on a fixed price. Restriction of supplies by producers and increased demand forced the price upwards to $10.15 to $10.44 per kg by mid-June. An announcement that the Monte Amiata would re-enter the mercury market and a general slackening in demand decreased the price to $U.S. 8.41 to 8.99 per kg early in July. Prices then recovered slightly but generally were stable until early in October when the price resumed its upward trend. Early in December a tender by India for 103 419 kg and anticipated restraint action by the producer group forced the price up to $U.S. 10.44 to 10.73 per kg where it remained for the balance of the year.

The average dealer price of mercury in New York, as quoted in **Metals Week,** was $U.S. 8.15 per kg ($U.S. 281.096 per flask) in 1979 compared with $U.S. 4.45 per kg ($U.S. 153.322 per flask) in 1978, an increase of 83 per cent. The cif main European port price as quoted in **Metal Bulletin,** London, ranged from a low of $U.S. 5.02 per kg at the beginning of 1979 to $11.02 at year end.

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

TARIFFS (concluded)

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
					(cents per pound)					
601.30	Mercury Ore	Remains free								
632.34	Mercury metal, unwrought and waste and scrap[1]	12.5	11.9	11.3	10.6	10.0	9.4	8.8	8.1	7.5

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1979	Base Rate	Concession Rate
28.05	Mercury, in flasks of a net capacity of 34.5 kg, of a f.o.b. value, per flask, not exceeding 224 EUA[2]	6.72 EUA per flask		
28.28	Mercury oxides	5.6%	5.6%	4.1%

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 21, No. L 335, December 1978.

[1] The suspension of duty on waste and scrap was extended until June 30, 1981. [2] EUA - European unit of account.

Molybdenum

D.G. FONG

The western world molybdenum market remained strong in 1979, with consumption growth being limited by availability of mine production. Demand was particularly strong in the western European countries, and consumption was again dominated by alloy steels, stainless steels and tool steels.

Production of molybdenum in 1979 in the western world at 89 770 tonnes (t) rose marginally over 1978. Canadian production of 10 029 t during the year was substantially below capacity because of labour problems. Reduced output as a result of protracted labour strikes at major Canadian molybdenum mines offset the production increase in the United States and contributed to the tight supply situation worldwide. Demand has outstripped supply for the sixth time in the last seven years. Consequently, industrial inventories were drawn down to a low level.

In response to the imbalance of supply and demand, molybdenum prices rose sharply in 1979. Strong demand and high prices have led to increased activities in exploration and development. A number of new molybdenum mines, especially in Canada and the United States, are being developed for production, while some producing mines are increasing their efforts to improve molybdenum recovery.

CANADA, PRODUCTION, TRADE AND CONSUMPTION

In 1979 Canadian shipments of molybdenum contained in concentrates oxide and ferromolybdenum was 11 187 t compared with 13 943 t in 1978. The sharp decline in shipments resulted from a series of strikes during the year at Brenda Mines Ltd., Gaspé Copper Mines Limited, Gibraltar Mines Limited, and Placer Development Limited's Endako Mine. Despite the 30 per cent decline in production, the value of shipments increased markedly during the year and was up 84 per cent to $330.1 million. Record world prices combined with the lower exchange value of the Canadian dollar contributed to the significant increase in producers' revenues and earnings.

All strikes at molybdenum mines were settled before the end of 1979. The Endako strike, which lasted from February 14 to November 1, had the most impact in terms of disrupting domestic supplies. Endako normally accounts for one-half of Canadian production and supplies nearly 60 per cent of domestic requirements. The strike further aggravated the already tight supply situation. During the strike, management continued to operate the facilities at about one-third of capacity. The oxide produced was offered to regular customers at $20 per pound, a price about midway between the producer and dealer prices then in effect. A total **force majeure** on deliveries, in effect for most of the strike, was reduced to 50 per cent on November 15 and then to 30 per cent on January 1, 1980.

Endako is also the only Canadian mine producer with roasting facilities to convert molybdenite to molybdic oxide. There is a second roaster at Duparquet, Quebec, but it is operated on a toll conversion basis with the oxide produced sold at dealer prices.

Faced with a shortage of operating roaster capacity, Canadian mine producers other than those on strike shipped concentrates to Europe for roasting, with the oxide being reimported.

Placer plans to increase its annual roasting capacity by 40 per cent to 10 800 t of molybdic oxide and to construct a $2.5 million lubricant-grade molybdenite plant at Endako. Construction of both projects was delayed by the strike in 1979. The lubricant plant is scheduled to begin production in mid-1980 at a capacity of 453 tonnes per year (tpy), and the roaster expansion, costing $6 million, will be operational during the first quarter of 1981.

The open-pit slope stability problem of 1978 at Brenda Mines Ltd., a copper-molybdenum mine and Canada's second-largest molybdenum producer, was successfully solved. However, due to the effect of a one-month strike, lower head grades, and

TABLE 1. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Production (shipments)[1]				
British Columbia	13 055 271	167,714,272	10 778 000	322,149,000
Quebec	888 134	11,354,237	409 000	7,965,000
Total	13 943 405	179,068,509	11 187 000	330,114,000
Exports				
Molybdenum in ores, concentrates and scrap[2]				
Japan	4 262 600	53,443,000	2 262 000	76,128,000
West Germany	728 500	9,480,000	1 899 000	43,802,000
Belgium-Luxembourg	4 214 800	30,496,000	2 926 000	34,645,000
United States	1 644 800	19,984,000	1 176 000	30,956,000
United Kingdom	1 654 200	12,036,000	1 956 000	30,501,000
France	300 500	3,482,000	580 000	13,681,000
Netherlands	78 700	973,000	184 000	6,984,000
Sweden	-	-	138 000	5,745,000
Other countries	536 900	7,078,000	362 000	8,475,000
Total	13 421 000	136,972,000	11 483 000	250,917,000
Imports				
Molybdic oxide (containing less than 1 per cent impurities)	329 500	3,069,000	370 000	7,388,000
Molybdenum in ores and concentrates[3] (Mo content)	613 788	6,128,263	271 962	4,798,000
Ferromolybdenum, over 50% molybdenum[3]	55 294	420,139	153 945	1,400,000
Consumption (Mo content)				
Addition agents	957 783r	..	779 594	..
Electrical and electronics	3 596	..	4 266	..
Other Uses[4]	307 261r	..	466 084	..
Total	1 268 640r	..	1 249 944	..

Sources: Statistics Canada; Energy, Mines and Resources 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 410), value in U.S. currency. These imports are not available separately in official Canadian trade statistics. [4] Alloy and pigment uses.
P Preliminary; .. Not available; - Nil; r Revised.

the treatment of a significant tonnage of oxidized stockpiled ore, the total output and recovery rate of molybdenum were substantially lower in 1979 compared with the year before. During the month-long strike, Brenda declared a 60 per cent **force majeure** on shipments to Europe, which was lifted on December 27, 1979, 2½ months after the settlement of the strike.

The strike at Gibraltar Mines which halted operations for much of 1978 was settled on February 6, 1979. Ore for the concentrator was derived during 1979 from the Pollyanna pit, where ore reserves were near exhaustion. The company was preparing its Gibraltar East pit for Stage II mining in 1980 when the mining rate will be raised to 98 000 from 75 600 tpd.

Molybdenum production at Bethlehem Copper Corporation's copper mine at Highland Valley, British Columbia came principally from the small Iona orebody where ore reserves were exhausted at the end of 1979. Future mill feed will be derived entirely from the Jersey pit. The output of byproduct molybdenum will decline in 1980 owing to the lower molybdenum content in the Jersey ore.

The Lornex Mining Corporation Ltd. has decided to increase its milling rate about 68 per cent by mid-1981 at its Highland Valley copper-molybdenum mine. The new facilities will include a third semi-autogenous mill line, a new crusher and additions to the ore conveyor system. The capital cost of the expansion will be about $160 million.

Three mines are being brought into production in Britich Columbia and New Brunswick. In B.C., Teck Corporation will spend $150 million to bring its Highmont copper-molybdenum mine on stream in 1980. Initial production will be at an annual rate of 3 600 t of molybdenum contained in sulphide concentrate, although in subsequent years production will decline to the 2 000 t level. The Sullivan Mining Group Ltd. and Billiton Exploration Canada Limited announced plans to bring the Mount Pleasant mine in New Brunswick into production in 1981 at a cost of $80 million. While primarily a tungsten deposit, Mount Pleasant will also produce about 360 tpy of molybdenum contained in concentrate.

In addition, Amax of Canada Limited began a $145 million program in 1979 to reopen a former molybdenum producer at Alice Arm, British Columbia. Work is expected to be completed in 1981 and when at full production, the Kitsault mine will produce 3 600 to 4 500 tpy of molybdenum contained in concentrates. Start-up is scheduled for mid-1981.

Also in British Columbia, two promising molybdenum prospects were being drilled and evaluated. Surface drilling conducted by Newmont Exploration of Canada Limited and Esso Minerals Canada has located molybdenite mineralization of economic interest south of

TABLE 2. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970 AND 1975-79

	Production[1] (shipments)	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	15 710 300	56 400	269 281	1 436 883
1976	14 618 607	14 680 600[r]	110 600	128 845	1 260 329
1977	16 567 555	15 310 400	192 100	74 330	1 149 736[r]
1978	13 943 405	13 421 000	329 500	55 294	1 268 640
1979[p]	11 187 000	11 483 000	370 000	153 945	1 249 944

Sources: Statistics Canada; Energy, Mines and Resources 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), over 50 per cent molybdenum. [5] Mo content of molybdenum products reported by consumers.
.. Not available; [p] Preliminary; [r] Revised.

TABLE 3. CANADA, MINE PRODUCTION IN 1979

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	4 768 162	0.077	5 083	53.24	2 706	474[1]
Noranda Mines Limited, Boss Mountain Division	Williams Lake, B.C.	Primary	1 800	496 108	0.142	1 134	56.24	638	22
Brenda Mines Ltd.	Peachland, B.C.	Coproduct	27 200	9 075 720	0.036	4 496	56.41	2 536	869
Lornex Mining Corporation Ltd., Lornex Mine	Highland Valley, B.C.	Byproduct	43 600	16 126 103	0.017	3 728	53.96	2 011	122
Utah Mines Ltd., Island Copper Mine	Port Hardy, B.C.	Byproduct	37 200	13 339 997	0.015	2 637	40.96	1 080	113
Gibraltar Mines Limited	McLeese Lake, B.C.	Byproduct	36 300	10 446 035	0.011	1 013	52.72	534	72
Bethlehem Copper Corporation, Iona Mine	Highland Valley, B.C.	Byproduct	17 700	6 536 861	0.006	502	52.59	264	7
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain	Holland Twp. Gaspé, Que.	Byproduct	32 800	5 635 594	0.019	797	49.49	394	..
Total								10 029	

Sources: Energy, Mines and Resources Canada; Company annual reports.
[1] Mo contained in molybdic oxide.
tpd tonnes of ore per day; .. Not available.

Revelstoke, on the Trout Lake property. The companies plan to complete their underground sampling program in 1980. Placer Development is carrying out a diamond drilling program and engineering studies on the Ruby Creek molybdenum property near Atlin. This property was optioned from Adanac Mining and Exploration Ltd. in 1978. Mineable ore reserves of 166.6 million t grading 0.063 per cent molybdenum have been delineated. Under the terms of option, Placer has the right to earn a 70 per cent interest in this property.

In northwestern Quebec, Dumagami Mines Limited continued an exploration program to evaluate its molybdenite occurrences at a property that includes the former Preissac Molybdenum mine in the Cadillac area. The company has plans to construct a 900 tpd concentrator by 1980 at an estimated cost of $10 million.

Canadian exports of molybdenum products in 1979 decreased by more than 14 per cent to 11 483 t. The value of exports, on the other hand, increased by about 83 per cent to $250.9 millions, a reflection of price increases during the year. Imports of molybdenum in all forms increased 42 per cent to 313 900 kg, while consumption in 1979 was at 1 250 t, 2 per cent lower than 1978. Molybdenum consumption in Canada normally accounts for about 11 per cent of mine production, with the remainder being marketed abroad.

Major molybdenum 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.

Ferromolybdenum is produced in Canada by Masterloy Products Limited of Ottawa which 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 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.

As a result of the tightening of the world molybdenum market, the voluntary supply allocation system, initially set up in 1977 with the co-operation of the departments of Industry, Trade and Commerce, and Energy, Mines and Resources, was continued through 1978 and 1979. The system helps to ensure that the raw material requirements of the Canadian iron and steel industry are met.

WORLD PRODUCTION, CONSUMPTION AND DEVELOPMENTS

Western world molybdenum mine production was 89 770 t, 2 per cent higher than the 1978 figure. Output in the United States, the world's leading producer, increased by 9 per cent to 65 303 t, while production in Canada because of a labour strike was off by 30 per cent. Supplies from other sources including Chile remained essentially unchanged from the previous year.

The molybdenum market remained strong in 1979 with apparent consumption in the western world estimated at 91 000 t. Demand was particularly strong in the stainless steel and superalloys sector; consumption was again dominated by alloy steel, stainless steels and tool steels, which together account for 76 per cent of total molybdenum consumption. Growth in demand was restricted by available supply and for the sixth time in the last seven years, molybdenum consumption outstripped production. Deficits in supply were satisfied by materials held in inventory and consequently, industrial inventories were depleted to very low levels.

The mine production increase in the United States in 1979 was largely due to the increase in output at AMAX Inc.'s new Henderson Mine in Colorado. A buoyant copper market and high molybdenum prices also led to increased output of byproduct molybdenum from other copper mines.

The Henderson mine was brought on stream by AMAX in mid-1977. Production in 1979 was 19 400 t of molybdenum contained in concentrates, an increase of 4 780 t over 1978. The mine is expected to reach design capacity of 22 700 tpy of molybdenum in 1980. AMAX's other molybdenum producer, the Climax mine, produced 22 270 t of molybdenum in 1979, a 5 per cent reduction from 1978 due to lower mill-head grade. Over the next five years, molybdenum production at the Climax Mine is expected to range from 23 000 t to 30 000 t annually.

AMAX will remain the predominant world molybdenum producer as it expects to bring on stream, or commence development of, three additional mines during the next decade. These include the Kitsault mine in British Columbia, scheduled for a 1981 start-up at 4 500 tpy of molybdenum, and the Mount Tolman property which is a co-operative venture between AMAX and the Colville Indian Tribes. The ore at Mount Tolman is close enough to the surface for open-pit mining. At year-end 1979, the company estimated the property to contain 816 million t of mineralization grading 0.10 per cent molybdenite (MoS_2) and 0.09 per cent copper.

The third AMAX prospect is Mount Emmons, located near Crested Butte, Colorado, with indicated resources of 150 million t grading 0.43 per cent MoS_2. Feasibility studies have indicated the deposit would have to be mined by underground methods at an annual production rate in the range of 10 000 t to 13 600 t of molybdenum. However, Mount Emmons is located in an environmentally sensitive area and local residents are opposing the development of the property.

Molycorp, Inc., the second-largest U.S. primary molybdenum producer, began developing the Goat Hill deposit as an underground mine in 1979. The new mine, located adjacent to Molycorp's open-pit operations at Questa, New Mexico, is expected to come on stream early in 1983 and reach full capacity of 16 000 tpd of ore in 1984. Molycorp plans to produce 9 000 tpy of molybdenum when full capacity is reached, compared with 2 500 t produced from the surface mine in 1979. Mining at the Questa open pit may be terminated before the start-up of the underground mine. The company has begun constructing a new molybdenum roaster at the site of its present plant in Washington, Pennsylvania, which will be operational in 1982. The new roaster will treat molybdenum concentrates from the Goat Hill mine and the existing plant will be maintained on a standby basis.

As a result of a turn-around of the copper market in 1979, a number of past producers were reopened; this, coupled

TABLE 4. WORLD PRODUCTION OF MOLYBDENUM IN ORES AND CONCENTRATES, 1977-79

Country[1]	1977	1978[p]	1979[e]
	(tonnes Mo content)		
United States	55 523	59 802	65 303
Canada[2]	15 627	14 347	10 029
Chile	10 938	13 196	13 600
U.S.S.R.[e]	9 700	9 900	10 200
People's Republic of China[e]	1 500	1 500	2 000
Peru	463	729	816
Republic of Korea	100	366	363
Bulgaria[e]	150	150	150
Japan	203	126	136
Philippines	12	24	113
Mexico	18[e]	11	23
Total	94 234	100 151	102 733

Sources: U.S. Bureau of Mines, Mineral Trade Notes, July 1979; U.S. Mineral Commodity Summaries, January 1980; Energy, Mines and Resources Canada; Statistics Canada.
[1] In addition to the countries listed, North Korea, Nigeria and Romania are believed to produce molybdenum, but output is not reported quantitatively. [2] Mine production.
[3] Estimated; [p] Preliminary.

TABLE 5. PRINCIPAL MOLYBDENUM PRODUCERS IN THE WESTERN WORLD, 1979

Company	Country	Per cent of Production
Amax Inc.	United States	46
Corporacion Nacional del Cobre de Chile (Codelco Chile)	Chile	15
Duval Corporation	United States	11
Kennecott Copper Corporation	United States	6
Noranda Mines Limited	Canada	4
Placer Development Limited	Canada	3
Molycorp, Inc.	United States	3
Others		12
		100

with increased molybdenum output at existing mines, led to a significant increase in by-product molybdenum production. In Arizona, Duva Corporation reopened its Esperanza Mine and Cyprus Mines Corporation resumed operation at its Pima Mine in 1979. Both mines had been closed in 1977 due to the depressed copper market. In addition, Magma Copper Company resumed full production at its San Manuel Mine, while Anamax Mining Company's Twin Buttes Mine boosted its output significantly during the year.

Other sizeable U.S. operations coming on stream include Anaconda Company's Hall Mine in Nevada and Cyprus Mines Corporation's Thompson Creek Mine in Idaho. Anaconda Company announced plans to develop the Hall open-pit mine for 1981 operation with an annual production capacity of 5 400 to 6 800 t of molybdenum contained in concentrates. Cyprus Mines announced in early 1980 its decision to bring the Thompson Creek Mine into production in 1983, with capacity output of 6 800 tpy to 9 000 tpy of molybdenum targeted for 1984.

In Chile, Codelco, operator of four state-owned copper-molybdenum mines, produced about 13 600 t of molybdenum in 1979, little changed from 1978. The company is working to improve recoveries, aiming at raising its current rate of recovery from 52 per cent to a high of 70 per cent.

PRICES

Molybdenum prices increased significantly during 1979 in response to the supply and demand imbalance. In the United States, prices for export materials were set higher than domestic sales. Amax Inc.'s export price for molybdenite concentrate rose about 50 per cent to $U.S.8.84 per pound while the price of technical grade molybdic oxide for the U.S. market increased 35 per cent to $U.S.7.50 per pound of contained molybdenum. Producers of byproduct molybdenite concentrate reported sales at $U.S.20 to $23 per pound. In October 1979, dealer oxide prices, reacting to the strike at Brenda Mines and a threatened strike at AMAX's principal roaster at Langeloth, Pa., were quoted at over $U.S.28 per pound. In December, with all major strikes in Canada settled, dealer prices subsided to the $U.S. 18 to 20 per pound range. Canadian molybdenum is marketed worldwide and Noranda and Placer normally set their molybdenum prices equivalent to the U.S. export price,

PRICES

Prices in U.S. currency, per pound of contained molybdenum, fob shipping point, as reported in **Climax** and **Metals Week** as of Dec. 31

	1978[1]	1979[1]
	($)	
Molybdenum concentrates[1] 95% MoS_2	5.86	8.84
Molybdic oxide[1] (MoO_3) in cans	6.56	9.54
Ferromolybdenum[1], 60% Mo minimum	7.71	10.86
Dealer export[2] (fas port)	17.00-18.00	16.50-17.75

[1] Climax quotes. [2] Metals Week quotes.
fob Free on board; fas Free alongside ship.

both domestically and in the export market. Byproduct molybdenum producers other than the Noranda mines usually sell their concentrates to dealers at a contract price. Effective January 1, 1980, Canada's new producer price for molybdic oxide was $U.S.11.57 per pound.

OUTLOOK

Canadian molybdenum production, which attained a record level of 16 568 t in 1977, is expected to increase to 24 500 t by 1985. Molybdenum consumption in Canada could more than double if the Alaska Highway Gas Pipeline is constructed. The provision of large-diameter pipe for the Canadian portion of the pipeline will require 5 300 t of molybdenum over a three-year period. Construction of the "pre-build" portion of the pipeline could begin in 1980.

Worldwide, the molybdenum market should remain tight until 1981, after which an oversupply is expected to develop. Initial production not required for immediate consumption will be needed to rebuild stocks depleted earlier. Growth in consumption, which has been expanding at 6 to 7 per cent per year, is expected to moderate by 1982 because of substitution by other micro-alloying agents and a general maturing of the molybdenum market.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
		(%)	(%)	(%)	(%)
32900-1	Molybdenum ores and concentrates	free	free	free	free
33505-1	Molybdenum oxides	10	10	15	25
37506-1	Ferromolybdenum	free	free	5	5
35120-1	Molybdenum metal in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing or wire, for use in Canadian manufactures	free	free	free	25
92847-1	Molybdates	10	10	15	25
92856-1	Molybdenum carbides	10	10	15	25

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
33505-1	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
37506-1	5.0	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
92847-1	15.0	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2
92856-1	15.0	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free

UNITED STATES

601.33	Molybdenum ore (per lb on Mo content)	12¢	11.6¢	11.3¢	10.9¢	10.5¢	10.1¢	9.8¢	9.4¢	9.0¢
419.60	Molybdenum compounds	4.1%	4.0%	3.9%	3.8%	3.7%	3.5%	3.4%	3.3%	3.2%
606.31	Ferromolybdenum	6.6%	10¢/ lb on Mo content + 3%	10¢/ lb on Mo content + 3%	6.3%	5.9%	5.6%	5.2%	4.9%	4.5%
628.70	Molybdenum metal, waste and scrap	10.5%	9.9%	9.4%	8.8%	8.3%	7.7%	7.1%	6.6%	6.0%
628.72	Molybdenum metal, unwrought	10¢/ lb on Mo content + 3%	9.5¢/ lb on Mo content +2.9%	9¢/ lb on Mo content +2.7%	8.6¢/ lb on Mo content +2.6%	8.1¢/ lb on Mo content +2.5%	7.6¢/ lb on Mo content +2.3%	7.2¢/ lb on Mo content +2.2%	6.7¢/ lb on Mo content +2.0%	6.3¢/ lb on Mo content +1.9%
628.74	Molybdenum metal, wrought	12.5%	11.8%	11.0%	10.3%	9.6%	8.8%	8.1%	7.3%	6.6%
417.28	Ammonium molybdate	6.2%	6.0%	5.7%	5.5%	5.3%	5.0%	4.8%	4.5%	4.3%
418.26	Calcium molybdate	4.9%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.7%	4.7%
421.10	Sodium molybdate	5.1%	4.9%	4.8%	4.6%	4.4%	4.2%	4.1%	3.9%	3.7%
423.88	Molybdenum carbide	3.6%	3.5%	3.4%	3.3%	3.2%	3.1%	3.0%	2.9%	2.8%

TARIFFS (cont'd.)

EUROPEAN ECONOMIC COMMUNITY

		1979	Base Rate	Concession Rate
26.01	Molybdenum ores and conc.	free		
28.28	Molybdenum oxides and hydroxides	8.0%	8.0%	5.3%
73.02	Ferromolybdenum	7.0%	7.0%	4.9%
81.02	Molybdenum metal			
	A. Unwrought powder	6%		
	other	5%		
	B. Wrought: bars, angles, plates, sheets, strip, wire	8%		
	C. Other	10%		
28.47	Molybdates	11.2%	11.2%	6.6%
28.56	Molybdenum carbides	9.6%	9.6%	8.0%

JAPAN

		1979	Base Rate	Concession Rate
26.01	Molybdenum ores and conc.			
	A. Quota	free		
	B. Other	7.5%	7.5%	free
28.28	Molybdenum trioxide	5.0%	5.0%	3.7%
73.02	Ferromolybdenum	7.5%	7.5%	4.9%
81.02	Molybdenum metal			
	A. Unwrought, powders and flakes	5.0%	5.0%	3.7%
	B. Waste and scrap	5.0%	5.0%	3.7%
	C. Other	7.5%	7.5%	4.9%
28.47	Molybdates	7.5%	7.5%	4.9%
28.56	Molybdenum carbides	5.0%	5.0%	3.7%

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20, No. L289, 1977; Customs Tariff Schedules of Japan, 1978; GATT Documents, 1979.

Nepheline Syenite and Feldspar

B.W. BOYD

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, jetty-stone and roofing granules.

Canada's nepheline syenite industry began in 1932 with the staking of five claims on Blue Mountain, 40 kilometres (km) north-east 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 of glass. 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.

TABLE 1. CANADA, NEPHELINE SYENITE PRODUCTION, EXPORTS, 1978 and 1979 AND CONSUMPTION, 1977 and 1978

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)	599 121	14 181 840	617 000	15 180 000
Exports				
United States	395 260	9 814 000	440 526	12 026 000
Italy	10 048	373 000	11 538	276 000
United Kingdom	10 823	309 000	11 205	248 000
Australia	1 896	100 000	1 283	62 000
Netherlands	91	4 000	2 328	50 000
France	599	27 000	689	48 000
Japan	208	11 000	562	39 000
Dominican Republic	462	14 000	922	36 000
Spain	324	14 000	325	15 000
Other countries	1 251	65 000	1 677	87 000
Total	420 962	10 731 000	471 055	12 887 000

	1977	1978
Consumption[1] (available data)		
Glass and glass fibre	57 694	47 836
Ceramic products	12 183	18 691
Insulation	10 489	13 590
Paints	2 601	7 669
Rubber products	1 291	679
Others[2]	1 756	329
Total	86 014	88 794

Source: Statistics Canada.

[1] Total and breakdown by Energy, Mines and Resources Canada. [2] Includes frits and enamel, paper and paper products, plastics, electrical apparatus and other minor uses.
P Preliminary.

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 1979 were reported to be a record 390 000 tonnes (t), an increase of 2 per cent over those of 1978. 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 haualge to an adjacent mill at Nephton. The mill 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. The magnetic separation circuit of the mill was expanded in 1979. The mill operates on three shifts a day, seven days a week and now has a capacity of about 400 000 t of product annually. Finished products are transported by rail through Havelock, Ontario, 29 km south of the mill, to domestic and export markets. The United States accounts for as much as 75 per cent of Indusmin's sales.

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 t per day and shipments in 1978 were well over 200 000 t. 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 1979 total nepheline syenite shipments amounted to a record 617 000 t valued at $15,180,000, a tonnage increase of 3 per cent from 1978 and a value increase of 7 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 past decade growth was stagnant because of several factors, including strikes in the consuming industries, shortages of rail cars and, finally, stable demand. From 1975 to 1979 demand grew by about 7 per cent annually and production increases kept pace.

As a result of substitution of nepheline syenite, output of feldspar declined steadily from 55 000 t in 1947 to 5 000 t in recent years. This competition led to the 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 trail 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.

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.

An extensive body of nepheline syenite outcrops in the Bancroft area of Ontario. Small tonnages of this material were mined

TABLE 2. CANADA, NEPHELINE SYENITE PRODUCTION AND EXPORTS, 1970, 1975-79

	Production[1]	Exports
	(tonnes)	
1970	454 110	351 940
1975	468 427	356 629
1976	540 121	418 975[r]
1977	574 558	443 763
1978	599 121	420 962
1979[p]	617 000	471 055

Source: Statistics Canada.

[1] Producers' shipments.
[p] Preliminary; [r] Revised.

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 1979, 76 per cent of Canada's nepheline syenite output was exported. Sales to the United States increased 11 per cent to 440 526 t, and accounted for 94 per cent of exports. Offshore sales were 30 500 t, an increase of 19 per cent over the previous year. The United Kingdom and Italy together imported 22 700 t of the offshore total.

Domestic shipments decreased 18 per cent to an estimated 146 000 t in 1979.

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 tile. Some material with high iron content is used in the manufacture of mineral wool, and as an aggregate.

TABLE 3. CANADA, ESTIMATED FELDSPAR CONSUMPTION, 1977-79

	1977	1978	1979
	(tonnes)		
Consumption[1]			
Whiteware	3 796	4 485	4 317
Other products[2]	475	101	89
Total	4 271	4 586	4 406

Source: Statistics Canada.

[1] Breakdown by Mineral Policy Sector, Energy, Mines and Resources Canada. [2] Includes porcelain enamel, artificial abrasives and other minor uses.

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 purpose, this mineral is essential. 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. The domestic market for feldspar appears to be firm at around 4 000 to 5 000 t per year.

TABLE 4. CANADA, IMPORTS AND CONSUMPTION OF CRUDE OR GROUND FELDSPAR, 1975-79

	Imports ($)	Consumption (tonnes)
1975	..	5 630
1976	106 000	4 053
1977	275 000	4 271
1978	762 000	4 586
1979p	501 000	4 406

Source: Statistics Canada.

p Preliminary; .. Not available.

WORLD REVIEW

The Norsk Nefelin Division of Elkem Spigerverket 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 t in 1963 to 200 000 t in 1973. An expansion, completed in 1973, raised capacity from 175 000 to 225 000 t per year, and subsequently production has exceeded that level in 1978 and 1979. 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. Production in 1979 reached 242 000 t an increase of 5 per cent over 1978 production which in turn was higher by 10 per cent than 1977 production.

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 1978 and 1979 is an estimated 3 million t, an increase of 9 per cent over the production in 1977.

TABLE 5. WORLD PRODUCTION OF FELDSPAR, 1978-79

	1978	1979e
	(tonnes)	
United States	667 000	667 000
West Germany	390 000	386 000
Italy	251 000	249 000
France	191 000	191 000
Norway	71 000	68 000
Sweden	52 000	50 000
Japan	42 000	41 000
Other countries	1 415 000	1 342 000
Total	3 079 000	2 994 000

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, January 1980.

e Estimated.

OUTLOOK

The outlook for nepheline syenite continues to improve. Canadian shipments offshore, mainly to Europe have, in the last two years, exceeded pre-1970 levels. This is believed to be because of the low capacity 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 in place of feldspar in glass manufacture.

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 1960s has moderated as markets formerly supplied by feldspar approached saturation. Since 1970, average growth has been less than 3 per cent. Energy conservation considerations in glass and ceramics manufacture should maintain or increase 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

The average price for nepheline syenite in Canada was $24.60/t although products range in price from half that value to over $100/t. Prices for glass grade nepheline syenite (30 mesh) were $24 to $27/t and for ceramic grade (200 mesh, bagged) $46 to $52/t at the end of 1979. The largest export market is the United States, where entry is duty free. In the European market the competition is from the Norwegian producer, whose prices were about $83 and $126/t for the glass and ceramic grades, respectively, delivered in Europe.

PRICES OF FELDSPAR IN U.S. CURRENCY

(per short ton, bulk, f.o.b. mine or mill, carload lots depending on grade)

	($)
North Carolina	
40 mesh, flotation	41.00
20 mesh, flotation	23.50
200 mesh, flotation	52.80
Georgia	
200 mesh	51.80
40 mesh, granular	41.00
Connecticut	
200 mesh	41.75
20 mesh, granular	29.00

Source: Engineering and Mining Journal, January 1980.

f.o.b. - Free on board.

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	7 1/2%	30%	free
29640-1	Ground feldspar for use in Canadian manufactures	free	free	30%	free

Tariffs (concl'd.)

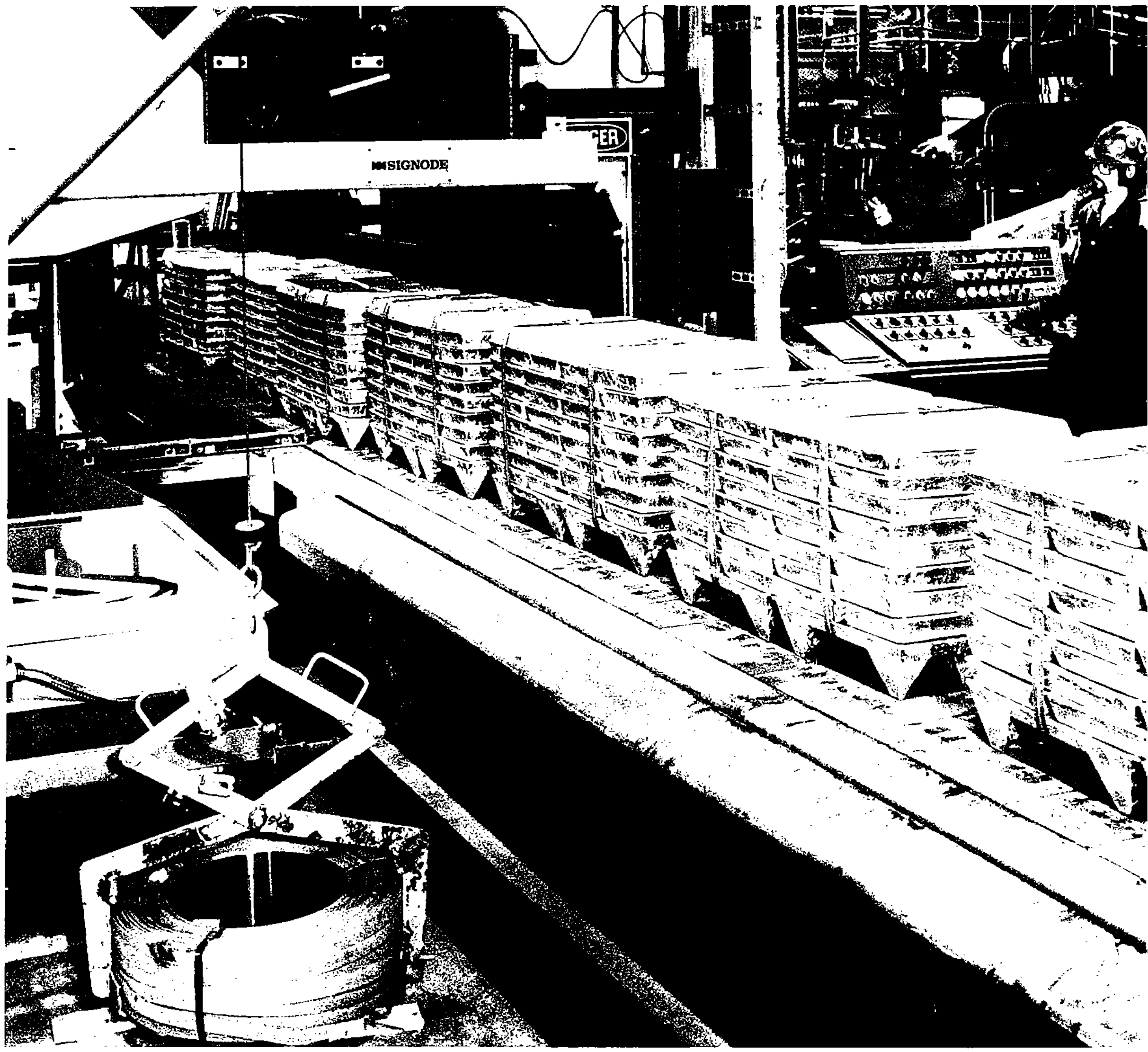
2. MFN Reductions under GATT (effective January 1 of year given)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
29625-1		7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5

United States

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
522.31	Crude feldspar					free				
						(%)				
522.41	Feldspar, crushed, ground or pulverized	3.5	3.4	3.3	3.2	3.2	3.1	3.0	2.9	2.8

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated 1978, USITC Publication 843; U.S. Federal Register Vol. 44, No. 241.



A worker operates automatic stacking equipment in the Kidd Creek mines zinc plant of Texasgulf Canada Ltd. at Timmins, Ontario, which stacks and straps skids of zinc slabs for shipment. (Herb Knott & Co. photo, courtesy of Texasgulf)

Nickel

M.J. GAUVIN

Canada's production of nickel in 1979 was 131 579 tonnes (t) valued at $826.4 million, compared with 128 310 t valued at $635.5 million in 1978. World mine production, estimated at 661 879 t for 1979 increased from the 621 210 t produced in 1978. The low level of Canadian and world production reflects the production cutbacks instituted by producers around the world and the effect of strikes, particularly in Canada. During 1979, Canada, normally the world's largest producer of nickel accounted for only 19.9 per cent of the total. The U.S.S.R. with about 21.1 per cent of world production, Australia with 12.2 per cent and New Caledonia with 11.7 per cent, together with Canada were the world's largest producers. Consumption of nickel in the non-communist world was about 610 000 t in 1979, some 16 per cent above the 1978 level.

Strong demand in 1979, a continuation of the upturn in 1978, coupled with restrained production reduced producer inventories from some 275 000 t at the end of 1978 to about 150 000 t, the low end of the range of what has been considered normal.

Prices stabilized early in the year as inventories declined and then rose sharply to all time highs.

CANADIAN OPERATIONS AND DEVELOPMENTS

Three companies mined nickel ore in Canada during 1979. 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 other concentrate producer, Union Minière Explorations and Mining Corporation Limited, operates a mine in northwestern Ontario.

Inco Limited is the world's largest producer of nickel. In 1979 it produced 115 667 t of finished primary nickel products compared with 121 110 t in 1978 and 189 150 t in 1977. Although the company instituted production cutbacks in 1977, planned production in 1978 and 1979 was further reduced by a strike at the company's Sudbury operations which began on September 16, 1978 and continued until June 5, 1979. Close to two months were required after the end of the strike to attain planned levels of production in the Ontario Division. In Ontario, the company operated ten 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. The Shebandowan facilities were brought back on stream in June. In Manitoba, Inco operated two mines, one concentrator and a smelter and refinery at Thompson. Inco also had seven mines on standby. The proven ore reserves of the company in Canada were 395 million t of ore containing 6.3 million t of nickel and 3.9 million t of copper.

TABLE 1. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
All forms				
Ontario	93 671	474,604,030	94 879	604,505,000
Manitoba	34 639	160,846,639	36 700	221,918,000
Total	128 310	635,450,669	131 579	826,423,000
Exports				
Nickel in ores, concentrates and matte[2]				
United Kingdom	16 987	86,735,000	16 002	112,143,000
Norway	22 091	75,976,000	26 734	103,628,000
Total	39 078	162,711,000	42 736	215,771,000
Nickel in oxides				
United States	21 321	92,831,000	8 413	50,177 000
EEC	4 237	20,680,000	6 101	45,512,000
Other countries	2 234	10,550,000	2 676	16,731,000
Total	27 792	124,061,000	17 190	112,420,000
Nickel and nickel alloy scrap				
United States	1 970	6,658,000	1 497	5,742,000
Netherlands	14	26,000	335	442,000
Japan	49	89,000	157	384,000
South Korea	116	533,000	70	334,000
Other countries	159	717,000	323	593,000
Total	2 308	8,023,000	2 382	7,495,000
Nickel anodes, cathodes, ingots, rods				
United States	74 242	337,106,000	56 961	333,206,000
EEC	18 785	86,419,000	17 111	99,109,000
Other countries	12 636	59,272,000	10 634	62,725,000
Total	105 663	482,797,000	84 706	495,040,000
Nickel and nickel alloy fabricated material, n.e.s.				
United States	11 974	66,594,000	9 395	65,087,000
Netherlands	36	425,000	491	3,575,000
Belgium-Luxembourg	254	1,180,000	481	2,918,000
Japan	192	996,000	405	2,351,000
Mexico	114	524,000	172	1,104,000
South Korea	3	26,000	145	858,000
Other countries	2 285	12,269,000	761	4,647,000
Total	14 858	82,014,000	11 850	80,540,000
Imports				
Nickel in ores, concentrates and scrap				
Australia	16 506	19,762,000	8 368	35,550,000
United States	4 687	3,831,000	3 252	5,355,000
South Africa	445	890,000	869	3,467,000
United Kingdom	9 968	6,333,000	4 455	2,180,000
Other countries	277	278,000	4 232	2,947,000
Total	31 883	31,094,000	21 176	49,499,000

TABLE 1. (concluded)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Nickel anodes, cathodes, ingots, rods				
United States	1 113	3,890,000	1 774	11,200,000
Norway	246	1,285,000	1 511	9,513,000
West Germany	20	154,000	11	104,000
France	-	-	19	103,000
Other countries	64	316,000	1	7,000
Total	1 443	5,645,000	3 316	20,927,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	519	3,311,000	901	3,728,000
Dominican Republic	2 000	3,282,000	85	586,000
West Germany	13	55,000	37	233,000
Other countries	43	194,000	16	77,000
Total	2 575	6,842,000	1 039	4,624,000
Nickel and alloy plates, sheet, strip				
United States	2 274	16,602,000	2 057	17,188,000
United Kingdom	31	132,000	861	7,280,000
West Germany	446	2,177,000	378	1,984,000
Other countries	21	103,000	42	90,000
Total	2 772	19,014,000	3 338	26,542,000
Nickel and nickel alloy pipe and tubing				
United States	1 361	13,857,000	1 722	22,235,000
West Germany	177	3,278,000	190	4,159,000
Sweden	22	736,000	67	890,000
Other countries	6	34,000	33	298,000
Total	1 566	17,905,000	2 012	27,582,000
Nickel and alloy fabricated material, n.e.s.				
United States	390	3,419,000	842	8,210,000
Philippines	-	-	356	1,752,000
Austria	-	-	48	601,000
United Kingdom	55	467,000	262	535,000
Other countries	228	1,293,000	54	411,000
Total	673	5,179,000	1 562	11,509,000
Consumption[3]	11 790	..	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. [2] For refining and re-export. [3] Consumption of nickel, all forms (refined metal and in oxides and salts) as reported by consumers.
P Preliminary; - Nil; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970, 1975-1979

	Production[1]	Exports In Matte etc.	Exports In Oxide Sinter	Exports Refined Metal	Exports Total	Imports[2]	Consumption[3]
				(tonnes)			
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	214 082	12 847	11 308
1976	240 825	74 296r	47 958	90 329r	212 583	16 829	9 972
1977	232 512	80 546	35 005	74 629	190 180	2 406	9 033
1978	128 310	39 078	27 792	105 663	172 533	1 443	11 790
1979P	131 579	42 736	17 190	84 706	144 632	3 316	..

Sources: Statistics Canada; Energy, Mines and Resources 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.

Falconbridge Nickel Mines Limited operated five mines, two concentrators and one smelter in the Sudbury area of Ontario. The North mine was on standby and the Fecunis concentrator was temporarily closed and on standby. The company recalled most of the employees on layoff to facilitate resumption of production at the Onaping and the East mines and to prepare the Lockerby mine for production by the end of the year. The Lockerby had been closed early in 1978, while the Onaping and East mines had been on standby since 1976. Employees at Falconbridge's Sudbury operations ratified a new collective agreement in August. The company's ore reserves at Sudbury were reported as 71.5 million t of ore containing 1.1 million t of nickel and 0.6 million t of copper.

The nickel refinery of Sherritt Gordon Mines Limited at Fort Saskatchewan, Alberta, operated at its highest level since 1972. During 1978 the company signed a long-term nickel feed contract with Inco Limited which ensured the continued viable operation of the refinery using Canadian material. The company had not had a substantial domestic source of refinery feed since the closure of its Lynn Lake mine in 1976. During 1979 the major portion of the company's refinery feed came from Inco.

Key Lake Mining Corporation is the operating company formed to develop two uranium-nickel orebodies in the Key Lake area of northern Saskatchewan. Key Lake Mining is owned by: Saskatchewan Mining Development Corporation, a provincial Crown corporation, with a 50 per cent interest; Uranerz Exploration and Mining Limited, with a one-third interest; and Eldor Resources Limited, a subsidiary of Eldorado Nuclear Limited, with a one-sixth interest. The company is planning for production in 1983. Several deposits in the Key Lake area having similar mineralogy are being explored and evaluated by other companies.

WORLD DEVELOPMENTS

While the Inco strike was the principal feature of the nickel scene during 1979, strikes at nickel producing facilities in other countries had a significant impact during the second half of the year. Production was stopped at Inco's Clydach refinery in Wales, the Louisiana plant of AMAX Nickel, Inc. and Inco's Guatemala operation. The rapid increase in prices during the first half of the year had a major impact on producers' earnings and reversed the depressing results of 1978. However, capacity utilization rates were less than 70 per cent on an aggregate basis in 1979 and a recovery to normal operating rates is not expected to occur until well into the 1980s.

TABLE 3. PRODUCING CANADIAN NICKEL MINES 1979 AND (1978)

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	12 790		..	..	2 505 670	38 308[1]	The East, Onaping and
Limited	(12 790)		(..)	(..)	(2 071 124	(32 360)[1]	Lockerby Mines reopened.
Falconbridge, Strathcona,							
East, Onaping and	2 720	(Falconbridge)					
Lockerby mines	7 710	(Strathcona)					
Falconbridge	2 360	(Fecunis Lake)					
Inco Limited	69 300		..	..	5 339 280[2]	100 699[3]	Production limited by the
Clarabelle, Coleman,	(69 300)		..	..	(7 748 515)[2]	(121 246)[3]	strike.
Copper Cliff South,	31 800	(Clarabelle)					
Creighton, Frood-Stobie,	21 800	(Frood-Stobie)					
Garson, Levack	5 400	(Levack)					
McCreedy West and Little	10 300	(Creighton)					
Stobie mines							
Sudbury							
Shebandowan mine	2 720		..	..	See above[2]	See above[3]	
Shebandowan	(2 720)		(..)	(..)	(See above)[2]	(See above)[3]	
Noranda Mines Limited	-		-	-	-	-	Mine closed in March 1978.
Langmuir Township	(635)		(1.39)	(..)	(65 427)	(637)	
Union Minière Explorations	3 600		0.11	1.15	956 291	242	Production was below
and Mining Corporation	(3 600)		(0.13)	(1.29)	(836 119)	(168)	capacity due to weak
Limited (UMEX)							copper markets.
Thierry mine							
Manitoba							
Inco Limited	12 700		..	..	2 269 703	See above[3]	Production limited by the
Pipe, No. 2 and Thompson	(12 700)		..	..	(2 139 900)	(See above)[3]	strike.
Thompson							

[1] Total nickel deliveries. [2] Includes Shebandowan. [3] 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, Hainault Township	900 Ni(0.69) Cu(0.72)	..	..	Surface buildings destroyed by fire in 1974, will have to be rebuilt.
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge	.. Ni(..) Cu(..)		Falconbridge	
Fraser mine				Under development for production in 1981.
Onex mine				Development deferred.
Thayer Lindsley mine				Development deferred.
North mine				Placed on standby, 1978.
Inco Limited, Sudbury	.. Ni(..) Cu(..)		Sudbury	
Copper Cliff North mine		..		Placed on standby, 1978.
Crean Hill mine		..		Placed on standby, 1978.
Fecunis mine				Acquired in an exchange with Falconbridge, on standby.
Levack East mine		..		Development deferred.
Murray mine		..		Placed on standby, 1971.
Totten mine		..		Development suspended, on standby.
Great Lakes Nickel Limited, Pardee Township	66 million tonnes reserves Ni(0.20) Cu(0.40)	..	..	Development to bring property on at a rate of 2.25 million tonnes of ore per year have been suspended and the project put on standby, 1974.
Teck Corporation, Montcalm Township	4.5 million tonnes reserves Ni(1.4) Cu(0.66)	..	..	Feasibility study completed. Development decision deferred pending an improvement in nickel markets.
Manitoba				
Inco Limited, Thompson	.. Ni(..) Cu(..)		Thompson	
Birchtree		..		Production suspended and placed on standby, 1977.
Pipe No. 1 mine		..		Development suspended 1977, on standby.
Soab		..		Placed on standby, 1971

Source: Energy, Mines and Resources Canada.
.. Not available.

The overseas operations of Inco Limited in Guatemala and Indonesia continued the startup phase of their operations. In Guatemala, most technical problems have been overcome at the 80 per cent owned Exploraciones y Explotaciones Mineras Izabal SA (Exmibal) project which has an annual capacity of 12 700 t of nickel contained in matte. Production in 1979 was about half its rated capacity. In Indonesia, technical problems at the 96 per cent owned P.T. International Nickel Indonesia held the company's production to some 11 300 t compared with the combined annual capacity of Stages I and II of approximately 45 000 t. The problem has been with the lining of the electric furnaces, due primarily to the silicic nature of the ore being mined in the initial stages.

In March, Falconbridge's subsidiary in the Dominican Republic, Falconbridge Dominicana, C por A, reactivated a second production line which had been shut down early in 1978 and ferronickel production was increased from 45 per cent to about 90 per cent of capacity.

TABLE 5. WORLD PRODUCTION OF NICKEL, 1978 and 1979

	1978	1979e
	(tonnes)	
U.S.S.R.e	140 000	140 000
Canada1	128 310	131 579
Australia	80 900	80 900
New Caledonia	66 100	77 500
Cuba	37 000	37 000
Philippine Republic	29 500	33 300
Indonesia	20 000	25 500
South Africa	22 500	24 600
Dominican Republic	14 300	23 500
Botswana	16 100	16 200
Greece	15 100	14 400
United States	12 300	12 300
Zimbabwe	11 000	11 000
Guatemala	1 800	6 400
Other	26 300	27 700
Total	621 210	661 879

Sources: World Bureau of Metal Statistics, May 1980; Energy, Mines and Resources Canada.
1 Production all forms.
e Estimated.

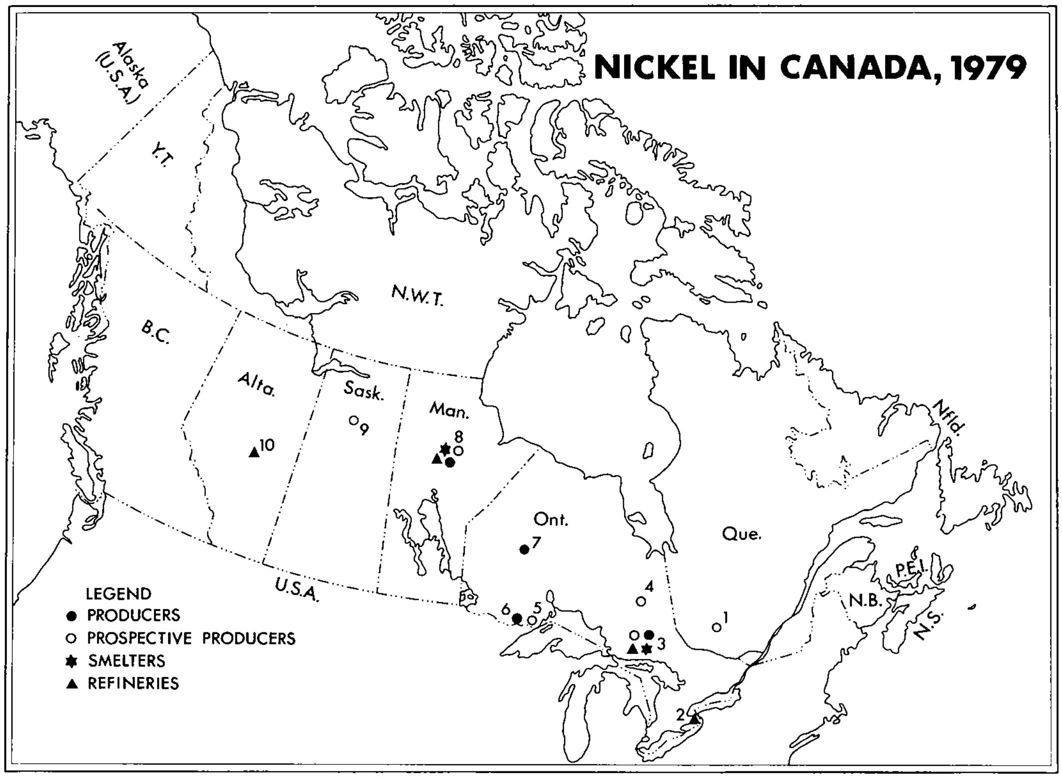
Société Métallurgique Le Nickel (SLN) increased production in New Caledonia. SLN's new 16 000 t a year nickel refinery at Sandonville, France suffered serious fire damage which stopped production for about nine months.

The $100 million Agnew mine in Western Australia, owned by Selection Trust Limited and M-I-M Holdings Ltd., was brought up to its planned rate of 10 000 t a year of nickel. All output up to a maximum of 15 000 t of contained nickel a year has been sold to AMAX Nickel, Inc. for a period of 10 years from the start of commercial production. Concentrates are shipped to the Western Mining Corporation Limited smelter and the resulting matte is shipped to AMAX Nickel's refinery at Port Nickel, Louisiana. Agnew plans to boost its rate to 12 000 t a year in 1980.

Cerro Matosa SA has started construction to bring its nickel deposit in northern Colombia into production in 1982. The project will have an annual capacity of 22 600 t of nickel in ferronickel grading 35 to 40 per cent nickel. The company has obtained loans totalling $225 million from the World Bank, the US Export-Import Bank and a banking syndicate headed by The Chase Manhatten Corporation. The project is owned by the state nickel company, Econiquel of Colombia, with a 45 per cent interest, Billiton NV with 35 per cent and The Hanna Mining Company with 20 per cent. The entire production will be purchased and marketed by the Billiton organization.

Cuba is continuing with the rehabilitation and expansion of its Nicaro and Moa Bay facilities. A third facility, with a design capacity of 30 000 t of nickel annually, is being constructed at Punta Gorda and is scheduled for completion in 1982. In Brazil, a $98 million nickel mining and smelting project in Goias state is being financed in part by the International Finance Corporation. The project, owned by Empresa de Desenvolvimento de Recursos Minerais SA (Codemin), will have a 5 000 t ferronickel smelter and is expected to be in production in 1982.

Matthey Rustenburg Refiners (Pty) Limited is building a new byproduct nickel refinery in South Africa. The plant will have a capacity of 18 600 t a year of nickel and will replace the present 15 000 tpy plant.



Producers

3. Falconbridge Nickel Mines Limited (Falconbridge, Strathcona, East, Onaping and Lockerby)
   Inco Limited (Clarabelle, Coleman, Copper Cliff South, Creighton, Frood-Stobie, Garson, Levack, McCreedy West, and Little Stobie)
6. Inco Limited (Shebandowan mine)
7. Union Minière Explorations and Mining Corporation Limited (Thierry mine)
8. Inco Limited (Pipe No. 2 and Thompson mines)

Prospective Producers

1. Renzy Mines Limited (Hainault Township)
3. Falconbridge Nickel Mines Limited (North, Fraser, Onex and Thayer Lindsley mines)
   Inco Limited (Murray, Totten, Copper Cliff North, Crean Hill and Fecunis)
4. Teck Corporation (Mountcalm Township)
5. Great Lakes Nickel Limited (Pardee Township
8. Inco Limited (Soab mine, Birchtree, Pipe No. 1)
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. UNITED STATES NICKEL PRICES IN UNITED STATES DOLLARS PER POUND, 1979

	Jan. 1	Feb. 2	Feb. 9	Mar. 13	Apr. 9	May 4	May 14	June 7	June 11	Dec. 4	Dec. 10	Dec. 19	Dec. 31
AMAX, briquettes	2.12	2.12	2.05	2.25	2.50	2.85	2.85	2.85	3.00	3.00	3.00	3.20	3.20
Falconbridge, electrolytic	2.08	2.05-2.10	2.05-2.10	2.25-2.30	2.50-2.55	2.50-2.90	2.85-2.90	2.85-3.05	3.00-3.05	3.00-3.25	3.20-3.25	3.20-3.25	3.20-3.25
Inco, pellets	1.93[1]	2.05	2.05	2.25	2.50	2.50	2.85	3.00	3.00	3.20	3.20	3.20	3.20
Falconbridge, ferronickel[2]	2.00	2.00	2.025	2.24	2.49	2.84	2.84	2.84	2.99	2.99	3.19	3.19	3.19
Hanna, ferronickel[2]	1.88	1.88	1.88	1.88	1.88	1.88	2.80	2.80	2.95	2.95	3.15	3.15	3.15

Sources: **Metals Week; American Metal Market.**
[1] Consumer quotations. [2] Per pound of contained nickel.

The development of two nickel projects in Indonesia was postponed temporarily. The 50 000 t Gag Island nickel mining, smelting and refining project of P.T. Pacific Nikkel Indonesia, a joint venture of United States Steel Corporation, Amoco Minerals Company and Koninklijke Hoogovens, has been deferred because of the global oversupply of nickel. For the same reason, the Japanese Development Company postponed plans to develop a nickel mine on Gebe Island. However, the project was later revived in partnership with the Indonesian government and may eventually include a ferronickel plant. Japanese nickel refiners reached agreement with Indonesia's P.T. Aneka Tambang for supplies of nickel ore and the agreement has become the basis of settlement with ore producers in other countries.

LAW OF THE SEA (LOS)

The resumed Eighth Session of the Third UN Conference of the Law of the Sea was held in New York from July 18 to August 24, 1979. Negotiations have been progressing on the form of regime that would govern the exploration and exploitation of seabed resources such as manganese nodules in the proposed International Seabed Area beyond national jurisdiction.

Negotiation texts emerging from the LOS Conference propose the establishment of an International Seabed Authority, a parallel system of exploitation involving access by mining corporations, the reservation of certain areas of the seabed for the Enterprise (an arm of the Authority) and a contract system of exploitation. Countries with land-based nickel production and a number of other countries felt that seabed resources should be phased in to meet growing world consumption.

While producing and consuming countries are not in complete agreement, there has been an **ad referendum** agreement between the Canadian and United States delegations on a production ceiling for seabed production based on world nickel consumption. Known as the 60/40 formula, it would allow seabed productions to equal the total incremental growth in world nickel consumption for the five years prior to the first commercial production, plus 60 per cent of the incremental growth in consumption thereafter as calculated by a formula.

At the end of the March-April meetings of the eighth session of the conference held in Geneva this formulation was incorporated in a revision of the informal composite negotiating text (ICNT-Rev 1). Most of the industrialized mineral consuming countries, including the United States, are pressing for the inclusion of a so-called "floor" mechanism that would establish a minimum guaranteed level of production available to seabed, irrespective of that stipulated by the production ceiling or market conditions. Such proposals have met considerable resistance, and as of the completion of the resumed session in August in New York, no resolution, had been reached. The financial obligations of contractors, the transfer of technology and the decision-making powers of the Authority are other aspects of the treaty that need resolution.

Work to determine the economics of deep seabed mining is being carried out by five consortia that represent interests in the United States, West Germany, Japan, Canada, the Netherlands and Belgium. Three consortia, Ocean Mining Associates, Ocean Management Inc. and Ocean Minerals Company completed prototype mining and lift system tests during 1978 and 1979.

A few countries have considered that there is need for interim legislation to license seabed exploration, and possibly exploitation, in advance of a full Law of the Sea Treaty. Bills dealing with these issues were introduced in the United States Congress during 1979.

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 stand-by power application. General Motors Corporation has announced the development of a zinc-nickel oxide battery which is stated to have up to 2.5 times the energy storage capacity of the conventional lead-acid battery. The fledging solar energy industry could provide a market for increasing amounts of nickel alloys where there is a need for durability and corrosion resistance.

OUTLOOK

Non-communist world nickel consumption is expected to drop somewhat in 1980. Nickel demand is related to economic activity and providing the recession predicted by economists is no worse than expected, the drop in demand is not expected to be severe.

Even though inventories are back to normal, nickel producers are still facing several difficult operating years, mainly because of much installed capacity that remains excess to needs. New capacity coming on stream could add a further 130 000 t to finished nickel capacity over the next five years. The chaotic conditions in the nickel market of the past few years are still fresh in the minds of nickel producers so that it is unlikely they will allow inventories to reach the excessive levels that prevailed during the last few years. Producers are expected to be cautious and to maintain restraints on production.

PRICES

Reduced production together with increased demand reduced producer inventories to normal levels in 1979. In the process, discounting was eliminated and prices which had stabilized early in 1979 rose sharply by year-end. At the beginning of February, Inco published list prices for its nickel products for the first time since July 1977. The prices of melting nickel and plating were set at that time at $2.05 (all prices are in United States funds) and $2.10 a pound respectively. Through a series of four price increases the price of plating nickel was increased to $3.05 by early June, and was maintained until December when the price of all nickel products were increased by 20 cents a pound. At year-end the posted prices for nickel products were: plating nickel, $3.25 a pound; melting nickel, $3.20 a pound; and charge nickel, nickel oxides and ferronickel from $3.08 to $3.29 a pound.

The London Metal Exchange (LME) started dealings for a three month nickel future contract on April 23, and spot trading commenced on July 23. The trading of nickel on the LME was strongly opposed by the established nickel producers who saw it as providing opportunity for speculation in a key industrial metal and as being potentially harmful both to consumers and to producers. The LME was of the opinion that the new contract would give greater depth to the market and provide needed hedging facilities. The standard contract of 6.0 tonnes may be in cathode, pellets or briquettes of a minimum 99.8 per cent purity. The 6.0 tonne contract conforms to the standard Russian delivery parcel. The nickel is delivered in sealed drums to LME warehouses where the drums are emptied, inspected and resealed.

TARIFFS

CANADA

Item No.		General Preferential	British Preferential	Most Favoured Nation	General
32900-1	Nickel ores	free	free	free	free
33506-1	Nickelous oxide	10%	10%	15%	25%

CANADA (continued)

Item No.		General Preferential	British Preferential	Most Favoured Nation	General
35500-1	Nickel and alloys containing 60% or more nickel by weight, not otherwise provided for, viz: ingots, blocks and shot; shapes or 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.	6 1/2%	10%	10%	20%

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
33506-1	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
37506-1	5.0	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
44643-1	10.0	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8

TARIFFS (concluded)

UNITED STATES

Item No.		
419.72	Nickel oxide	free
423.90	Mixtures of two or more inorganic compounds in chief value of nickel oxide	free
601.36	Nickel ore	free
603.60	Nickel matte	free
606.20	Ferronickel	free
620.03	Unwrought nickel	free
620.04	Nickel waste and scrap	free
620.32	Nickel powders	free
620.47	Pipe and tube fittings if Canadian article and original motor vehicle equipment	free

		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
419.70	Nickel chloride	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
419.74	Nickel sulfate	5.0	4.8	4.6	4.3	4.1	3.9	3.7	3.4	3.2
419.76	Other nickel compounds	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
426.58	Nickel salts: acetate	5.0	5.0							
426.62	Nickel salts: formate	5.0	5.0							
426.64	Nickel salts: other	5.0	5.0							
620.08	Nickel plates and sheets, clad	12.0	11.3	10.5	9.8	9.0	8.3	7.5	6.8	6.0
620.10	Other wrought nickel, not cold worked	5.0	4.8	4.6	4.4	4.3	4.1	3.9	3.7	3.5
620.12	Other wrought nickel, cold worked	7.0	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
620.16	Nickel, cut, pressed or stamped to nonrectangular shapes	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
620.20	Nickel rods and wire, not cold worked	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
620.22	Nickel rods and wire, cold worked	7.0	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
620.26	Nickel angles, shapes and sections	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
620.30	Nickel flakes, per pound	5.0¢	4.4¢	3.7¢	3.1¢	2.5¢	1.9¢	1.2¢	0.6¢	free
620.40	Pipes, tubes and blanks, not cold worked	3.0	2.9	2.9	2.8	2.8	2.7	2.6	2.6	2.5
620.42	Pipes, tubes and blanks, cold worked	4.0	3.9	3.8	3.6	3.5	3.4	3.3	3.1	3.0
620.46	Pipe and tube fittings	9.0	8.3	7.7	7.0	6.3	5.6	5.0	4.3	3.6
620.50	Electroplating anodes, wrought or cast, of nickel	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
642.06	Nickel wire strand	7.0	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
657.50	Articles of nickel, not coated or plated with precious metal	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Phosphate

G.S. BARRY

Phosphorus (P) is essential to all plant and animal life. Most soils contain phosphorus in two forms: in the apatite minerals and certain iron and aluminum phosphates; and in organic compounds. As a plant nutrient soil phosphorus is classified as: available with difficulty - most calcium and magnesium phosphates (apatite), some iron and aluminum compounds, and slowly decomposing organic matter; moderately available - some iron, aluminum and calcium compounds and rapidly decomposing organic matter; and readily available - phosphates that are soluble in water and weak acids. Applications of soluble "phosphoric acid" to the soil provide plants with available phosphorus.

Naturally occurring rock deposits, are the most common source of phosphorus; others are bones, guano, and some types of iron ores that yield byproduct basic slag containing sufficient phosphorus to warrant grinding and marketing.

Phosphate rock, (commonly referred to in the trade as "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,Cl,OH).

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.

Approximately 80 per cent of world phosphorus consumption goes into fertilizers; other uses include organic and inorganic chemicals, soaps and detergents, pesticides, insecticides, alloys, animal-food supplements, motor lubricants, ceramics, beverages, catalysts, photography, and in dental and silicate cements.

World fertilizer demand increased in 1979 for the fourth consecutive year and sales of phosphate rock showed a significant rise. Apparent consumption (deliveries) was 131.0 million tonnes (t) of phosphate rock, higher than production recorded at 130.4 million t. Export sales of phosphate rock increased by 3.1 per cent to 53.5 million t. Furthermore exports of phosphoric acid from Morocco, Tunisia and South Africa increased significantly. A 1979 survey of phosphoric acid plants conducted by the International Phosphate Industry Association (ISMA) placed world plant capacity at 28 741 000 t P_2O_5 per annum.

The average grade of western world phosphate rock produced in 1979 declined nearly 1 per cent compared to 1978. This is a trend that will continue for some time.

TABLE 1. CANADA, PHOSPHATE ROCK IMPORTS, 1978 AND 1979, AND CONSUMPTION, 1977 AND 1978

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Imports				
United States	2 952 737	76 202 000	3 256 733	95 846 000
Netherlands Antilles	2 617	193 000	1 587	146 000
Morocco	6 000	72 000	138	7 000
Israel	24	1 000	-	-
Total	2 961 378	76 468 000	3 258 458	95 999 000

	1977	1978P
	(tonnes)	(tonnes)
Consumption[1] (available data)		
Fertilizer, stock and poultry feed	1 522 018	1 547 270
Other[2]	149 381	286 526
Total	1 671 399	1 833 796

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Breakdown by Energy, Mines and Resources Canada. [2] Includes chemicals, refractory and foundry uses.
P Preliminary; - Nil.

Canada imports all of its phosphate rock requirements, mainly from the United States. Imports in 1979 were 3 256 733 t, an increase of 10.0 per cent. The value of imports was $96 million. In terms of unit value the price rose by 14.1 per cent from $25.82 per t in 1978 to $29.46 per t in 1979.

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 Lièvre River area of southwestern Quebec, where many deposits were worked extensively between 1869 and 1900, before low-cost Florida rock entered world markets.

Carbonatites usually occur as roughly circular plugs intruding older metamorphic rock.

In 1975, International Minerals & Chemical Corporation (Canada) Limited (IMCC) began work on a phosphate deposit which was discovered in 1967 in a weathered carbonatite complex in Cargill Township near Kapuskasing, northwestern Ontario. Some 190 drill holes were completed in 1975-76 and reserves of about 60 million t grading 20 per cent P_2O_5 were outlined. A feasibility study completed late in 1976 indicated that the deposit was sub-economic, but held prospects for future development. In 1979, Sherritt Gordon Mines Limited took a three year option to buy the property from IMCC.

The company commenced additional drilling and intends to proceed with full evaluation of the deposit which would include a shallow test shaft and pilot plant processing. Up to $5 million could be spent on this project. Because the domestic production of phosphoric acid would result in neutralization of sulphuric acid which will be increasingly available in northwestern Ontario and thus have a favourable environmental impact, financial help through grants from the Department of Regional Economic Expansion (DREE) is being considered.

If the exploration and testing of the Cargill deposit continues to yield positive results production by the 1983 to 1985 period is envisaged. However, there is also a possibility that development would be postponed until the 1990s when rock imported from Florida is forecast to become more expensive. 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 t of mineralized rock of which 5 million t in one 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.

TABLE 2. CANADA, PHOSPHATE FERTILIZER SHIPMENTS, 1976-79[1]

	1975/76	1976/77	1977/78	1978/79	1979 July-December
			(tonnes P_2O_5 equivalent)		
Domestic markets					
Atlantic provinces	23 702	25 407	28 578	18 867	9 022
Quebec	38 061	40 554	34 935	23 540	8 678
Ontario	88 918	83 484	78 158	63 379	32 521
Manitoba	59 952	63 008	81 687	89 576	46 437
Saskatchewan	79 123	75 786	110 351	131 636	70 707
Alberta	97 599	105 631	121 531	140 880	59 048
British Columbia	8 116	8 665	9 879	12 440	2 905
Total Canada	395 472	402 535	465 120	480 318	229 318
Export markets					
United States	159 625	179 699	153 305	144 670	87 669
Offshore	40 868	50 851	31 120	46 814	31 654
Total exports	200 493	230 550	184 425	191 484	119 323
Total shipments	595 964	633 085	649 545	671 803	348 641

Source: Canadian Fertilizers Institute. (shipments by Canadian producers).

[1] Fertilizer year: July 1 to June 30.
Note: Totals may not add due to rounding.

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. Co-products of the process are ferrophosphorus, carbon monoxide and calcium silicate slag. About 9 t of phosphate rock grading 66 to 68 per cent BPL are required to manufacture 1 t of phosphorus. Although elemental phosphorus can be used for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds. There are two plants producing elemental phosphorus in Canada, one in Newfoundland and one in Quebec. Erco Industries Limited operated its reconstructed No. 2 furnace at Long Harbour, Newfoundland in mid-1978, restoring its effective capacity to 72 500 tpy. Due to market conditions, Canadian elemental phosphorus plants operated at about 75 per cent capacity during 1979.

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.

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 co-product of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce 1 t of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 t of phosphate rock (70 to 72 per cent BPL) and 0.47 t of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluid slurry that facilitates removal of calcium sulphate by filtering. Filtered acid containing 30 to 32 per cent P_2O_5 equivalent may be used, either directly in the manufacture of phosphate fertilizers, or concentrated by evaporation to as high as 54 per cent P_2O_5 equivalent prior to further use or sale as "merchant acid". Further concentration is less common but may be pursued to produce viscous liquids known as superphosphoric acids.

TABLE 3. WESTERN WORLD PRODUCTION OF PHOSPHATE ROCK, 1977-1979

	1977	1978	1979P
	(000 tonnes)		
United States	47 256	50 037	51 611
Morocco	17 259	19 678	20 175
Tunisia	3 614	3 712	4 040
South Africa	2 403	2 699	3 221
Togo	2 857	2 827	2 916
Jordan	1 782	2 303	2 826
Israel	1 232	1 759	2 216
Nauru	1 146	1 999	1 838
Senegal	1 802	1 762	1 804
Brazil	608	1 094	1 695
Christmas Island	1 260	1 386	1 357
Syria	425	800	1 170
Algeria	997	1 136	1 084
Total	82 641	91 192	95 953

Source: The British Sulphur Corporation Limited, Phosphorus and Potassium.

Typical raw material requirements per 1 t P_2O_5 equivalent produced are 3.1 t of phosphate rock (74 to 75 per cent BPL) and 2.6 t of sulphuric acid (100 per cent basis). Also, for every t P_2O_5 equivalent produced, about 4.5 t 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, 11-55-0 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 1 045 000 t P_2O_5 equivalent.

During 1979 good progress was made on the construction of a uranium oxide recovery plant. Earth Sciences Incorporated (ESI) designed the plant 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 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

TABLE 4. CANADA, PHOSPHORUS AND PHOSPHATE FERTILIZER PLANTS, 1979

Company	Plant Location	Annual Capacity (tonnes)	Principal End Products	Source of Phosphate Rock	Basis for H_2SO_4 Supply for Fertilizer Plants
Elemental phosphorus					
Erco Industries Limited	Varennes, Quebec	18 000	el ph	Florida and	
	Long Harbour, Nfld.	72 500	el ph	N. Carolina	
Total elemental phosphorus		90 500			
Phosphate fertilizer					
		(P_2O_5eq.)			
Canada Wire and Cable Limited	Belledune, N.B.	150 000	am ph	Florida	SO_2 smelter gas
Canadian Industries Limited	Courtright, Ont.	90 000	am ph	Florida	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	86 000	am ph	Montana	SO_2 smelter gas
	Trail, B.C.	82 000	am ph	Utah	SO_2 smelter gas
International Minerals & Chemical Corporation (Canada) Limited	Port Maitland Ont.	130 000	H_3PO_4, ss ts, ca ph	Florida	sulphur, SO_2 smelter gas
Esso Chemical Canada	Redwater, Alta.	204 000	am ph	Florida	sulphur
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	41 000	am ph	Florida	sulphur
Western Co-operative Fertilizers Limited	Calgary, Alta.	192 000	am ph	Idaho	sulphur
	Medicine Hat, Alta.	70 000		Idaho	
Total, phosphate fertilizer		1 045 000			

Source: Energy, Mines and Resources Canada.

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; H_3PO_4 is made elsewhere.

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 3.12 per cent from 51 869 000 t in 1978 to 53 491 000 t in 1979. In addition some 4 million t in trade was ascribed to East European countries. The quantity of P_2O_5 traded each year as both phosphoric acid and fertilizers is steadily rising and reached 28 per cent of all phosphate trade.

Morocco. L'Office Chérifien des Phosphates (OCP) sold 18.0 million t of phosphate rock from Morocco and West Sahara in 1979. Through expansion and new operations at

TABLE 5. CANADA, TRADE IN SELECTED PHOSPHATE PRODUCTS, 1978 and 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Imports				
Calcium phosphate				
United States	17 439	5 895 000	15 538	6 106 000
South Africa	-	-	3 908	883 000
Total	17 439	5 895 000	19 446	6 989 000
Fertilizers:				
Normal superphosphate, 22% or less P_2O_5				
United States	3 999	513 000	1 718	250 000
Triple superphosphate, over 22% P_2O_5				
United States	46 184	5 589 000	71 850	10 878 000
Phosphatic fertilizers, nes				
United States	231 735	39 322 000	306 249	62 706 000
Belgium-Luxembourg	664	292 000	1 320	684 000
Israel	513	314 000	697	442 000
Trinidad-Tobago	-	-	4	2 000
Portugal	3 125	815 000	-	-
France	36	16 000	-	-
Total	236 073	40 759 000	308 270	63 834 000
Chemicals:				
Potassium phosphates				
United States	1 417	1 105 000	1 086	1 001 000
Israel	-	-	91	70 000
France	-	-	18	18 000
Other	8	8 000	2	6 000
Total	1 425	1 113 000	1 197	1 095 000
Sodium phosphate, tribasic				
United States	1 191	234 000	613	244 000
West Germany	60	29 000	18	45 000
France	23	7 000	88	29 000
Belgium-Luxembourg	34	8 000	37	9 000
Netherlands	53	21 000	18	5 000
Taiwan	5	2 000	-	-
Total	1 366	301 000	774	332 000
Exports				
Nitrogren phosphate fertilizers, nes				
United States	350 563	49 990 000	418 566	64 813 000
Pakistan	111 413	19 924 000	60 275	12 629 000
Belgium-Luxembourg	-	-	27 312	5 476 000
Paraguay	21	3 000	16	11 000
Thailand	10 291	1 227 000	-	-
New Zealand	550	57 000	-	-
United Kingdom	49	14 000	-	-
Total	472 887	71 215 000	506 169	82 929 000

Source: Statistics Canada.

P Preliminary; nes Not elsewhere specified; - Nil.

four sites, Morocco plans to expand phosphate production to about 25 million t in 1985. Morocco now uses 2.23 million t of phosphate rock to produce phosphoric acid and fertilizers that are exported. On a long term basis Morocco intends to process about one-third of all phosphate exports. Maroc Chimie (OCP Group) operates two phosphoric acid plants at Safi with a total capacity of 305 000 t P_2O_5. Maroc Phosphore I, a 495 000 tpy P_2O_5 phosphoric acid plant which began operating in 1975, is working well and construction is to begin on a fourth unit of 165 000 tpy capacity, due on stream in 1980-81. Maroc Phosphore II, which will have a capacity of 495 000 tpy P_2O_5, is also on schedule and will come on stream in 1980. Furthermore, Maroc Phosphore plans to construct a 695 000 t plant - Phosphore III or Jorf Lasfar I - in the mid-1980s.

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. The war between Morocco and the Polisario prevented OCP from mining the Bu Craa deposit for the third consecutive year.

United States. The United States exported 14 779 000 t of phosphate rock in 1979, 8.0 per cent more than in 1978. Generally exports increased to all markets except Iran which lost its annual shipments of some 500 000 t. The United States started first time shipments of similar quantities to Australia and New Zealand.

Construction was under way at the CF Industries, Inc. Hardee Co. mine in Florida, due in production in 1980 at 2 million tpy and at the Baker/Western Fertilizers Soda Springs mine in Idaho due for production in 1981-82 at 3.6 million tpy. Amax-Phillips Petroleum Company partnership plans to open a 4.0 million tpy mine on the Desoto-Manatee Counties in Florida by 1982. Amax acquired the property of Noranda Phosphate Inc., a holder of an undeveloped phosphate deposit next to the proposed joint venture. In exchange Noranda Mines Limited assumed ownership of Heath Steele Mines Limited a base metal mine in New Brunswick.

W.R. Grace and Company and International Minerals & Chemical Corporation (IMC) established a joint venture to develop the Four Corners mine near Bradenton, Florida by 1982 at a capacity of 3 to 4 million tpy. W.R. Grace and Co. also has a deposit in Hardee County which it plans to bring into production at about 3 million tpy. Texasgulf Chemicals Company will expand its Lee Creek mine in North Carolina from 3.5 to 5.0 million tpy by 1982. NC Phosphate, a joint venture by Agrico Chemical Co. and Kennecott Copper Corporation plan to open a 4 million tpy mine at Canvas Creek in North Carolina. Estech General Co. in partnership with Zen-Noh, Mitsubishi and Royster Co. plans to open a new 3.1 million t mine in Manatee County by 1983. It will replace the Silver City mine due to close that year.

A study on phosphate reserves carried out by the U.S. General Accounting Office (GAO) claimed that "the best data available now shows phosphate reserves at 2.2 billion t, and indicates that these will be adequate for the next 20 years. Production is expected to peak within 10 years and decline thereafter." The study was mainly based on USBM data that count into reserves only material that can be mined at less than $15 per t. Spokesmen for U.S. industry disputed this thesis stating, for example, that there are vastly larger quantities of material mineable in the $15 to $40 per t range and that it will become economically viable to mine it in the future.

U.S.S.R. The Soviet Union produces between 22 and 24 million t of phosphate rock annually. Production was steady for many years but declined rapidly in the past two years due to ore depletion, principally in mines in the Kola Peninsula. The country's exports declined substantially for a few years from 6 million t level in 1972 to 3.7 million t in 1978-79. Western Europe, which obtained about 2 million tpy in the early 1975s, imported less than 400 000 t in 1979. In particular, the U.S.S.R. withdrew the export of the high grade Kola apatite concentrates which have very few world suppliers and command increasingly higher premiums.

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 tpy of 70 per cent P_2O_5 superphosphoric acid for 20 years, starting in 1980. Small shipments of potash and ammonia from the U.S.S.R. were made in 1978 and 1979 but further expansion of this two way trade was prevented by major supply difficulties on the part of the U.S.S.R., followed by the U.S. trade embargo on grains and phosphatic fertilizers as a result of the invasion of Afghanistan.

Togo. This country produced 2.916 million t of phosphate in 1979. Exports of this high-grade material (78 to 81 per cent TPL - average 36.15% P_2O_5) 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 tpy by 1980.

Banaba. In November 1979 the last shipment of phosphate rock was made from Banaba, Pacific Islands. Exports declined steadily from the three-quarters of a million t level to 372 000 t in 1979. Production in 1979 was recorded at 419 800 t. Banaban rock will be particularly missed because it was very high grade, 83 to 88 per cent BPL. Australia and New Zealand will replace Banaban rock mainly with imports from the United States.

Jordan. This country produced 2.825 million t of rock in 1979 and exported 2.7 million t. Further expansion of the El Hasa deposit was undertaken in 1979 and capacity will be raised to 3.5 million t by 1980. In addition the Jordan Phosphate Mines Co. Ltd. intends to commission the Jebel-El-Abiuth mine in early 1980 with a total annual capacity of 1.5 million t of phosphate rock (to be reached by 1982).

Mexico. In 1979 Mexico produced only 123 000 t of rock grading 33 per cent P_2O_5. Mexico now imports almost all of its phosphate rock for fertilizer production but has large reserves in Baja, California. A phosphate rock mine is under construction and will come on stream in mid-1980 at San Juan de la Costa at a capacity of 750 000 tpy. Another 1.5 million tpy mine is scheduled for production in 1982 at San Domingo. Longer term plans presented by Rofomex S.A. two years ago called for a large 5 million tpy mine in the mid-1980s.

Israel. Israel's rock exports increased from 1.4 to 1.7 million t as a result of expansion of the Nahal Zin mine from 1.5 to 2.0 million tpy capacity, completed late in 1979.

Australia. Western Mining Corporation closed its Duchess phosphate mine in 1978, but the company plans to reopen the deposit at a reduced capacity of 250 000 tpy by March 1981. Australia imports about 2.5 million t of rock annually.

Brazil. Besides large imports of finished phosphatic fertilizers, Brazil imports about 750 000 tpy of phosphate rock. However, the country has large reserves and intends to become self-sufficient in the mid-1980s. The Tapira mine in Minas Gerais state was brought into production at 900 000 tpy in 1979. This was reflected in the country's production which rose from 1.07 million t in 1978 to 1.7 million t in 1979. The Catalao mine in Goias state was under development in 1979 (500 000 tpy) and another mine in the same locality is planned for 1982 at 620 000 tpy. Industrias Luchsinger Madorin announced that it plans to bring into production by 1983 at 1 million tpy, a deposit in Anitapolis, Santa Caterina.

Others. Besides those countries 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 Egypt, Iran, Peru, Saudi Arabia, Senegal, Tunisia and Turkey.

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 3.8 per cent to 3 396 000 t in 1979.

TABLE 6. LISTED EXPORT PRICES[1] FOR FLORIDA PHOSPHATE ROCK

Grade	January 1979	January 1980
	(U.S. $ per tonne fob Tampa or Jacksonville)	
76/77% TPL	..	..
73/75% TPL	40	47
70/72% TPL	37	44
68/70% TPL	35	41
66/68% TPL	33	39
64/66% TPL	31	37

Source: British Sulphur Corporation Limited, Phosphorous and Potassium, January-February, 1980.

[1] These prices do not include the charge for severance tax in Florida.

.. No quote.

Phosphate fertilizer production (measured as producer shipments) was 671 803 t P_2O_5 content in fertilizer year 1978-79. Data on imorts of phosphate fertilizers summarized as total P_2O_5 content is no longer available, volume on individual types of fertilizer is available on Table 1.

Phosphate rock prices increased moderately from \$18-20 to \$25 per t during 1979 (fob Tampa - 68% BPL), but prices of finished fertilizers increased more strongly principally because of very strongly rising sulphur prices. For example, diammonium phosphate (DAP) increased from \$120 to \$160 per t level during 1979 and the price of triple superphosphate (TSP) from \$90 to \$115 per t.

OUTLOOK

The outlook for 1980 and early 1980s is for very stable phosphate rock prices and price increases that are not out of line with inflation. The current recession had a dampening effect on agricultural prices and these in turn will compel many farmers to be skimpy on fertilizer application in 1980, counting rather on making up any soil deficiency by increased application in 1981, a year when grain prices are expected to start a steady and vigorous rise. Rock consumption growth will fluctuate between 3 and 6 per cent for the next few years.

Between 25 and 30 million t of new capacity is planned for the first part of the 1980s, and if most of this expansion takes place, a significant oversupply situation in phosphate rock may develop in the mid-1980s. It would last for 2 to 4 years before it could correct itself. There is a strong probability that sulphur and sulphuric acid will be in tight supply for all of the early 1980s, thus whereas rock prices may not undergo unusual increases, finished fertilizers may exhibit a relatively higher price performance. The availability of sulphur may be the ultimate limit-setting factor in phosphate fertilizer production.

Platinum Metals

S.A. HAMILTON

The platinum-group metals are platinum, palladium, rhodium, iridium, ruthenium and osmium, with platinum and palladium being by far the more abundant and important. The major source of ores containing platinum-group metals is the Merensky Reef Formation of the Bushveld Complex in the Republic of South Africa. In the U.S.S.R. and Canada, platinum-group metals are recovered as byproducts in the processing of nickel and nickel-copper ores. In the U.S.S.R. some platinum is produced from platinum placers. A small amount of platinum is recovered from the refining of copper ores.

The major producers of platinum-group metals in 1978, in decreasing order of production volume, were the U.S.S.R., the Republic of South Africa and Canada. Minor producers were Colombia, Australia, the United States and Yugoslavia. The rank order for 1979 is similar, except that no estimates of production are available for Australia and Yugoslavia. The ores of the U.S.S.R. contain far more palladium than platinum; those of the Republic of South Africa contain more platinum, while the ratio in Canadian ores is roughly in balance.

Canadian production of platinum-group metals in 1979 fell to 5 754 000 grams (g) valued at $56,193,000 compared with 10 768 428 g valued at $65,292,791 in 1978 owing to a strike at the Sudbury complex of Inco Limited that began in September 1978 and continued into June 1979. Production of platinum-group metals - nearly the last step in the metal extraction process - did not return to normal levels until late 1979. **Force majeure** on shipments of platinum-group metals by Inco Limited was not removed until early 1980. Production of platinum-group metals by Falconbridge Nickel Mines Limited and Union Minière Explorations and Mining Corporation Limited (Umex) was uninterrupted and at normal levels throughout the year. Despite the large decline in volume of production, the value of production was down by only 18 per cent owing to substantial increases in the producer price of platinum, palladium and rhodium.

World primary production of platinum-group metals in 1979 was estimated by the United States Bureau of Mines (USBM) at 207 304 kg, 3.8 per cent above the 199 631 kg produced in 1978. The Republic of South Africa and the U.S.S.R. were the leading world producers of platinum metals in 1979, with output estimated at 99 530 kg for each, in both cases a substantial increase over 1978 (Table 3). They accounted for 96 per cent of the world output in 1979 and Canada, the third-largest producer, accounted for about 2.8 per cent.

The strength that developed in the platinum metals market in 1978 persisted in 1979. Sales increased to all industries except the glass and jewellery industries. For the first time global sales for use in the automotive industry surpassed sales for jewellery fabrication. This strong industrial demand coupled with speculative investment interest that developed during the second half of the year maintained a tight market with rising prices, and free market prices substantially above producer prices.

Japan and the United States remained the leading consumers of platinum metals in the non-communist world in 1979. Over the years, Japan has been the world's major consumer of platinum. However, consumption by the Japanese jewellery industry in 1979 was adversely affected by the sharp price increases, reducing Japanese consumption by 8 300 kg.

The USBM estimated platinum-group metals sales in 1979 to United States industry at 85 720 kg compared with 70 279 in 1978. Percentage sales by weight in 1979 were: platinum, 51.1; palladium, 41.1; ruthenium, 4.1; rhodium, 3.0; iridium, 0.6 and osmium, less than 0.1.

The automotive industry was the largest consumer of platinum metals in the U.S., mainly for catalytic converters. Sales of platinum and palladium to this industry in 1979 are estimated at 24 983 kg and 6 910 kg, respectively, up sharply from 18 585 kg and 6 184 kg in 1978. Other large users are the electrical and chemical industries, followed by the dental and medical professions, and the petroleum and glass industries. A relatively small amount of platinum metals is used in the U.S. for jewellery and decorative purposes, amounting to 1.8 per cent in 1979. 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, at the end of 1979 to be 23 678 kg compared with 26 792 kg at the end of 1978.

TABLE 1. CANADA, PLATINUM METALS, PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979P	
	(grams)	($)	(grams)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	10 768 428	65,292,791	5 754 000	56,193,000
Exports				
Platinum metals in ores and concentrates				
United Kingdom	10 557 111	55,062,000	4 739 174	46,754,000
Brazil	-	-	80 900	384,000
France	-	-	47 184	191,000
United States	-	-	38 351	168,000
Total	10 557 111	55,062,000	4 905 609	47,497,000
Platinum metals, refined				
United States	573 610	2,141,000	854 599	5,063,000
United Kingdom	273 088	1,455,000	372 962	1,378,000
Brazil	30 388	46,000	96 732	353,000
Other countries	33 810	99,000	411 530	395,000
Total	910 896	3,741,000	1 735 823	7,189,000
Platinum metals in scrap				
United States	1 230 360	8,518,000	1 406 841	14,092,000
West Germany	-	-	84 601	935,000
United Kingdom	94 026	414,000	8 398	49,000
Japan	-	-	31 104	39,000
Total	1 324 386	8,932,000	1 530 944	15,115,000

TABLE 1. (Cont'd.)

	1978		1979P	
	(grams)	($)	(grams)	($)
Re-export[2]				
Platinum metals, refined and semiprocessed	169 234	334,000	43 172	359,000
Imports				
Platinum lumps, ingots, powder and sponge				
United States	202 079	1,920,000	179 685	2,189,000
United Kingdom	50 668	680,000	51 258	882,000
Total	252 747	2,600,000	230 943	3,071,000
Other platinum group metals				
United States	1 317 419	1,496,000	508 231	2,823,000
United Kingdom	74 244	298,000	84 819	639,000
Switzerland	-	-	2 893	13,000
South Africa	102 641	249,000	-	-
Total	1 494 304	2,043,000	595 943	3,475,000
Total platinum and platinum group metals				
United States	1 519 498	3,416,000	687 916	5,011,000
United Kingdom	124 912	978,000	136 077	1,520,000
Switzerland	-	-	2 893	14,000
South Africa	102 641	249,000	-	-
Total	1 747 051	4,643,000	826 886	6,545,000
Platinum crucibles[3]				
United States	662 784	6,817,000	775 752	15,001,000
Platinum metals, fabricated materials, not elsewhere specified				
United Kingdom	519 521	3,806,000	429 352	4,131,000
United States	228 424	1,259,000	263 229	2,125,000
Total	747 945	5,065,000	692 581	6,256,000

Sources: Energy, Mines and Resources Canada; 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 are recovered as a byproduct in 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, northwestern Ontario and its mines near Thompson, Manitoba. The residue from the refining of nickel and copper ores containing the platinum-group metals is shipped by Inco 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 to the United States for recovery of the platinum-group metals. The platinum-group metals recovered from Canadian ores consist of about 43 per cent platinum, 45 per cent palladium and 12 per cent other platinum metals.

The copper ore deposit of Union Minière Explorations and Mining Corporation Limited (Umex) near Pickle Lake, Ontario contains platinum metals and some nickel. These metals are contained in the copper concentrates produced at the 3 600 concentrator and shipped to Noranda, Quebec for smelting. For reasons of corporate confidentiality, Canadian consumption of platinum-group metals is not available.

FOREIGN DEVELOPMENTS

Republic of South Africa. The Republic of South Africa is the only country among the major producers that mines platinum metals-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 the ore deposits in the Merensky Reef are estimated to be in the following proportion: platinum, 61 per cent; palladium, 26 per cent and other platinum-group metals, 13 per cent. Small amounts of osmium and iridium are recovered as a by-product from the treatment of Witwatersrand gold ores.

An increase in industrial usage, a decline in U.S.S.R. sales to the world market and an increase in speculative buying persuaded South African producers in the latter part of 1978 to restore production to mid-1977 levels. In 1979 production was increased to record levels and the strong price of platinum enabled the companies to report record earnings for the year.

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. 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 a year.

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 (Pty) Limited, a company owned jointly by Rustenberg with Johnson, Matthey & Co., Limited, the marketing agent for Rustenberg's products.

With demand strong and record prices for most of the platinum-group metals, Rustenberg operated its facilities at or near capacity throughout the year. Gross revenue increased by 63 per cent due to both higher volume of sales and higher product prices. Based on contracts thus far secured, the company feels that expansion of production capacity is warranted and is examining various possibilities.

While all Rustenberg's production has come from the Merensky Reef, a second reef which contains chrome associated with the platinum-group metals and known as the Upper Group No. 2 Reef (UG2), occurs beneath the Merensky Reef. Rustenberg is continuing its research and exploration program to evaluate mining costs and to develop a process to economically recover both chromium and platinum metals.

Impala Platinum Limited, the second-largest platinum metals producer in the non-communist world, operates a mine-concentrator-smelter complex in the state of Bophuthatswana and a refinery in the Republic of South Africa. All these operations are near Rustenberg. In 1979 Impala also reported a very satisfactory year based on increased sales and rising prices. A planned expansion will increase capacity from 27 990 kg to 31 100 kg by 1981.

In the Transvaal district of South Africa, Western Platinum Limited - jointly owned by Lonrho Limited, Falconbridge Nickel Mines Limited and Superior Oil Company - operates a mine-concentrator-smelter-refinery complex having an annual rated capacity of 4 666 kg of platinum metals. Western Platinum recovers platinum-group metals using the NIM process developed by the National Institute of Metallurgy. The NIM process reduces treatment time 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 of the

TABLE 2. CANADA, PLATINUM METALS, PRODUCTION AND TRADE, 1965, 1970, 1975-79

	Production[1]		Exports: Domestic[2]		Exports: Re-exports[3]		Imports[4]	
	(grams)	($)	(grams)	($)	(grams)	($)	(grams)	($)
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	1 325 319[r]	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[r]	3,793,000[r]
1978	10 768 428	65,292,791	11 468 007	58,803,000	169 234	334,000	1 747 051	4,643,000
1979[p]	5 754 000	56,193,000	6 641 032	54,686,000	43 172	359,000	826 886	6,545,000

Sources: Energy, Mines and Resources Canada; 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; [r] Revised.

TABLE 3. WORLD MINE PRODUCTION OF PLATINUM-GROUP METALS, 1977-79

	1977	1978P	1979e
		(grams)	
U.S.S.R.[e]	90 200 000	94 865 000	99 531 000
Republic of South Africa[e]	91 755 000	91 755 000	99 531 000
Canada	14 474 687	10 768 428	5 754 000
Colombia	538 557	433 551	467 000
Australia[e]	301 700	286 200	..
United States	172 469	256 479	311 000
Yugoslavia	176 979	177 290[e]	..
Other countries	1 035 248	1 089 030	1 710 000
Total	198 654 640	199 630 978	207 304 000

Sources: U.S. Bureau of Mines, **Mineral Trade Notes,** Vol. 76, No. 8, August 1979; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1980 for 1979; and Energy, Mines and Resources Canada.
P Preliminary; [e] Estimated.

processing of nickel-copper ores 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 United States Bureau of Mines estimated the U.S.S.R. production of platinum-group metals to be 99 530 kg for 1979, compared with 94 865 kg in 1978. The U.S.S.R. is carrying out a major expansion program to develop nickel-copper deposits in the Norilsk region. Part of the expansion has been completed but some phases are apparently not progressing as rapidly as planned. The overall program is targeted for completion by 1984 and 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 ratios of platinum metals recovered have been estimated at about 60 per cent palladium, 30 per cent platinum and 10 per cent of the other platinum metals.

Colombia. Mine production of platinum metals in Colombia in 1979 was estimated by the USBM to be 467 kg. The platinum metals are recovered as a co-product from gold-platinum metals placer operations in the Chaco and Narimo districts.

United States. Production of primary platinum metals in the United States was derived as a byproduct of copper refining, and amounted to 311 kg in 1979 compared to 256 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 in southwestern Montana. According to the USBM, exploration and evaluation of this geological structure continued in 1979. In May 1978, The Johns-Manville Corporation (JM) announced discovery of a high grade platinum-palladium occurrence. In May 1979 JM and Chevron U.S.A. Inc. formed a joint venture to complete exploration and evaluation of the deposit. This project may take five years.

RECYCLING

Recycling of platinum metals, especially platinum, is important 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 of it being toll-refined. This is important to those industries that use platinum metals in their processes for purposes such as catalysts, as it reduces the effect the high cost of platinum metals have on the cost of the goods produced.

USES

The main applications for platinum-group metals are in the automotive, electrical, chemical, dental and medical, glass, petroleum and jewellery industries. The industrial use of these metals is based on special properties such as suitability for catalytic activity, resistance to corrosion and oxidation at elevated temperatures, good electrical conductivity, high melting point, high strength, ductility and aesthetic qualities. Platinum and palladium have wide industrial applications, especially in the catalytic field. The others - iridium, rhodium, ruthenium and osmium - are used mainly as an alloying element with platinum and palladium, but small amounts are used individually in special applications.

The jewellery industry is a major consumer of platinum metals in Japan but not in the United States or Europe where gold is preferred because of its lower price. Major South African producers have launched an aggressive campaign in the United States and Europe to promote greater use of platinum metals in jewellery fabrication, but recent price increases have discouraged this use, even in Japan.

The recent development of catalytic converters for the 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 are best attained by the use of platinum and palladium as catalysts in converters. The more-stringent standards established for automotive emission control for model-year 1980 and subsequent years will likely require increased metal loadings in catalytic converters. Actual requirements will depend on the volume of car sales and on the ratio of small cars to large ones.

Platinum-palladium converters now in use do not control nitrogen oxide emissions and, to meet the standards for these, it appears that rhodium will be a third metal in catalytic converters. The rhodium type converter developed to date requires a relatively high amount of rhodium and could not be adopted universally because the supply of the metal cannot meet the potential requirements. Research activities are oriented toward developing a catalytic converter that contains platinum/rhodium in the same ratio as occurs in the South African ores.

Platinum catalysts are used in petroleum reforming 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 phased elimination of tetraethyl lead in gasoline. The petroleum industry in the United States consumed 5 288 kg of primary platinum metals in 1979 compared with 3 370 kg in 1978.

Platinum alloyed with other platinum-group metals finds wide application as a catalyst in the chemical industry, as 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 11 306 kg in 1979 compared with 10 456 kg in 1978.

Platinum is used extensively in the electronic industry in printed circuits, electrical furnaces, thermocouples and electrical contacts for telephone equipment. At one time platinum metal only was used in these applications but a palladium-silver alloy containing 60 per cent palladium and 40 per cent silver is now commonly used. Consumption of platinum-group metals in the electrical industry in the United States was 17 828 kg in 1979, compared with 14 087 kg in 1978.

A platinum-rhodium alloy is used in bushings and spinnerets used in the production of fibre glass, synthetic fibres and in the glass manufacturing industry. Much of the platinum metal used in this field is recycled through toll refining. Consumption of platinum-group metals in the U.S. glass industry was 3 291 kg in 1979 compared with 3 662 kg in 1978.

Platinum metals are used in a number of other applications: dental and medical, laboratory equipment, medical research; fuel cells for direct generation of electric current, and crucibles for the growing of laser crystals and synthetic gems. These latter applications are in expanding areas of high technology, so that the requirement for platinum-group metals is likely to increase.

Although the actual consumption of platinum may be small, a socially important recent development is the use of a platinum-based drug to combat advanced stages of certain forms of cancer.

PRICES

Demand for platinum group metals improved in 1978 and remained strong throughout 1979, leading to a tight supply situation and upward movement of producer and spot prices. Spot prices were also affected by speculative demand for platinum that developed in conjunction with the speculative rush on gold and silver.

The average producer and dealer prices for platinum in 1979 as quoted by **Metals Week** were $U.S.11.31 a gram ($351.65 an ounce) and $14.29/g ($444.60/oz), respectively. Corresponding figures for palladium were $U.S.3.64/g ($113.14/oz) and $3.84/g ($119.55/oz).

Platinum. At the beginning of 1979 the producer price of platinum was quoted by **Metals Week** at $U.S.9.65/g. This was raised to $10.45/g at the beginning of February, to $11.25/g effective April 27, to $12.22/g on August 22 and to $13.50/g on December 19 to close the year. Dealer prices moved up strongly during the year, mainly in response to speculative demand, to close at $22.90/g. Despite the producer price increases, the dealer price remained above the producer price throughout the year.

Palladium. The increase in the producer price of palladium from $2.57/g in January to $4.82/g at the end of December was more spectacular than that of platinum, almost doubling during the year. The dealer price as quoted by **Metals Week** increased during the year from $2.33 to $5.90/g. The dealer price at the beginning of the year was below the producer price, but as speculative fever hit all of the precious metals, the dealer price overtook and passed the producer price. One reason given for the upsurge in palladium demand was that in some uses it can be substituted for gold. Another factor was concern that the Soviet Union is reducing platinum-group metals sales to the western world.

Rhodium. The producer price of rhodium at the beginning of 1979 was quoted by **Metals Week** in a range of $17.68-$20.89/g. In late February producers fixed rhodium at $22.50/g but, by early June, Rustenberg Platinum was demanding $25.72 on contracts. By year-end all producers were quoting this price. Demand for rhodium for use in automotive catalytic converters accounts for most of the price increase. Stocks of rhodium are not large and any news concerning potential usage can cause the price to move sharply upwards. A major reason for the sharp price increases was the uncertainty of adequate supply to meet the United States automotive industry needs for price. Demand for rhodium for use in automotive catalytic converters accounts for most of the price increase. Stocks of rhodium are not large and any news concerning potential usage can cause the price to move sharply upwards. A major reason for the sharp price increases was the uncertainty of adequate supply to meet the United States automotive industry needs for rhodium in catalytic converters. The dealer price was generally slightly above the producer price throughout the year.

Iridium, Ruthenium and Osmium. The producer price of osmium remained unchanged in 1979 at $4.90/g. Iridium opened the year at $9.80/g and rose to $11.25/g by year-end. The producer price of ruthenium declined from $2.00/g in January to $1.45/g by December.

OUTLOOK

The strong demand that has developed for platinum-group metals is expected to continue in the 1980s and the metals, particularly platinum and ruthenium, will remain in tight supply. Platinum has been mainly an industrial metal and large stocks have not been built up because over the years supply and demand have been maintained in close balance. J. Aron & Company Inc. of New York estimated that in 1978 world stocks were reduced by 12 440 kg to 15 550 kg. To ensure an adequate supply for industrial requirements, South African producers have cancelled previous cutbacks and are taking steps to raise their output to near present-plant capacity. The U.S.S.R. markets platinum in accordance with its own priorities which do not necessarily have any relationship to world demand. Sales over the past two years have been below levels established in previous years. Thus, 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. steps up its activities on the open market, its sales will be carried out in a manner least disruptive to the price structure. The U.S.S.R. is the leading world producer of palladium (due to the high palladium-to-platinum ratio in the ores). There is at present no shortage of palladium and none is anticipated.

The price of platinum should remain at a relatively high level in the early 1980s, because demand is strong and planned expansion of production capacity will not come on stream for some years. The structure of the platinum industry is such that high prices will not make significant amounts of extra metal readily available from producers, scrap dealers or speculators. The South African producers estimate that it will take three to four years to increase capacity and capital costs will be high. The producers are seeking some assurances that capital expenditures can be recovered before committing themselves to major programs.

In the medium to long term, 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 affect the overall supply. Some sources suggest 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 possibility of substitution. Applications that are now in the initial stages of development may, within the decade, become major users of platinum-group metals. In particular, development of the fuel cell as an important source of electrical power could generate demand for large quantities of platinum. However, the platinum electrodes in fuel cells are recyclable, so that once initial demand is satisfied, replacement fuel cells would use recycled platinum. Other major growth areas are likely to be in the electrical and electronics industry and the chemical processing industry.

In the long term, consumption of platinum metals should show steady growth. The large reserves of these metals contained in the Merensky Reef in the Republic of South Africa and Bophuthatswana can be developed to ensure balanced supply and demand. Failure by producers to ensure ample supplies of the platinum metals would encourage consumers to find substitutes.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
36300-1	Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15	free

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
601.39	Precious metals ores	Remains free								
605.02	Platinum metals, unwrought, not less than 90% platinum	Remains free								
605.03	Other platinum metals, unwrought	20.0	18.5	17.1	15.6	14.1	12.6	11.2	9.7	8.2

TARIFFS (concl'd)

UNITED STATES (cont'd.)

Item No.		1979	1980	1981	1982	1983 (%)	1984	1985	1986	1987
605.05	Alloys of platinum, semi-manufactured, gold-plated	25.0	23.1	21.3	19.4	17.5	15.6	13.8	11.9	10.0
605.06	Alloys of platinum, semi-manufactured, silver-plated	12.0	11.3	10.6	9.9	9.3	8.6	7.9	7.2	6.5
605.08	Other platinum metals, semi-manufactured, including alloys of platinum	20.0	18.5	17.1	15.6	14.1	12.6	11.2	9.7	8.2
644.60	Platinum leaf	20.0	18.5	17.1	15.6	14.1	12.6	11.2	9.7	8.2

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Potash

G.S. BARRY

Excellent markets for Canadian potash were recorded in 1979 for the second year in succession and are expected to remain fairly strong despite the United States embargo on grain shipments to the U.S.S.R. Overseas demand continued strong and North American consumption, which stagnated somewhat in 1978, reached new highs in 1979. During the third and fourth quarter of the year demand ran 24 per cent ahead of the previous year's level. Canadian mines operated at 85 per cent of capacity for the entire year, but more significantly, output in the fourth quarter was at 91 per cent of capacity. Production was recorded at 6 714 670 tonnes (t) K_2O, 9.7 per cent higher than the year before. Producers' stocks in Canada declined to 377 682 t, a 55 per cent decline from year-end 1978.

North American producers' stocks are a bellwether of tight supply-demand conditions. For the fertilizer year 1977-78 the average monthly stock position was 1 401 000 t, for the fertilizer year 1978-79 it was 1 197 000 t and for the last six months of 1979 the average monthly stock position was only 674 000 t.

By year-end there was a settlement of all legal proceedings between the Saskatchewan government and independent potash producers through the signing by all parties of a new comprehensive tax agreement. The five-year agreements are retroactive to July 1, 1979.

The Potash Corporation of Saskatchewan (PCS) announced a \$2.5 billion, 10-year expansion plan that will almost triple the corporation's production capacity.

Shaft sinking and underground development on the two new prospective mines near Sussex, New Brunswick made good progress in 1979.

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 (K) 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 accounts for 39 per cent of the international trade in potash. Canada exports 73 per cent of its production to the United States and that quantity accounted for 71 per cent of the U.S. consumption of 6.9 million t K_2O.

PRODUCTION AND DEVELOPMENTS IN CANADA

Saskatchewan. There are ten potash mines in Canada, all in the Province of Saskatchewan. At the end of 1979 total installed capacity was 7 950 000 t K_2O or 13 040 000 t of muriate of potash-KCl. At the end of the previous year, capacity was estimated at 7 575 000 t K_2O and the increase was the first substantial addition made since 1970-71. In 1979 the industry operated at 85 per cent of capacity compared to 80 per cent the year before. For the last quarter of the year production was at 91 per cent and the same production rates are expected for the first quarter of 1980. These were by far the highest levels of capacity utilization since the beginning of potash mining in Canada.

TABLE 1. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1978 AND 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Production, potassium chloride				
Gross weight	10 001 463	..	10 969 690	..
K_2O equivalent	6 109 555	..	6 698 504	..
Shipments				
K_2O equivalent	6 344 010	504,535,137	7 046 000	695,305,000
Imports, fertilizer potash				
Potassium chloride				
United States	1 920	228,000	2 033	281,000
Belgium-Luxembourg	9	15,000	-	-
United Kingdom	49	8,000	8	5,000
West Germany	1	...	2	1,000
Total	1 979	251,000	2 043	287,000
Potassium sulphate				
United States	21 847	2,598,000	20 094	2,435,000
United Kingdom	-	-	12	21,000
Total	21 847	2,598,000	20 106	2,456,000
Potash fertilizer, nes				
United States	59 323	3,790,000	49 667	3,998,000
Potash chemicals				
Potassium carbonate	1 336	608,000	1 117	631,000
Potassium hydroxide	5 790	1,612,000	3 857	1,637,000
Potassium nitrate	2 523	656,000	3 150	978,000
Potassium phosphate	1 572	1,113,000	1 197	1,095,000
Potassium bitartrate	-	-	-	-
Potassium silicates	974	384,000	866	411,000
Total potash chemicals	12 195	4,373,000	10 187	4,752,000
Exports, fertilizer potash				
Potassium chloride, muriate				
United States	6 901 084	363,073,000	7 716 307	512,761,000
Japan	672 923	34,170,000	673 037	46,503,000
Brazil	412 073	21,119,000	545 074	40,105,000
Singapore	205 190	10,575,000	362 418	26,043,000
People's Republic of China	13 791	898,000	321 974	21,844,000
India	332 563	17,970,000	313 308	22,731,000
South Korea	260 331	13,544,000	255 814	17,331,000
Australia	148 087	7,949,000	133 517	9,187,000
Taiwan	62 548	3,880,000	88 905	5,842,000
South Africa	51 639	3,669,000	41 291	3,644,000
Other countries	327 063	16,871,000	191 230	14,563,000
Total	9 387 292	493,718,000	10 642 875	720,554,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; .. Not available; ... Less than $1,000; nes Not elsewhere specified.

Saskatchewan potash production at 6.7 million t K_2O was 9 per cent higher than in 1978. Furthermore, in the same period shipments exceeded production by almost half a million tonnes, resulting in a 54 per cent decrease of inventories at Canadian mines. The value of potash shipments totalled $700 million, an increase of 70 per cent over 1978. The potash mines employed about 3,700 people in 1979 with an additional several hundred employed by contractors 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 an 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).

From 1976 to 1978 PCS acquired 38.5 per cent of the potash-producing capacity of the Saskatchewan mines for a total of $530 million. Since that time the corporation has spent more than $50 million to rehabilitate some of the mines and add modestly to the capacity of others.

PCS, controlling 40.3 per cent of production capacity, produced an estimated 4.3 million t of muriate of potash (KCl) in 1979 and the private companies produced an additional 6.6 million t. PCS's control was up from 39 per cent following the purchase of private companies in the 1976-78 period. The PCS share of production included 0.9 million t that PCS buys annually from the International Minerals & Chemical Corporation (IMCC) under a long-term agreement. During 1979, PCS completed an expansion at the Cory and Lanigan mines to reach a capacity of 1.36 million t KCl, and 1.0 million t KCl, respectively. Another phase of expansion is in progress at Lanigan to boost capacity to 1.36 million t KCl by 1980. Meanwhile at the Rocanville mine, 180 000 t of KCl of capacity was added at the beginning of 1979 for a total capacity of 1.27 million t KCl. Further expansion will increase capacity to 1.82 million t KCl by the end of 1981.

In November PCS and the Province of Saskatchewan announced a ten-year, $2.5 billion expansion program that could result in a capacity increase to 14.6 million t KCl for PCS by 1989. In essence, this program would first bring up the capacity of all existing mines to maximum shaft capacity within the "two shafts" per mine configuration. This would provide an additional 2.6 million t KCl capacity by 1984-85 (this is a net amount above the programs described above). This part of the program is estimated to cost about $1 billion.

Options for expansion in the mid-1980s include a third shaft, resulting in a 50 per cent capacity increase in the existing mines, and/or one or two entirely new, very large mines (about 3.0 million t each). PCS has some prime concessions at a minimum of three locations. At Bredenbury, about 40 kilometres (km) north of Esterhazy, some preliminary feasibility studies for a new mine were completed in the past. The $2.5 billion includes allowance for inflation and the capital for increasing PCS's hopper railcar fleet from 1,000 to about 1,500 cars. Financing the expansion will most likely be through retained earnings and bond issues, but the use of funds from the Saskatchewan Heritage Fund, which currently holds $418.5 million in equity in PCS, is not ruled out.

PCS made $46 million profit during the fiscal year 1978-79. It pays no federal taxes and for the moment plans no dividends. A research unit was set up to investigate the possibility of producing potash sulphate (for crops sensitive to the chlorine content of fertilizers) for which there is a big market in Japan, and caustic potash for the pulp and paper industry. It is expected that a decision whether to put a plant in operation will be made in 1980.

The private-sector companies all have modest capital spending plans, mainly to refurbish their existing operations, which will result in modest capacity gains. On a longer-term basis, IMCC is considering an option to add a third shaft K-3, to their large K2, K1 mine complex at Esterhazy.

At the end of 1978 Noranda Mines Limited bought the 49 per cent interest that CF Industries Inc. of Illinois had in Central Canada Potash Co. Limited (CCP). This brought Noranda's interest in the company to 100 per cent and on February 1, 1979 CCP became a Division of Noranda Metal Industries Limited by statutory declaration. CF Industries will remain the customer for most of CCP's potash.

TABLE 2. CANADA, POTASH PRODUCTION AND SALES BY GRADE[1] AND DESTINATION, 1978 AND 1979

	1979					1979	1978
	Standard[2]	Coarse	Granular	Soluble	Chemical	Total	Total
	(tonnes K_2O equivalent)						
Production	1 712 906	2 669 632	1 580 756	674 788	76 588	6 714 670	6 123 544
Sales							
Domestic	23 542	299 692	46 726	9 009	-	378 969	369 968
United States	677 187	2 122 960	1 511 454	619 266	-	4 930 867	4 497 666
Offshore							
Australia	14 089	66 586	42 735	77	-	123 487	85 688
Bangladesh	4 672	42 948	-	-	-	47 620	43 067
Brazil	62 958	198 421	101 709	4 709	-	367 797	274 417
Chile	-	-	-	13 498	-	13 498	20 266
China	147 348	-	-	12 471	-	159 819	38 751
Costa Rica	3 347	-	-	-	-	3 347	6 919
Denmark	16 015	-	-	-	-	16 015	56 080
India	201 769	-	-	11 366	-	213 135	245 847
Indonesia	13 074	-	-	-	-	13 074	-
Italy	-	-	-	20 162	-	20 162	10 088
Japan	257 109	69 183	-	96 525	-	422 817	370 013
Korea	156 014	787	-	-	-	156 801	145 202
Malaysia	99 906	4 703	-	255	-	104 864	87 737
Mexico	12 740	-	-	-	-	12 740	12 758
Nepal	-	-	-	-	-	-	1 334
New Zealand	19 746	-	-	-	-	19 746	31 137
Nicaragua	-	-	-	-	-	-	3 180
Philippines	39 468	-	-	-	-	39 468	30 047
Romania	23	-	-	-	-	23	23
Solomon Islands	138	-	-	-	-	138	-
South Africa	-	16 566	-	-	-	16 566	41 771
Sri Lanka	20 367	-	-	-	-	20 367	46 686
Swaziland	-	8 183	-	-	-	8 183	2 431
Taiwan	65 072	-	-	-	-	65 072	38 688
United Kingdom	872	-	-	-	-	872	3 442
Offshore Total	1 134 727	407 377	144 444	159 063	-	1 845 611	1 595 572
Total sales	1 835 456	2 830 029	1 702 624	787 338	-	7 155 447	6 463 206

Source: Potash and Phosphate Institute.

[1] Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60 per cent K_2O equivalent; soluble and chemical grade a minimum of 62 per cent K_2O equivalent. [2] Standard includes Special Standard, production of which was 218 978 tonnes K_2O equivalent in 1979, and 261 988 in 1978; and sales of chemical grade.

- Nil.

The optimistic expansion forecasts for Saskatchewan must be tempered somewhat by the cautious remarks made recently by the Honourable John R. Messer, Saskatchewan Minister of Mineral Resources, to the effect that the province has seen a "boom and bust" cycle in potash in the past and has no intention of allowing this situation to be repeated.

TABLE 3. CANADA, POTASH PRODUCTION AND TRADE, YEARS ENDED JUNE 30, 1965; 1970 AND 1975-79

	Production[2]	Imports[1,2]	Exports[2]
	(tonnes K_2O equivalent)		
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	6 206 542	26 095	5 828 548
1979	6 386 617	38 543	6 256 216

Sources: Potash and Phosphate Institute; Canadian Fertilizer Institute.

[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers. [2] Change of data source. Prior to 1978, figures were obtained from Statistics Canada.

At the beginning of 1979 a number of court cases brought against the Province of Saskatchewan by independent corporations were still pending. These challenged the validity of the "reserves tax", the potash prorationing fee, increases in royalties, etc. Intense negotiations between the provincial government and the industry arrived at a compromise and all litigation effectively ended in October and November when all six private potash producers signed a five-year agreement known as the "Potash Resource Payment Agreement".

Under the agreement, which took effect rectroactively as of July 1, 1979, the producer pays to the province a "base payment" and a "graduated payment". The regulation stipulates that the base payment shall be the sum of:

(a) \$6.00 per K_2O short ton for the first 300,000 K_2O short ton of saleable potash produced from the mine during each year; and

(b) \$7.50 per K_2O short ton for each additional K_2O short ton of saleable potash produced from the mine during the year.

Permitted deductions are related to Crown royalty payments, and royalties payable to the owner of freehold lands. There is also a provision for deductions against the base payment if gross mine revenue of the preceding year is low.

The graduated payment is specified to be the aggregate of the following amounts:

(a) 10% of the lesser of:

i) the producer's operating profit for the year; and

ii) 5% of the producer's capital investment account as at the end of the year;

(b) 20% of the lesser of:

i) the producer's operating profit for the year less 5% of the producer's capital investment account as at the end of the year; and

ii) 10% of the producer's capital investment account as at the end of the year;

(c) 30% of the lesser of:

i) the producer's operating profit for the year less 15% of the producer's capital investment account as at the end of the year; and

ii) 10% of the producer's capital investment account as at the end of the year;

(d) 40% of the lesser of:

i) the producer's operating profit for the year less 25% of the producer's capital investment account as at the end of the year; and

ii) 10% of the producer's capital investment account as at the end of the year; and

(e) 50% of the producer's operating profit for the year less 35% of the producer's capital investment account as at the end of the year.

A provision that allows the application of some credits in deductions for the "base payment" scheme to be transferred to the "graduated payments" scheme. There is an allowance in lieu of depreciation equal to 4.5% of the "opening investment account" (an account that includes most of the past capital expenditures incurred by the mine prior to July 1, 1979). There is also an allowance equal to 10% of the additional capital invested during the tax year.

The Canadian potash deposits are the most extensive in the world. One of the recent United States Geological Survey publications, Mineral Commodities Summaries - 1980, places world reserves at 13.2 billion short tons, of which 2.7 billion tons are in Canada. Reserves estimated by Energy, Mines and Resources Canada are much higher - 56 billion t 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 20 per cent recovery factor, it was calculated that 360 000 t of product (K_2O equivalent) per km^2 can be recovered. Based on a single bed recovery, this would place reserves at 10.5 billion t; however, since about one-third of the area is underlain by two mineable beds, this estimate of "conventional" reserves was raised to 14 billion t. 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, or 42 billion t.

New Brunswick. The Potash Company of America (PCA) will complete shaft sinking at its Sussex mine to a depth of 650 m in the spring of 1980. This will be followed by three months of underground exploration. Site preparation for a second production shaft is completed, but actual sinking awaits the results of underground exploration. PCA recently announced that additional drilling increased reserves by 40 per cent and final capacity may be higher than the projected level of 700 000 t of KCl per year.

Denison Mines Limited, a new entrant in the potash mining field, purchased the rights to the Salt Springs (Clover Hill mine) potash deposit from the International Minerals & Chemical Corporation in March 1979, with the objective of bringing this deposit into production by mid-1983. Shaft sinking commenced in late August and reached 200 m by December. Total depth will be 800 m with completion scheduled for September 1980, to be followed by about three months of underground development. The potash beds are folded and are at variable depths ranging from 400 to 800 m and grades are high (25 to 30 per cent K_2O). A final production decision will be made before the spring of 1981 and the company should be in a position to start shipping potash in 1983, operating at a capacity of between 0.9 and 1.18 million t KCl per year.

Both companies will extract about 1.5 t of common salt for every tonne of potash. Some salt will be returned to the mines as backfill and some will have to be piped to the Bay of Fundy. Denison Mines is closer to tidewater and may opt for a pipeline, whereas PCA is considering a mining regime that would include additional extraction of 400 000 to 500 000 t of high purity crystalline salt with the specific purpose of creating cavities where excess tailings will be returned for a period of five to six years. The crystalline salt will be marketed in New Brunswick and in the northeastern United States.

Other provinces. High prices for potash and expectations of steady markets in the 1980s generated renewed interest in potash prospects in Nova Scotia where several exploration licences were granted during 1979. While exploring for hydrocarbons, Chevron Standard Limited intersected significant potash in a drill hole on the Malagawatch Peninsula of Lake Bras d'Or on Cape Breton Island in Nova Scotia. Follow-up drilling will commence in the summer of 1980. Geophysical and other work is also planned for the Manitoba-Saskatchewan border area and in Newfoundland.

MARKETING

Sales of Canadian potash in 1979 were 7 168 616 t K_2O equivalent, a 10.7 per cent increase over the preceding year. Offshore exports, at 1 845 855 t, were 15.7 per cent higher despite a reduction in November and December due to the accidental damage to the Second Narrows Bridge in Vancouver which curtailed exports after October 12, 1979. Full export levels were not restored until March 1980. Domestic agricultural sales in 1979 at 358 868 t were 2.6 per cent higher than in 1978 but this modest increase followed a 43.9 per cent increase in the preceding year. Domestic nonagricultural potash sales were 20 100 t. Canadian exports to the U.S. were 4 930 866 t in 1979, compared to 4 509 105 t in 1978. The increase was due principally to the resolution of rail shipping problems and to excellent fall application of potash by farmers who were not yet reacting negatively to the grain sales embargo to the U.S.S.R. However, spring 1980 potash application could be much lighter.

Canpotex Limited represents all the Canadian potash producers for offshore sales except Potash Company of America and PPG Industries Canada Ltd. Canpotex potash exports were up 14.7 per cent in 1979 after a very strong year in 1978. There are local indications that 1980 will be another record year. Canpotex sells to offshore markets only, which are generally defined as all markets excluding Canada and the United States. In 1979 Canpotex sold 2.7 million t of product (in various grades of muriate of potash) which is 89.3 per cent of the total offshore exports. Sales were made to 22 different countries. Asian countries were the largest purchasers (69 per cent), and Latin American countries, mainly Brazil, (23 per cent) and Oceania (6.3 per cent) accounted for most of the remainder.

World market conditions were tight throughout the year, particularly because the U.S.S.R. could not ship more than half of its commitments to many countries in Asia. With North American inventories down to below-minimum levels, and with constraints on transport, some international tenders received no bids at all for potash requirements.

Some potash sales abroad are financed by the Canadian International Development Agency (CIDA). For fiscal year April 1, 1979 to March 31, 1980, CIDA loans were given for 23 519 t of potash for Sri Lanka and 59 334 t for Bangladesh.

Transport of "offshore" potash to Vancouver is carried out by 85-car unit trains at a cost of just under $20 a tonne (KCl). Approximately 1,100 rail cars are utilized in this service and about 500 will be added in 1980. Turn-around time for a car is about 12 days compared with 30 to 40 days on shipments to the U.S. Potash movement to Vancouver in 1979 established a new record, just surpassing 3 million t despite a series of mishaps such as: the Neptune Terminal loading equipment being out for 1 1/2 months after being hit by a ship; a 10-day strike by longshoremen; collapse of a Fraser River railway bridge; destruction of the key CNR Narrows bridge in Vancouver when hit by a ship in October and a strike by B.C. Railway employees in late 1979. From October 1979 to March 1980, potash trains were uncoupled and cars were put on barges to circumvent the missing CNR bridge, reducing overseas shipments to about two-thirds of anticipated levels.

There was a large increase in shipments of potash through Thunder Bay, from about 60 000 t in 1977 to 430 000 t in 1979. CN Rail instituted project "PORTS" (Potash Relay Terminal System), utilizing the Lake Superior terminal originally built for loading iron ore directly from "solid trains" to ships that serve the Great Lakes ports in the U.S. and Canada. Potash is offloaded there onto tracks that service inland customers located less than 100 to 120 km from ports.

Canpotex sells about 60 per cent fob Vancouver and 40 per cent c&f customer's port. Most customers buy bulk product but a warehouse is maintained in Singapore to supply bagged product to southeast Asia. Canpotex Shipping Services Ltd. charters its own ships for some overseas contracts. In early 1979 Canpotex negotiated with major ship-chartering groups the institution of a new charter party agreement tailored to their needs and known as "Fertivoy". This system will further improve the dependability of ocean shipping of potash.

In the spring of 1979 an experimental solid train was moved to Trois Rivières, Quebec. Potash Corporation of Saskatchewan signed an agreement with CP Rail that will utilize a non-stop unit train system that will move up to 227 000 t of muriate of potash per year to two rented warehouses in Seneca, Illinois, and Waterloo, Iowa, thereby partially eliminating supply problems that occur during the peak periods of demand in the spring and fall. If the system works well three other warehouse facilities are planned to serve the

DISTRIBUTION, CANADIAN POTASH SALES, 1979

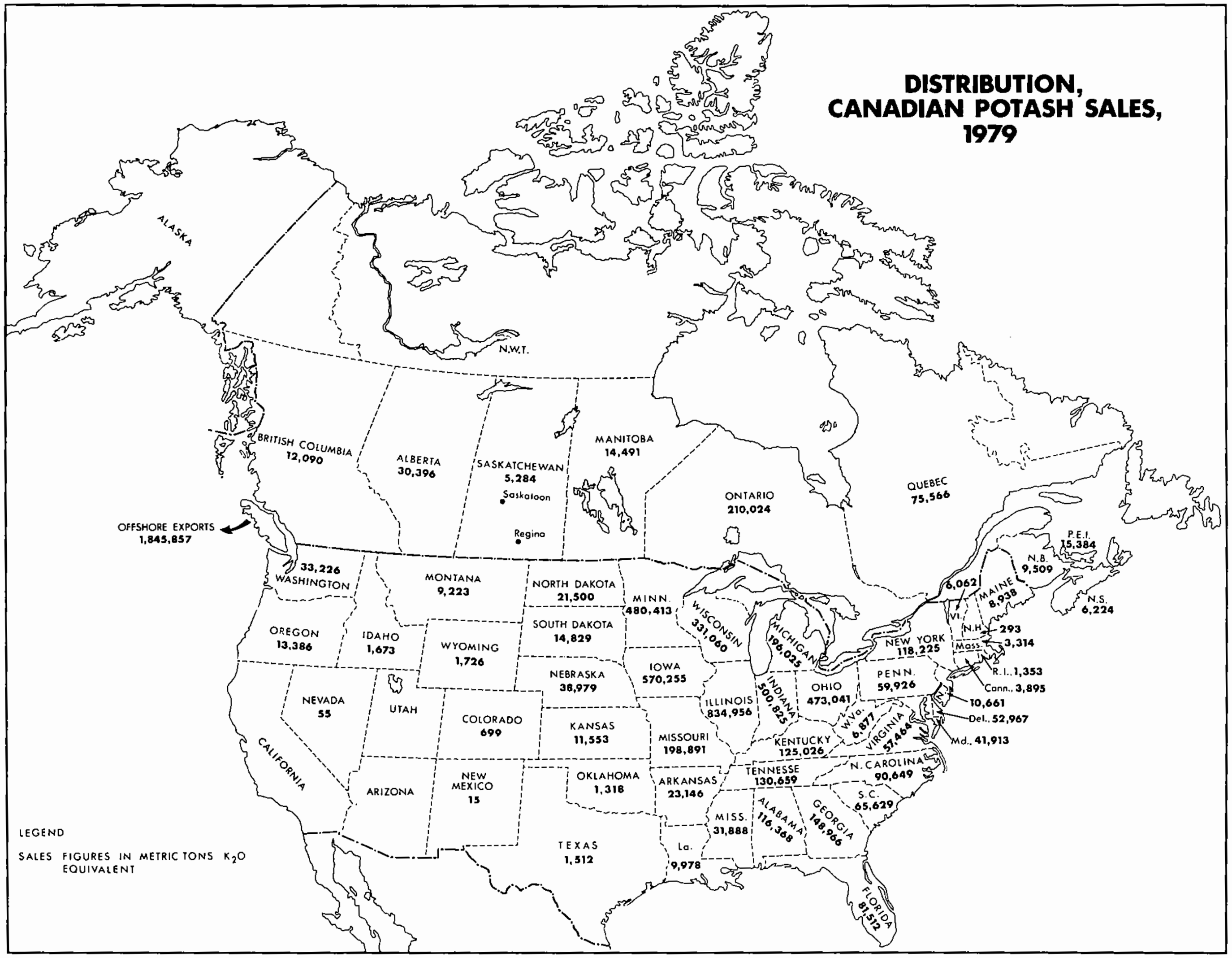


TABLE 4. CANADA, POTASH SALES BY PRODUCT AND AREA, 1978 AND 1979

		Agricultural					Industrial			Total
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	Sales
		(tonnes K_2O equivalent)								
Alberta	1978	823	719	10 493	762	12 797	9 267	1 950	11 217	24 014
	1979	4 518	512	13 156	238	18 424	10 879	1 093	11 972	30 396
British Columbia	1978	353	3 092	3 867	121	7 433	809	28	837	8 270
	1979	425	3 968	6 941	-	11 334	676	80	756	12 090
Manitoba	1978	655	4 353	4 300	25	9 333	45	215	260	9 593
	1979	889	6 150	7 227	159	14 425	66	-	66	14 491
New Brunswick	1978	-	10 170	28	-	10 198	-	-	-	10 198
	1979	-	9 455	54	-	9 509	-	-	-	9 509
Northwest Territories	1978	-	-	-	-	-	-	98	98	98
	1979	-	-	-	-	-	-	-	-	-
Nova Scotia	1978	-	5 595	-	-	5 595	-	-	-	5 595
	1979	-	6 224	-	-	6 224	-	-	-	6 224
Ontario	1978	6 237	199 474	791	848	207 350	1 350	6 392	7 742	215 092
	1979	2 840	182 796	17 229	675	203 540	566	5 919	6 485	210 025
Prince Edward Island	1978	-	11 633	-	-	11 633	-	-	-	11 633
	1979	-	15 384	-	-	15 384	-	-	-	15 384
Quebec	1978	841	82 322	57	150	83 370	125	7	132	83 502
	1979	333	74 206	818	-	75 357	209	-	209	75 566
Saskatchewan	1978	30	682	671	590	1 973	-	-	-	1 973
	1979	1 820	998	1 300	554	4 672	322	290	612	5 284
Totals	1978	8 939	318 040	20 207	2 496	349 682	11 596	8 690	20 286	369 968
	1979	10 825	299 693	46 725	1 626	358 869	12 718	7 382	20 100	378 969

Source: Potash and Phosphate Institute.

\- Nil.

TABLE 5. CANADIAN POTASH INDUSTRY, 1970 TO 1979, AND FORECAST, 1980 TO 1990

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Principal Data - Actual										
Capacity - 000 tonnes K_2O	6 888	7 522	7 522	7 522	7 522	7 522	7 522	7 575	7 575	7 950
Production - 000 tonnes K_2O	3 173	3 573	3 928	4 249	5 480	5 479	4 996	6 089	6 123	6 675
Value of production $Cdn. millions	119	152	164	179	272	360	401	504	535	734
Employment - mines	2 916	2 526	2 588	2 930	3 316	3 418	3 588	3 855	3 640	3 905
- construction (estimated)							200^{e}	400^{e}	650^{e}	1 000^{e}
Capital investment $Cdn. millions[1]	----------	----------	----------	----------	70^{e} total	----------	----------	----------	25^{e}	120^{e}

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Principal Data - Estimated											
Capacity - 000 tonnes K_2O	8 000	8 280	9 050	9 580	10 880	12 070	12 850	13 570	14 690	15 410	16 000
Production - 000 tonnes K_2O	7 200	7 452	8 145	8 622	9 792	10 863	11 565	12 213	13 221	13 869	14 400
Value of production $Cdn. millions	828	857	1 018	1 173	1 420	1 695	1 943	2 198	2 552	2 871	3 211
Employment - mines	4 000	4 020	4 260	4 380	4 830	5 200	5 380	5 520	5 800	5 900	5 952
- construction	1 300	----------	----------	----------	Av. 1 600/yr.	----------	----------	----------	----------	----------	----------
Capital investment $Cdn. millions	160	300	320	330	----------	----------	----------	2 100 total	----------	----------	----------

Critical Assumptions

Capacity: Canadian share of world capacity will increase from 24% in 1979 to 32% in 1989 (the U.S.S.R. being the chief competitor).

Production: World consumption will rise by 4.3%/yr. and, with tight supply, Canadian mines could operate at 90% of capacity.

Prices: After stability at a high level of \$115/t K_2O in 1980-81 prices could rise up to 2% above inflation levels; the Informetrica Implicit price deflator was used to indicate this relationship and calculate unit values, which were used to calculate value of production.

Employment: Production per mine employee in 1980 is estimated at 1 800 t/man yr. It is assumed that productivity will rise by 3%/yr. in the 1980s, which is the basis for calculating direct mine employment.

[1] Capital Investment: \$705 million was spent on the potash industry prior to 1970.

U.S. corn belt. Seasonality remains a problem and CP also tried assessing premiums on shipments for March, May, April and October and discounts for the remaining eight months of the year. Although the differential could be as high as $10 a tonne, this system appeared to have a very limited effect in smoothing shipping seasonality.

PRICES

Potash prices fob Saskatchewan mines were at U.S. $45 to $46 a tonne for standard muriate of potash at the beginning of 1978, rose to U.S. $56 to $58 by mid-year and to U.S. $70 to $72 by the end of the year, a price rise of over 50 per cent. Costs of transport and distribution to farmers rose appreciably, but not to the same extent as the product, so that the average price paid by United States farmers rose by about 27 per cent with standard muriate of potash selling for about U.S. $125 to $130 a tonne by year-end compared to about U.S. $100 a tonne paid in the fall of 1978. Potash prices rose less, however, than prices of various nitrogenous fertilizers where the impact of energy costs was felt the strongest. The high price levels attained towards the end of 1979 are likely to persist into 1980. Coarse and granular grades of muriate of potash commanded premiums of U.S. $8 to $11 a tonne throughout the year. United States prices, fob Carlsbad, New Mexico, were usually at a premium of U.S. $4 to $6 a tonne over the Canadian price. The price of potassium sulphate (standard) was U.S. $110 a tonne (U.S. $220 a tonne K_2O equivalent) fob Carlsbad at year-end.

Labour

Employment at the nine Saskatchewan potash mines increased from 3,650 workers in 1978 to 3,905 in 1979. The United Steelworkers of America represent workers at PCS-Cory, PCA-Saskatoon, Allen Potash, Cominco-Vanscoy and Central Canada (Noranda). Kalium (PPG) is non-union, International Minerals & Chemical Corporation (Canada) Limited and PCS Lanigan are represented by the Oil, Chemical and Atomic Workers and PCS-Rocanville voted in 1979 to set up an independent employee's association. Contracts with the USWA expire in April 1981 and the union will attempt to promote the concept of industry-wide bargaining in the Saskatchewan industry for the next round of negotiations.

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 1979 is estimated at 26.5 million t, exceeding production by 0.2 million t, and creating a fall in inventories to below normal levels. Demand is calculated as estimated consumption plus 6 per cent.

United States. Production in 1979 was 2 122 106 t (K_2O equivalent) up 2.6 per cent from 1978, while sales increased by 6.8 per cent to 2 288 262 t. Inventories by year-end were 248 583 t, 30 per cent lower than the preceding year. Apparent consumption of potash increased 12 per cent in 1979 to 6.9 million t and the larger part of the increase was met by a 10 per cent increase in imports to 5.2 million t. U.S. exports dropped by 20 per cent to 622 716 t. Ten companies produce potash in three western states, with New Mexico accounting for about 87 per cent of production. In March, 1979 Kaiser Aluminum & Chemical Corporation resumed operation at their solar evaporation potash mine at Wendover, rebuilt after the refinery was burned out in October, 1978. AMAX Inc. started construction during the year of solar evaporation ponds to recover potash from mine and mill effluents at its Carlsbad plant. There are three plants producing potassium sulphate from potassium chloride and sulphuric acid.

Total name plate capacity of the U.S. potash mines is estimated at 2.57 million t (K_2O equivalent). However, production only equalled 82.5 per cent of capacity in excellent marketing circumstances, indicating that this capacity may be slightly overestimated since operations at about 90 per cent of capacity should have been possible under normal circumstances.

The Occidental Petroleum Corporation concluded a 20-year barter arrangement with the U.S.S.R. that would have involved the import of potash and ammonia by Occidental in exchange for superphosphoric acid. Initial potash shipments were received in 1977 and 1978 and large shipments were expected in 1979. However, internal production and distribution problems in U.S.S.R. prevented exports so that a shipment of only 12 000 t was recorded during 1979. The grain-phosphoric acid embargo may add to complications in this trade. After Canada, which provided 94.4 per cent of U.S. potash imports, Israel was the supplier of 3.5 per cent of the country's import requirements.

United Kingdom. Cleveland Potash Ltd. (CPL) will continue to operate its Boulby mine despite continuing losses. Towards the end of the year the mine approached its break-even operational rate of 0.5 million t KCl but it is doubtful that the mine will ever achieve its originally designated rate of 1.0 million t KCl per year. Since beginning mining operations in 1973 the mine has lost $248 million. During the year Imperial Chemical Industries Ltd. (ICI) sold its 50 per cent holding in CPL to Anglo American Corporation of South Africa Ltd. (formerly 12.5 per cent) and Charter Consolidated Limited (formerly 37.5 per cent). The Charter-Anglo American partnership decided to operate the mine at least to 1981. ICI will continue to buy most of the CPL potash under an agreement that expires in 1986.

In August 1979 Consolidated Gold Fields Limited announced that their proposed potash solution mine at Whitby, originally planned for production by 1986 was not economic and plans for its construction were suspended for an indefinite period.

West Germany. Production in 1979 was up by 5.9 per cent to 2 616 000 t and further improvements are still expected. Consumption was steady for the third consecutive year at 1.18 million t (fertilizer year 1978/79). Exports for the calendar year 1979 were up slightly, with Belgium the main recipient.

Spain. There is a steady improvement in production from year to year to 668 000 t (K_2O) in 1979. Further increases in output are expected as Explosivos Rio Tinto has just completed an expansion program from 300 000 t per year (tpy) (K_2O) to 350 000 tpy at its two Catalonia mines. Spain now consumes domestically slightly less than half of its output.

France. Mines de Potasse d'Alsace (MDPA) completed new production facilities for industrial-grade potash (62.5 per cent K_2O). Total industrial potash capacity at MDPA is now 280 000 tpy of a total potash capacity of 2.2 million t. The company installed compactors during 1979. French exports declined substantially but domestic consumption showed improvement.

Italy. During the year a final decision was made by Industria Sali Potassici e Affini (ISPEA) to open the new Milena deposit to replace the almost exhausted mines of San Cataldo and Palo. This will result in a slight increase in annual production but total nominal capacity will not increase since it is limited to 450 000 tpy of sulphate (235 000 tpy K_2O) by the size of the two existing refineries at Pasquasia and Campofranco.

Belgium. This country is the largest producer of potassium sulphate in the world (280 000 t in 1979). Two companies operate three plants at Kwaadmechelen, Tessenderlo and Vilvoorde with a total capacity of 465 000 t of sulphate. These companies; Produits Chimiques de Limbourg and Tessenderlo Chemie, are affiliates of Enterprise Miniere et Chimique (EMS) which also controls the French potash mines. France and West Germany are the main suppliers of potassium chloride and, in reciprocation, France accounts for about a quarter of Belgium sulphate sales.

Brazil. This South American country is the second-largest world importer of potash after the United States. In 1979 imports exceeded 1 million t and Canada accounted for 37 per cent of Brazil's requirements through the export of 367 797 t K_2O. 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. The deposits are complex and rather low grade (mainly carnalite) but there is an opportunity to exploit one small higher grade sylvinite deposit (Santa Rosa de Lima) at a rate of about 300 000 tpy K_2O. French technical and financial assistance was negotiated in 1978 and by mid-1979 a decision was made to call for tenders. It was announced in September that the potash mine and beneficiation facilities will be constructed by a Brazilian consortium, Odebrecht-Harrison Engentaria de Minas Ltd. VG, formed by a Brazilian company and Patrick Harrison & Co. Ltd. of Toronto. Petromin will run the mine, which may be completed in the 1983-85 period.

Mexico. Brines bearing potassium sulphate occur in Baja California. Exportador de Sal S.A., a joint venture between a Mexican state corporation and the Mitsubishi Corporation, will initiate a feasibility study aimed at the eventual exploitation of up to 300 000 tpy of potassium sulphate based on solar evaporation.

India. The country is a large importer of potash, having no proven reserves. There are, however, some geological indications of potash-bearing saline formations in the western part of Rajasthan. In the Naguar basin considerable potash was encountered and intensive surveys are planned there for the immediate future. India's consumption in 1978-79 was 598 400 t K_2O, of which 39 per cent came from Canada.

People's Republic of China. Production of potash in China is estimated to be below 0.5 million tpy. The construction of a new large potassium chloride plant located on the Tsarhan Salt Lake in Tsinghai Province was announced in 1979. Details on capacity are not available. China is likely to remain a major importer of potash, reaching 1.5 million t K_2O in 1989.

Israel. Dead Sea Works (DSW) decided to expand its potash capacity by 470 000 tpy (KCl) by 1982 and a further 430 000 tpy by 1985, bringing total capacity to 2.1 million tpy product. The new plant will use a cold crystallization process that will save energy. No additions will be necessary to existing evaporation ponds. Capital costs for the first phase are estimated at $U.S. 81 million (in 1978 dollars) and total costs at about $U.S. 180 million. The government will contribute a grant of $U.S. 30 million.

Jordan. Construction is proceeding satisfactorily at the Jordan Dead Sea project of the Arab Potash Co., planned for initial production in 1982. Jacobs International Ltd. was awarded the contract for overall supervision of the start-up and operation of this $425 million project until it reaches full operational capacity of 1.2 million tpy KCl in 1985 or 1986. Voest-Alpine of Austria was awarded the $100 million refinery and storage contract, while Wimpey Construction of U.K. is currently building the dykes and evaporation ponds that cover 110 km^2 on the south end of the Dead Sea.

Thailand. Very extensive saline formations with potash-bearing members occur in the Korat and Sackhon basins in northeastern Thailand (with extensions into Laos). AMAX Exploration, Inc. intends to conduct an intensive exploration program on a 36 km^2 concession in the Wanonniwatt district, 500 km northeast of Bangkok. The potash occurs mainly as carnalite and other salts not very easy to beneficiate but in some localities high grade sylvinitic ore (KCl) has been encountered.

East Germany. The German Democratic Republic is consistently modernizing its potash industry and increasing its exports. By the end of 1979 its capacity was estimated at 3.5 million t (K_2O) and this will be further increased by about 300 000 t before a levelling takes place. Domestic consumption in 1978 was 569 000 t and a consumption level of 600 000 t K_2O can apparently be readily achievable and maintained for the early 1980s. About two-thirds of the surplus is exported to Comecon and other communist nations.

U.S.S.R. The capacity of the potash industry of the U.S.S.R. is being consistently expanded. It now stands at about 10 million t K_2O and according to long range plans would increase by as much as 50 per cent during the course of the decade. A number of factors such as lack of storage facilities, poor ground conditions, grade-control problems and a bottleneck in beneficiating techniques combined to depress effective capacity utilization by about 20 per cent during 1979. Furthermore, inland transportation problems endemic to the industry were further aggravated by a severe winter and these factors resulted in the inability of the U.S.S.R. to export contracted potash to several countries in Western Europe, Japan and the Far East. Practically nothing was delivered by the U.S.S.R. to Occidental Petroleum under their 20-year, 0.6 million tpy (K_2O) agreement which under original objectives would have resulted in major exports to the U.S. in 1979. The embargo on U.S. exports of grain and phosphatic fertilizers to the U.S.S.R. may not have a direct result on potash, but a trading pattern for the early 1980s is not yet discernible.

OUTLOOK

Production, optimum capacity utilization, price performance and depletion of stocks in 1979 all combined to a record that will be hard to duplicate. Nevertheless, the early 1980s will most likely continue to be years of tight potash markets and excellent export opportunities, barring world economic disaster such as a major depression. A number of agricultural organizations, producer spokesmen and forecasting groups have placed world potash consumption growth rates for the 1980s in the 3.5 to 5.5 per cent range. Energy, Mines and Resources Canada estimates indicate that consumption in the developed countries will range from 2.0 to 3.5 per cent, while that of the developing countries should average about 7 per cent. On

TABLE 6. WORLD POTASH CAPACITY 1978-89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	(000 tonnes K_2O equivalent)											
North America												
Canada	7 575	7 950	8 000	8 280	9 050	9 580	10 880	12 070	12 850	13 570	14 690	15 410
United States	2 570	2 570	2 500	2 500	2 500	2 500	2 500	2 300	2 200	2 000	1 800	1 700
Total	10 145	10 520	10 500	10 780	11 550	12 080	13 380	14 370	15 050	15 570	16 490	17 110
Western Europe												
France	2 200	2 200	2 200	2 100	2 000	2 000	2 000	2 000	2 000	1 800	1 700	1 700
Germany, Fed. Rep.	2 920	2 920	2 920	3 000	3 000	3 000	3 100	3 100	3 100	3 100	3 100	3 100
Italy	235	235	250	260	270	270	270	270	270	270	280	300
Spain	780	780	850	900	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
United Kingdom	600	600	600	600	600	600	600	600	600	600	600	600
Total	6 735	6 735	6 820	6 860	6 870	6 870	6 970	6 970	6 970	6 770	6 680	6 700
Eastern Europe												
German Dem. Rep.	3 200	3 400	3 400	3 500	3 600	3 800	3 800	3 800	3 800	3 800	3 800	3 800
U.S.S.R.	9 650	10 000	10 800	11 600	12 400	13 200	14 000	15 000	15 500	15 800	16 000	16 400
Total	12 850	13 400	14 200	15 100	16 000	17 000	17 800	18 800	19 300	19 600	19 800	20 200
Asia												
Israel	750	750	750	750	1 000	1 000	1 000	1 260	1 260	1 260	1 260	1 260
Jordan	-	-	-	-	100	300	600	720	720	720	720	720
China, People's Rep.	360	360	360	400	400	500	500	500	500	500	500	500
Thailand-Laos	-	-	-	-	-	-	-	-	-	100	200	200
Total	1 110	1 110	1 110	1 150	1 500	1 800	2 100	2 480	2 480	2 580	2 680	2 680
Others												
Brazil	-	-	-	-	-	-	-	-	200	250	250	250
Chile	25	25	30	30	30	30	30	30	30	30	30	30
Peru	-	-	-	-	-	-	-	100	100	100	100	100
Congo	-	-	-	-	-	-	-	-	-	100	200	200
Total	25	25	30	30	30	30	30	130	330	580	680	680
World Total	30 865	31 790	32 660	33 920	35 950	37 780	40 280	42 750	44 130	45 000	46 230	47 270

this basis the annual growth in world demand should average about 4.3 per cent over the next ten years.

Known and forecast mine capacity increases for the same period indicate sufficient potential to meet the above demand levels. However, some anticipated expansions are based on very tenuous information and there is a high probability that delays and cancellation will take place. The highest uncertainty can be attributed to developments in the U.S.S.R., where planned capacity additions are even more substantial than those in Canada. New underground mining operations in Brazil, Thailand and the Congo as well as potash recovery from brines in Peru and China are all associated with uncertainties in both capacity objectives and timing of initial output. Some of these proposals may be postponed from the 1980s decade to that of the 1990s.

Tight market conditions are likely to prevail for quite a few years with short-lived spot shortages preventing optimum soil application and thus reducing crops. On the other hand, any period of oversupply would not necessarily translate immediately into much lower prices since it would allow the producers to replenish stocks. Storage capacities are being expanded at production and at distribution centres, and the industry will have the ability to carry much higher inventories than in the peak periods of the past.

The average level of prices reached in the later part of 1979 will be sustained for several years with the probability of a modest increase of about 1 to 2 per cent per year above inflation levels. Such a scenario would result in the quantity, value, and export earnings of Canadian potash rising in the next 10 years to the top five of our non-fuel mineral commodities.

Rare Earths[1]

D.A. CRANSTONE

The rare earth elements, sometimes called the lanthanons or lanthanides, are a group of 15 chemically similar metals having atomic numbers 57 to 71 in Group III of the periodic table of elements. Scandium and yttrium are similar to the rare earth elements in many respects and are usually classed with them.

These elements are neither rare nor earths. By comparison, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, less common than all other rare earths except promethium, is more abundant than silver, gold and platinum combined. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. The term "earth" is derived from earlier terminology when insoluble oxides, the common compounds of rare earths, were simply referred to as earths.

Lanthanon-bearing minerals contain all members of the rare earth elements, but either the light (cerium) group or the heavy (yttrium) group predominates in each mineral. The rare earth metals are typically associated with alkalic intrusive igneous rocks and also occur as secondary concentrations in placer, beach sand and phosphatic sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer and beach sand deposits, uranium ores, and phosphatic rocks.

Monazite is a rare-earth phosphate that contains nearly 70 per cent rare-earth oxides (REO) and about 1.5 per cent yttrium oxide. Modern placer deposits in the form of heavy mineral sands are the major source of monazite, where it is usually exploited as a byproduct of rutile, ilmenite and zircon mining operations. Only in a few cases have primary deposits been exploited for monazite, a deposit in South Africa having been the world's major source of monazite from 1953 to 1963. Bastnaesite is a fluorcarbonate of the cerium subgroups. It contains about 75 per cent REO and only about 0.05 per cent yttrium, and occurs in economic quantities in vein deposits, contact metamorphic zones and pegmatites and other igneous rocks. Xenotime, the yttrium phosphate isomorph of monazite is the main source of yttrium and the "heavy" rare earth elements. The relative abundance of the various rare earths in the ores presently being mined is not directly related to the market demand for the individual products. As a result, some rare earth products are readily available at low prices while others, particularly high-purity metal and compounds, are considerably more expensive. Research continues to explore the properties of the rare earth metals to identify potential new markets; but, for some, no significant use has yet been found.

1 This review was not published in 1978.

Development has proceeded; first, to find markets for those compounds that are available; and second, to find and develop sources of supply to meet changing industrial requirements.

New uses have developed steadily in recent years. Beginning with the traditional cigarette lighter flints and carbon-arc uses, rare earth elements have now found application in glass polishing, television tube phosphors, nodular iron, high-strength low-alloy steel and high-strength magnet applications. Rare earth elements in zeolite catalysts for petroleum refining was the major use for rare earths for the second half of the 1960s and most of the 1970s, but by 1979 more rare earth oxides were being consumed in the metallurgical industry than in any other industry. The latest uses of rare earth products are at the forefront of technological development, in refractory ceramics, in the latest developments in fluorescent lighting, in data storage, in the energy field, in catalysts used to reduce nitrogen oxides back to nitrogen and in hydrogen sponge alloys. Distribution of world consumption of rare earth oxides between the metallurgical, petroleum refining and glass industries in 1978 has been estimated at 35 per cent, 33 per cent, and 26 per cent, respectively.

New markets for specific members of the rare earth group have resulted in increased production of all of the rare earth metals because of their natural association in ores. Similarly, production costs for some rare earth members, produced as byproducts of the refining process, have diminished. Availability and declining costs have been important factors in the development of new uses. There is growing optimism that the rare earth metals industry will expand at a steady rate now that industrial uses are becoming more diverse. The energy shortage should have an important effect on rare earth market growth in the 1980s, as the use of rare earth phosphors in high performance fluorescent tubes and of lanthanum and mischmetal in hydrogen storage systems should increase significantly.

CANADIAN INDUSTRY

From 1966 to 1970, uranium mines in the Elliot Lake district of Ontario were the world's major source of yttrium concentrate. All rare earths except promethium have been detected in these ores. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.028 per cent thorium oxide (ThO_2) and 0.057 per cent rare earth oxides.

Canadian production of rare earths since 1967 has undergone drastic adjustments; yttrium concentrate suppliers reduced shipments each successive year until 1971, when deliveries stopped. Shipments of yttrium concentrate from one Canadian producer, Denison Mines Limited, were resumed in 1973 and continued to the end of 1977. There was no production of rare earths in Canada in 1978 or 1979.

TABLE 1. RARE EARTH ELEMENTS

Atomic No.	Name	Symbol	Abundance in Igneous Rocks
	(Light rare earths)		(parts per million)
21	Scandium	Sc	5.0
57	Lanthanum	La	18.3
58	Cerium	Ce	46.0
59	Praseodymium	Pr	5.5
60	Neodymium	Nd	23.8
61	Promethium	Pm	(Not measurable)
62	Samarium	Sm	6.5
63	Europium	Eu	1.1
64	Gadolinium	Gd	6.3
	(Heavy rare earths)		
39	Yttrium	Y	28.0
65	Terbium	Tb	0.9
66	Dysprosium	Dy	4.5
67	Holmium	Ho	1.1
68	Erbium	Er	2.5
69	Thulium	Tm	0.2
70	Ytterbium	Yb	2.6
71	Lutetium	Lu	0.7
	Total		153.0

Denison ceased production of yttrium concentrate in 1978 because yttrium recovery had become uneconomic, owing to higher costs of the chemical reagents used in the yttrium circuit. Denison had been shipping its yttrium concentrate to Molycorp Inc. and had previously shipped yttrium concentrate to

Michigan Chemical Corporation, but shipments to the latter company were terminated in mid-1970 when Michigan Chemical experienced difficulty in marketing the product.

During 1966 and 1967 Rio Algom Mines Limited recovered thorium and rare earth concentrate at its Nordic mill, but did not resume production when the milling of uranium ores was subsequently transferred to the Quirke mill.

Rare earth elements, primarily the light element group, are associated with apatite in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario. Multi-Minerals Limited is seeking to develop the deposit, and was trying at last report in 1975 to determine the feasibility of promoting an integrated complex that would produce pig iron, phosphoric acid and rare earth products.

In addition to the large reserves in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 65 kilometres (km) east of Elliot Lake (where the REO content is about twice that of Elliot Lake ores) and in the Bancroft area of Ontario.

TABLE 2. CANADIAN SHIPMENTS OF RARE EARTH CONCENTRATES

	Y_2O_3 Concentrates (kilograms)	Values ($)
1979	-	-
1978	-	-
1977[1]	30 400	..
1976[1]	26 308	..
1975[1]	34 927	..
1974	39 366	..
1973	..	..
1972	-	-
1971	..	..
1970	33 112	657,000
1969	38 756	671,500
1968	51 406	936,067
1967	78 268	1 594,298
1966	9 400	130,223

Sources: Statistics Canada; [1] Annual Reports, Denison Mines Limited.

.. Not available; - Nil.

In 1978 and 1979 Kerr Addison Mines Limited operated its 90 per cent owned Agnew Lake Mines Limited uranium mine in Ontario. The recovery method for this mine is the underground and surface leaching of broken ore. Uranium production has been below expectations because of problems with the underground leaching process, and was expected to decline in the first quarter of 1979 from the levels achieved during the final two quarters of 1978. Although the leach solution contains substantial amounts of thorium, lanthanum, yttrium, cerium, gadolinium, dysprosium, erbium and ytterbium, none have been been recovered. As a decision was made in September 1979 to place the mine on a salvage basis, future recovery of these rare earths seems unlikely.

Phosphorite formations in western Canada contain small quantities of rare earths, as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite rich carbonatites.

Shipments of rare earth concentrates since 1966 are summarized in Table 2. Statistics for 1971 and 1973 have been withheld to avoid disclosing company confidential data.

The Denison yttrium concentrates contain all of the rare earth elements. An analysis published in the 1980 edition of Roskill Information Services Ltd.'s "The Economics of Rare Earths and Yttrium" gives the following analysis in terms of oxides: lanthanum (La_2O_3) 0.8%; cerium (CeO_2) 3.7%; praseodymium (Pr_6O_{11}) 1.0%; neodymium (Nd_2O_3) 4.1%; samarium (Sm_2O_3) 4.5%; europium (Eu_2O_3) 0.2%; gadolinium (Gd_2O_3) 8.5%; terbium (Tb_4O_7) 1.2%; dysprosium (Dy_2O_3) 11.2%; holmium (Ho_2O_3) 2.6%; erbium (Er_2O_3) 5.5%; thulium (Tm_2O_3) 0.9%; ytterbium (Yb_2O_3) 4.0%; lutetium (Lu_2O_3) 0.4%; and yttrium (Y_2O_3) 51.4%; total 100%.

WORLD INDUSTRY

The minerals monazite and bastnaesite are the main source of the cerium group of rare earths. These are processed to recover mixed rare earths for low-value products such as mischmetal or further processed at much higher cost to separate individual rare earth metals.

Monazite recovery is a byproduct of mining beach sands for rutile, zircon and ilmenite. Australia, India, Brazil, Malaysia, the United States and South Africa are the principal producers. In the United States, monazite is recovered from beach sands in Georgia and Florida.

The Molycorp mine at Mountain Pass, California, operated by Molycorp, Inc., a subsidiary of Union Oil Co. of California, is the main source of concentrates for cerium-group rare earths; unlike monazite, bastnaesite concentrates from this unusual carbonatite deposit do not contain thorium. The ore, mined in a small, low-cost openpit, grades 8 to 10 per cent rare earth oxides. The rare earth distribution as oxides, in per cent is: cerium 50.0%; lanthanum 33.0%; neodymium 12.0%; praseodymium 4.0%; samarium 0.5%; gadolinium 0.2%; europium 0.1%; and yttrium group 0.2%. The adjacent mill produces a flotation concentrate grading 60 per cent rare earth oxide, a leached concentrate grading 70 per cent, a calcine grading 90 per cent and seven modified concentrates. A chemical and solvent extraction plant makes intermediate rare earth products and separates a number of rare earths, including europium. Mining and milling capacity is about 27 200 tonnes (t) a year of rare earth oxides. The chemical plant can process 13 600 tpy of these. Further processing is carried out at Louviers, Colorado; York, Pennsylvania; and Washington, Pennsylvania. The balance of the bastnaesite concentrates are sold as concentrates.

With the takeover of Molycorp by Union Oil Co. of California in 1977 production statistics for the Molycorp operation are no longer available in terms of production of REO but only in terms of tonnages of rare earth concentrates. Production of rare earth concentrates in 1978 was 28 295 t, and in 1979 was 33 030 t, as compared with 30 720 t in 1977.

To meet the growing demand for some of the more specialized rare earth compounds, in 1978 Molycorp announced a major multi-million dollar expansion of its Mountain Pass, California bastnaesite processing facilities, with six new solvent extraction circuits to be constructed for increased production of gadolinium and samarium. Molycorp also planned to construct new circuits for cerium, lanthanum, neodymium and praseodymium.

Rhone Poulenc Industries, of France, also a major producer of rare earth metals and chemicals, is expanding production facilities at its La Rochelle plant in France and is also building a new plant at Freeport, Texas. In conjunction with the French Commissariat à l'Énergie Atomique, Rhone Poulenc has formed a subsidiary company, Crismatec SA, which will be involved in research, production and marketing of electronic components, and especially of gallium-gadolinium-garnet crystals used for computer magnetic storage systems.

The two U.S. producers of mischmetal, Ronson Metals Corporation and Reactive Metals & Alloys Corporation, report record production and shipments. The availability of mischmetal was good during most of 1978 as a result of expansions that came on stream during the first half. U.S. and Canadian requirements were strong in 1979, so that North American mischmetal supplies had to be supplemented by imports from Japan, Germany and Austria.

In November 1978, a Japanese academic mission visiting Peking was told that China hopes to export to Japan the rare earth elements found in large quantities in the Sinkiang-Uighur Autonomous Region. Chinese production of rare earth concentrates became significant in 1979 and is expected to reach some 6 000 tpy within a few years. Japan imported 70 t of rare-earth chlorides from China in 1978 and 1 037 t in 1979. The Chinese also produce yttrium from xenotime deposits.

American Metallurgical Products Co. opened a new $1 million plant at Springdale, Pa. in 1978, for production of rare earths and of mischmetal. Production is expected to be between 3 and 5 million pounds a year. The plant, with two smelting furnaces, is supplied with REO of 90 per cent purity by Molycorp, Inc.

In April 1979, Sherritt Gordon Mines Limited acquired a 60 per cent interest in Spectra-Flux, Inc. of Watsonville, California, a small company producing cobalt-samarium magnets. Sherritt also completed installation of a cobalt-samarium production facility at Fort Saskatchewan in 1979 and introduced the new powder to the market. Earlier, Sherritt had undertaken a research program to further develop and improve the cobalt-rare earth alloy powder technology it had purchased from Canadian General Electric Company Limited.

Indian Rare Earths Limited is developing a new mineral sands complex in the State of Orissa, with completion scheduled for mid-1981. Production capacity will be some 4 000 tpy of monazite. There are also plans to set up a monazite processing plant at Orissa. Because of the thorium content of monazite, India requires that it be processed to rare earth compounds domestically. Indian Rare Earths was also building a pre-concentrator plant at Manavalakurichi, to be opened early in 1979, to upgrade low grade sands from nearby dunes and beach washings.

Exports of yttrium oxide and europium oxide from the U.S.S.R. were stopped in July 1979 because of an increase in domestic demand for rare earth phosphors by the Soviet televison manufacturing industry, which expanded its production to meet the increased demand for colour television sets that was expected to be generated by the 1980 Moscow Olympics.

CONSUMPTION AND USES

World consumption of rare earths increased in both 1978, and 1979, especially in the iron and steel industry. Samarium was in tight supply owing to its increased use in permanent cobalt-samarium magnets.

There is considerable interest in the development of less costly rare earth metal mixtures as substitutes for samarium in magnets. These "adjusted mischmetals" are in plentiful supply but potential users must first determine the alloy compositions most suitable for mass production of magnets.

A significant development in 1979 was the demand for rare earth chemicals by the automotive industry. Yttrium-stabilized zirconia exhaust gas sensors for carburetor control became standard for most U.S. produced automobiles. Also, rare earth stabilization of the gamma-alumina coatings that carry the active catalysts, such as the platinum metals for three way exhaust purification systems, is now slated for use in many 1981 automobiles.

Some 65 per cent of the western world's consumption of rare earths occurs in the United States, about 10 per cent in Japan, and about 25 per cent in the rest of the western world, mostly in Europe. The principal consuming countries other than the United States import all or nearly all of their raw material requirements either in the form of bastnaesite from Molycorp, Inc., monazite concentrates from Australia, or rare earth chlorides from India and Brazil. Because the U.S. production of monazite by the two companies in Florida is small, considerable quantities of monazite are imported into that country. Japan imports most of its raw material requirements in the form of bastnaesite and rare earth chlorides. France, the world's third largest rare earth processing country, imports most of its raw material in the form of monazite. Other European countries that are important processors of the rare earths are West Germany, the United Kingdom and Austria, with these countries using both monazite and bastnaesite as raw materials.

Mischmetal is a suitable nodulizing alloy that promotes ductility in cast iron by neutralizing the harmful effects of trace elements that inhibit the formation of nodular graphite. The ductile iron industry has realized significant cost savings through the substitution of mischmetal for more expensive additives.

Mischmetal, the primary commercial form of mixed rare earth metals, is prepared by the electrolysis of fused rare earth chloride mixtures. Mischmetal contains 94 to 99 per cent rare earth metals plus traces of calcium, carbon, aluminum, silicon and iron. A typical composition is 52 per cent cerium, 18 per cent neodymium, 5 per cent praseodymium, 1 per cent samarium and 24 per cent other rare earths including lanthanum. Some grades are nearly free of cerium. Ferrocerium is an alloy of mischmetal and iron.

In recent years the practice of adding some 1.5 kg of mischmetal or of rare earth silicides to each tonne of high-strength low-alloy (HSLA) steels has become general, to counter the deleterious effects of sulphur. The conventional method of treating undesirable sulphur is to combine it with magnesium; but magnesium sulphide elongates when rolled so that the resulting steel is weaker in the transverse direction. The addition of rare earths results in a HSLA steel that is nearly equally strong in the transverse and longitudinal directions. HSLA steels are being used increasingly in gas and oil pipelines, automobiles, trucks, trains, ships and construction equipment. Mischmetal has a stable market in the production of lighter flints, but the lighter flint market is becoming relatively less important as mischmetal applications grow in the iron and steel metallurgical fields.

The other major use of the rare earth group is for catalysts in the cracking operation of petroleum refining. Although naturally mixed elements were originally used in catalysts, the trend has been to the use of chloride mixtures of lanthanum, neodymium and praseodymium. Although unit consumption in this field is up, it has been of declining importance in recent years, relative to other uses. Palladium is a substitute for the rare earth elements as a catalyst in petroleum-refining.

The third most important market for rare earth metals, in terms of volume, is the glass polishing industry. Commercial-grade cerium and mixed rare earth oxides are used extensively in optical, mirror and plate glass polishing. Usage for plate glass polishing has been reduced since the introduction of the Pilkington float glass process, but there is no comparable substitute for rare earth oxide compounds in high-quality optical polishing.

The glass industry employs rare earth additives for their many unique characteristics. Cerium oxide, in small quantities, is an effective glass decolourizer. Owing to their ability to absorb ultraviolet light, cerium and neodymium oxides are used in the manufacture of transparent bottles to inhibit food spoilage, and in welders' goggles, sunglasses and optical filters. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac, europium an orange-red, and erbium a pink colour. Lanthanum is a major component of optical glass, and cerium glass is used for windows in atomic reactors.

Rare earth oxides and fluorides are used in signficant quantities in carbon-arc lamps where a high intensity white light is desirable.

A new type of fluorescent lamp is now on the market that emphasizes three narrow spectral bands around the blue-violet, green and orange-red wavelengths to produce a synthesized white light. This new light has a greater "perceived brightness" than even natural sunlight and permits a reduction in the number of lighting units in buildings. The new light uses two rare earth phosphors that contain europium.

High-value applications are in the electronics field, where rare earth oxides are used as phosphors in colour television tubes, in temperature-compensating capacitors and in associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is comparatively small, the value is disproportionately large because of the high degree of purity required in this application. Minor quantities of rare earth elements are used in laser materials, atomic fire extinguishers, nuclear reactor absorption and shielding materials, magnesium and aluminum alloys, brazing alloys, low-corrosion alloys, gemstones, self-cleaning oven catalysts, ceramic and porcelain stains and microwave controls.

Rare earth-cobalt permanent (RE) magnets are an important and growing market. Samarium-cobalt permanent magnets that have many times the strength of any conventional permanent magnet are now in use. These magnets are usually fabricated by powder metallurgical methods that facilitate the procedure for inducing a high magnetic flux. High-strength permanent magnets are used in special applications such as aerospace equipment, where the greater cost can be justified in terms of better performance. Considering the many developments that have occurred within the few years since RE magnets were first discovered, a strong growth rate seems likely in the use of these magnets for the next several years in electric motors, generators, meters, speakers, frictionless bearings, self-holding magnetic earrings and other jewellery. United States automobile manufacturers are studying the use of mischmetal-cobalt magnets in starter motors, in starter motors, fuel gauges, electronic ignition systems, windshield wipers, window and seat drives, and in new developments such as continuous monitoring of tire pressure. Full realization of these potential uses will require further cost and weight reduction, assured availability of cobalt and utilization of rare earth metals other than samarium.

Rare earth metal catalysts have been identified as possible inexpensive alternatives to platinoid catalysts in automobile exhaust converters. Rare earth-based converters have shown promise in reducing carbon monoxide and nitrogen oxide emissions but more research is necessary. Initially, the automotive industry opted for platinum-based systems to meet emission control standards set for United States vehicles in 1975.

Research on rare earth metal uses has taken many directions and some very promising developments have resulted. "Hydrogen sponge" alloys have been developed that consist of nickel, and in some cases manganese, in combination with rare earth metals. These alloys can absorb up to 400 times their own volume of hydrogen gas. One cubic foot of these alloys can hold enough hydrogen to generate over 4 kilowatt-hours of heat energy. The ease with which the absorption process can be reversed by a relatively small change in temperature or pressure, the selectivity of the process to hydrogen gas, and the convenient temperature and pressure ranges over which it can occur, are keys to its usefulness. Potential applications are in solar heating, nonpolluting engines, heat sinks, gas purification and compression, and auxiliary power generation.

The development of magnetic bubble memory films for data storage and processing promises to become a major new application for rare earth materials especially for gadolinium. Gadolinium-gallium garnet (GGG) has been found to be suitable for the production of precision wafers for these memory films. This new storage medium permits faster information handling with fewer moving parts, lower energy use and greater storage capacity. It also decreasesvulnerability to the effects of power loss. GGG bubble memory storage capacity is claimed already to be competitive with other storage media presently in use in terms of cost per bit of information.

Yttrium is receiving attention from researchers for use in refractory ceramics for use in gas turbines, combustion chambers, nuclear reactors and heat exchangers.

WORLD PRODUCTION

Australia and the United States together are estimated to have produced about 31 000 t (about 75 per cent of the world's production) of rare earth minerals in 1978. Brazil, India, Malaysia and the U.S.S.R. produced between 2 000 and 3 000 t each (most of the remainder of the world's production). Minor production came from Thailand, Zaire, Nigeria and Sri Lanka. Indonesia and North Korea may produce monazite but their output, if any, is not reported.

WORLD RESERVES

The Mountain Pass deposit of Molycorp contains an estimated 4.5 million t of REO, probably 80 to 90 per cent of the U.S. reserves and a large part of world reserves. The latter are estimated by the United States Bureau of Mines (USBM) to contain about 7 million t of REO and 35 million t of yttrium. Some 18 million t of the world's yttrium reserves are in India, and 3.2 million t are in the United States. Additional resources of REO and yttrium exist in the world, so that annual world demand for these elements represents only a tiny fraction of known reserves and additional resources. Although not included in reserve figures published by the USBM, China is believed to have the world's largest reserves of rare earths.

PRICES

The December 1978 and 1979 issues of **Industrial Minerals** (London) quotes 70 per cent leached bastnaesite concentrates, per pound rare earth oxides (REO), at 76 cents (1978) and $U.S. 1.00 (1979); Australian monazite, minimum 55 per cent REO, per long ton fob Australia, Australian $250-300 (1978) and $350-400 (1979); and Malayan xenotime concentrate, minimum 25 per cent Y_2O_3, per pound cif $U.S. 2.00-3.00 (in both 1978 and 1979).

Prices for rare earth oxides, as quoted in **American Metal Market,** were in U.S. dollars per pound:

	Dec. 28, 1978	Dec. 20, 1979
cerium 99.9%	7.50	8.00-9.00
europium 99.99%	775.00	990.00
gadolinium 99.9%	55.00	55.00
lanthanum 99.99%	6.60	7.00
neodymium 99.99%	30.00	32.00-38.00
praseodymium 95%	16.50	16.50
samarium 99.9%	35.00	35.00
yttrium 99.99%	38.00	36.00-42.00

At the end of 1978 prices of rare earth metals, 99% minimum purity, in U.S. dollars per pound for minimum lots of 500 to 2 000 pounds depending on the metal, were: cerium, $17.50; lanthanum, $21.70; samarium, $56.80; yttrium, $105.00; and mischmetal, $4.05. At the end of 1979, these prices had risen to $25.50, $29.50, $65.00, $150.00 and $4.50 respectively.

Rhenium

S.A. HAMILTON

Rhenium was first isolated in 1925 and produced commercially in small quantities in 1930. Output increased with improvements in recovery technology and the development of new uses. The only known commercial source for rhenium is molybdenum concentrates 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 ranging from 300 to 2 000 ppm. Rhenium has also been identified in certain 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 porphyry copper deposits which have been the major source of rhenium in the United States and Chile. Rhenium has also been identified in the porphyry copper ores of Lornex Mining Corporation Ltd. and Brenda Mines Ltd. in British Columbia.

The United States is the largest producer of rhenium metal and rhenium salts in the non-communist world, mainly through toll refining of foreign molybdenum concentrates. Some rhenium has been recovered from molybdenum-bearing porphyry copper ores in the western states. In 1979, M & R Refractory Metals, Inc. in Winslow, N.J. and S.W. Shattuck Chemical Co., Inc. in Denver, Colo. recovered rhenium from Canadian molybdenite concentrate on a toll conversion basis, the rhenium being returned to Utah Mines Ltd. for subsequent sale. Kennecott Copper Corporation, near Salt Lake City, Utah, which had suspended its rhenium recovery operation in 1975, resumed rhenium recovery in late 1978 and was the only facility recovering rhenium from American molybdenite ore in 1979.

Chile, a substantial producer of rhenium, recovers rhenium from byproduct molybdenite concentrates produced from its large porphyry copper deposits. Prior to 1974 rhenium exported from Chile was contained in molybdenite concentrates shipped for treatment to the United States and elsewhere. In 1974 Chile began to export ammonium perrhenate (NH_4ReO_4) to the United States. 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 (West Germany). With the exception of the U.S.S.R., these countries recover rhenium from molybdenite concentrates imported from producing countries. In 1979 the Federal Republic of Germany exported substantial quantities of ammonium perrhenate to the United States as well as small quantities of unwrought rhenium metal. Data published by the United States Bureau of Mines (USBM), indicated that the United States imported substantial quantities of ammonium perrhenate (NH_4ReO_4) in 1979. Rhenium is generally used in this form by industry but it can be further processed to rhenium metal powder.

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 1979 at its Island Copper mine ranged from 900 to 1 500 ppm, and averaged about 1 008 ppm. This compares with an average of about 1 198 ppm in 1978. In 1979, shipments of molybdenite concentrates by Utah Mines to the United States and West Germany totalled approximately 2 638 tonnes (t) compared with shipments of approximately 2 264 t, all to the United States, in 1978. The rhenium contained in the concentrates was treated at the smelters 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 1979 shipments and estimated grade and recovery as reported by Utah Mines, the rhenium recovered from Canadian ores in 1979 was about 1 600 kilograms (kg).

Statistical data on world output and total value of rhenium are not available. In order to avoid disclosing company confidential data, rhenium production in the United States in 1979 has not been reported. World production of rhenium in 1978 was estimated at 7 121 kg by the USBM. Production in 1979 was estimated at 7 257 kg. Imports into the United States, the world's leading consumer, were 5 677 kg in 1978 and 4 990 kg in 1979. U.S. consumption of rhenium, was 5 670 kg in 1978 and 5 443 kg in 1979.

TABLE 1. WORLD MINE PRODUCTION OF RHENIUM, 1978 and 1979

	1978[e]	1979[e]
	(kilograms)	
Chile	1 996	2 041
West Germany	2 041	2 041
Canada	1 724	1 815
U.S.S.R.	907	907
Peru	181	181
Other countries	272	272
Total[1]	7 121	7 257

Source: U.S. Bureau of Mines Mineral Commodity Summaries, January 1980.

[1] Totals do not include U.S. production figures, which are withheld to avoid disclosing company data.
[e] Estimated.

The USBM also 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 in either 1978 or 1979 because of the possibility of disclosing confidential data. Stocks that were built up in the early 1970s have now largely been depleted.

TECHNOLOGY

Rhenium has become an important industrial metal because of its special properties. The metal is highly refractory, having a melting point of 3100°C, second to 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 ammonium perrhenate (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 toward 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. 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.

Catalytic units employing platinum-rhenium catalysts account for about 50 per cent of total U.S. petroleum reforming capacity, up from about 25 per cent of capacity in 1973. Platinum-rhenium catalysts are also used in the production of benzene, toluene and xylenes, although this use is small compared with that in gasoline production. Over the past five years, use of rhenium in bimetallic catalysts has averaged 90 per cent of total rhenium demand.

OUTLOOK

Rhenium has been used as an industrial metal for a short period and has not developed a clearly defined growth pattern. The uncertainty of supply is a factor limiting the development of new uses. The potential supply of the metal is 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 and 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 of the molybdic oxide producers recover rhenium from the treatment of by-product molybdenite concentrates because of the high capital costs involved in building a recovery plant. These molybdic oxide operations are a potential source of rhenium, given a stable price pattern that would justify committing funds for the construction of a recovery plant.

In the short-term the major use of rhenium will continue to be in bimetallic platinum-rhenium catalysts in the petroleum reforming industry. Use in this application could increase as more stringent standards for automotive emissions are introduced and the use of tetraethyl lead in gasoline is reduced. Substitutes are available and are being evaluated for catalytic applications.

Consumption of rhenium in the United States is forecast by the USBM to grow at an average annual rate of 0.4 per cent to the year 2000 when it is expected to total 4 100 kg. Consumption in the rest of the world is forecast to grow at a greater rate than in the United States, reaching 3 650 kg in 2000. The low growth rate forecast for U.S. consumption results from an expected decline in demand for rhenium in petroleum refining in the 1990s and an expected decrease in demand for gasoline beginning in the early 1980s.

PRICES

The **Metals Week** list price for rhenium was suspended in September 1978. The spot price of rhenium metal and compounds reached a low of less than \$U.S. 300 per pound in late-1978. The price recovery that took place through 1979 saw the price of rhenium metal powder reach \$U.S. 2,000 per pound at the end of 1979 and \$U.S. 2,500 early in 1980. The main reason for the price rise was increased demand from the bimetallic catalyst manufacturers. The tight rhenium supply situation (and accompanying price increase) has been aggravated by the reduction of tetraethyl lead in gasoline to meet air quality standards set by the Environmental Protection Agency. However, increased use of methyl tertiary butyl ether, an environmentally acceptable additive to gasoline, could relieve the pressure on rhenium supply and prices in the future.

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

Canada is self-sufficient in salt. Production however is mainly concentrated in eastern Canada and thus imports are necessary but exports are consistently higher than imports.

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 8.8 per cent in 1979 to almost 5.0 million tonnes (t). Fine salt, produced by multi-stage vacuum pan evaporation at six plants, totalled 743 312 t, just slightly higher than the previous year, while production of salt in brine, generally for caustic soda, chlorine and sodium carbonate production, increased by 9.5 per cent to 1.2 million t. 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 down by 4.1 per cent in 1979 to 1.28 million t, with British Columbia, Ontario and Quebec being the main importers. Exports principally to the United States, were up 13.3 per cent to 1.8 million t.

During 1979, Seleine Inc., a subsidiary of Quebec Mining Exploration Company (SOQUEM), continued mine development on a salt deposit on the Madeleine Islands, Quebec with the objective of production by 1982. Potash Company of America announced that it will mine byproduct salt at its potash mine now under construction near Sussex, New Brunswick. These two mines will add about 1.4 million t to the annual capacity of eastern Canada.

TABLE 1. CANADA, SALT PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production				
By type				
Mined rock salt	4 559 531	..	4 962 401	..
Fine vacuum salt	728 302	..	743 312	..
Salt content of brines used or shipped	1 106 894	..	1 212 362	..
Total	6 394 727	..	6 918 075	..
Shipments				
By type				
Mined rock salt	4 625 528	59 076 268	4 934 574	..
Fine vacuum salt	719 472	35 545 561	735 704	..
Salt content of brines used or shipped	1 106 894	3 704 629	1 212 362	..
Total	6 451 894	98 326 458	6 882 640	113 855 000
By province				
Ontario	4 865 202	61 679 276	5 178 663	70 235 000
Nova Scotia	923 289	19 845 290	998 973	24 327 000
Saskatchewan	297 467	9 635 093	293 276	11 288 000
Alberta	358 098	7 117 119	401 728	7 939 000
Manitoba	7 838	49 680	10 000	66 000
Total	6 451 894	98 326 458	6 882 640	113 855 000
Imports				
Salt and brine				
United States	980 659	9 701 000	906 738	11 209 000
Mexico	327 767	2 764 000	340 082	2 906 000
Spain	21 760	320 000	14 145	291 000
Bahamas	-	-	9 357	109 000
Other countries	288	18 000	5 849	304 000
Total	1 330 474	12 803 000	1 276 171	14 819 000
Salt and brine by province of landing				
Newfoundland	14 484	222 000	28 476	648 000
Nova Scotia	7 320	102 000	-	-
New Brunswick	-	-	15	2 000
Quebec	299 781	1 461 000	112 558	1 409 000
Ontario	508 525	5 153 000	630 193	6 815 000
Manitoba	373	23 000	42	3 000
Saskatchewan	36	3 000	677	18 000
Alberta	5	1 000	1 818	69 000
British Columbia	499 950	5 838 000	501 837	5 855 000
Total	1 330 474	12 803 000	1 275 616	14 819 000
Exports				
Salt and brine				
United States	1 603 499	12 500 000	1 798 685	17 000 000
Guyana	1 225	154 000	8 208	521 000
Leeward-Windward Islands	1 988	86 000	2 856	126 000
St. Pierre-Miquelon	308	19 000	8 909	112 000
Cuba	-	-	2 000	13 000
Other countries	1 563	129 000	1 452	130 000
Total	1 608 583	12 888 000	1 822 110	17 902 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
p Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, SALT SHIPMENTS, 1965, 1970, 1975-1979

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and recovered in Chemical Operations	Total	Imports	Exports
	(tonnes)					($)
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
1978	4 625 528	719 472	1 106 894	6 451 894	1 330 474	12 888 000
1979P	4 934 574	735 704	1 212 362	6 882 640	1 276 171	17 902 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

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 because of the great distance to major markets, 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 m 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 has a purity of 97 per cent NaCl or better. Some states in the USA, as users of highway salt, require a minimum purity of 97.5 per cent. 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.

TABLE 3. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS, 1979

Company	Location	Initial Production	Remarks
Nova Scotia			
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.
Domtar Inc.	Amherst	1947	Brining for vacuum pan evaporation.
Ontario			
Allied Chemical Canada, Ltd.	Amherstburg	1919	Brining to produce soda ash.
The Canadian Salt Company Limited	Ojibway	1955	Rock salt mining at a depth of 300 m.
	Windsor	1892	Brining, vacuum pan evaporation and fusion.
Dow Chemical of Canada, Limited	Sarnia	1950	Brining to produce caustic soda and chlorine.
Domtar Inc.	Goderich	1959	Rock salt mining at a depth of 536 m.
	Goderich	1880	Brining for vacuum pan evaporation.
Prairie Provinces			
Hooker Chemical Canada Ltd.	Brandon, Man.	1968	Operations closed May 28, 1978.
International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask.	1962	Byproduct salt from potash mine for use in snow and ice control.
The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	Producing fine salt from by-product brine from potash mine.
Saskatoon Chemicals Ltd.	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine.
Domtar Inc.	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion.
The Canadian Salt Company Limited	Lindbergh, Alta.	1968	Brining, vacuum pan evaporation and fusion.
Dow Chemical of Canada, Limited	Fort Sask., Alta.	1968	Brining to produce caustic soda and chlorine.

Source: Mineral Policy Sector, Energy, Mines and Resources Canada.

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 though a series of two or more cased wells. A brine field normally has from 2 to 20 wells, depending on the quality 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 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 Madeleine 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 1979 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 development program and mine improvements that will allow them to continue mining for at least 10 years. However, at that time reserves may become exhausted unless new salt horizons suitable for mining are found. In this region, it is a problem to find salt reserves with a grade which is high enough to meet most commercial requirements.

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 was 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. After additional drilling, the company determined in late 1979 that it was feasible to store 80 million barrels at a development cost of approximately $400 million. At present, the U.S. government reversed its decision on the necessity of storage of this type but there was renewed congressional interest at the beginning of 1980.

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 mine will be in production in 1982. In addition to potash the company intends to extract common salt at a rate of 400 000 to 500 000 t per year and sell most of the output in eastern United States. The salt will be mined in a separate section of the mine which contains beds of high purity. Cavities created by the extraction of the commercial salt will be backfilled with waste salt from the flotation of the potash.

Denison Mines Limited is bringing another potash mine into production by 1983 in the same region. It is not certain yet whether the mine will have byproduct salt for sale.

Quebec. Quebec Mining Exploration Company (SOQUEM) continued its rock salt mine development program on Gross-Ile (Dauphin deposit) on Madeleine Islands during 1979. Some $15 million have been spent to date and an additional $40 to $50 million will be required to bring the property into production by 1982. Capacity of the mine will be about 1 250 000 t. The Quebec Department of Highways is expected to take the greatest part of the output under a long-term contract. The company also has a letter of intent to sell some highway salt in the United States. An application for a $17 million DREE grant for infrastructure (60-40 federal-provincial) was turned down in early 1980 principally on the grounds that production will replace salt already available from existing Ontario and Nova Scotia mines where the loss of the Quebec market could result in unemployment. It was also noted that sales to the Quebec Department of Highways may be made in a non-competitive manner. Quebec government officials stated that direct provincial aid will replace DREE funding.

The Madeleine 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. Potash is also known to occur in the southern part of the Islands.

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.

TABLE 4. WORLD SALT PRODUCTION, 1977-1979

	1977	1978p	1979e
	(000 tonnes)		
United States	39 407	38 915	41 567
People's Republic of China[e]	17 237	19 537	19 958
U.S.S.R.[e]	14 297	14 497	14 696
West Germany	12 322	12 658	12 701
United Kingdom	8 202	7 310	7 348
France	5 350	6 525	6 876
Canada	6 039	6 452	6 672
Mexico	4 900	5 635	5 625
Italy	5 030	4 931	5 080
Australia	4 715	4 665	4 536
Poland	4 357	4 395	4 536
India	3 759	4 380	4 536
Other countries	32 750	33 851	33 660
Total	158 365	163 751	167 791

Sources: U.S. Bureau of Mines; Energy, Mines and Resources Canada.
[p] Preliminary; [e] Estimated.

During 1979, 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 t to 3.5 million t. At that time, the company announced that the project will take two and a half years to complete. However, the possibility of the development of a new salt mine in Quebec appears to have put this proposition in abeyance.

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 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 Saskatoon, Saskatchewan and Fort Saskatchewan, Alberta. The Brandon, Manitoba plant was closed in May 1978. 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) supplies a small 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 of Canada Limited 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 t in 1954 to an estimated 2.6 million t in 1979.

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.

TABLE 5. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1976-1979

	1976	1977	1978	1979[e]
	(tonnes)			
Snow and ice control[1]	2 224 234	2 600 838	2 368 627	2 984 541
Industrial chemicals	917 094[r]	946 920	911 645	1 040 366
Fishing industry	77 505[e]	87 124[e]	81 246[e]	99 207[e]
Food processing				
Fruit and vegetable processing	19 859[r]	19 437[r]	19 120	26 450
Bakeries	13 639	13 705	13 781	17 633
Fish products	22 108	26 889	28 909	26 030
Dairy products	8 732	7 965	11 095	10 916
Biscuits	3 104	2 176	1 765	2 519
Poultry processors	74	49	30	126
Miscellaneous food preparation	23 700[r]	21 493	24 188	26 450
Grain mills[2]	47 012	53 646	59 965	63 396
Slaughtering and meat processors	37 905	43 741	43 714	47 442
Pulp and paper mills[3]	37 691	40 000	38 500	53 000
Leather tanneries	11 416	9 951	9 205	12 175
Miscellaneous textiles	2 656	953	1 691	2 099
Breweries	550	236	214	210

Sources: Statistics Canada; Salt Institute; Pulp and Paper Canada, April 1980.
[1] Fiscal year ending June 30. [2] Includes feed and farm stock salt in block and base forms.
[3] Not included in 1978 Statistics Canada Survey. Figures are estimates as published in "Pulp and Paper Canada".
[e] Estimated by Mineral Policy Sector, Energy, Mines and Resources Canada; [p] Preliminary; [r] Revised.

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 longer term. 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 in some provinces. A number of municipalities are experimenting with higher sand to salt ratios. New road construction in North America is also experiencing a significant decline further accentuated by the recent economic decline. Thus, the overall growth in salt consumption may be in the order of 1.5 to 2.5 per cent. The development of much new capacity in eastern Canada may bring in a period of overcapacity that would have severe negative effects on the industry and may even lead to the permanent closure of some older mines. Prospects for significantly higher exports may have a mitigating effect.

TARIFFS

CANADA: 1. Customs Tariffs, 1979

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

2. M.F.N. Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
92501-3	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

United States - Custom Tariffs (MFN)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
420.92	Salt in brine	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
420.94	Salt in bulk	3.0	2.6	2.3	1.9	1.5	1.1	0.8	0.4	free
420.96	Salt, other	Remain free								

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Sand and Gravel

D.H. STONEHOUSE

THE CANADIAN INDUSTRY

Production of sand and gravel in Canada has increased steadily if not spectacularly over recent years, apace with population growth and tied closely to construction needs. Per capita consumption remained in the 11-tonne (t) range during 1979 despite slow construction activity in eastern and central Canada, moderate growth in western Canada and continued good growth in Alberta, a pattern established the previous year. Total output of sand and gravel increased by only about one per cent in 1979 to 275 million t while the value of output rose by 8 per cent to $449 million.

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 again reduced during 1979, as construction in real terms slowed. Housing starts were down to 197,049, the lowest since 1970. Although nonresidential construction showed strength, the net demand for aggregates was down. Individual home construction triggers the need for about 300 t of aggregate per unit while apartment construction requires only about 50 t, 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.

TABLE 1. CANADA, VALUE OF CONSTRUCTION BY PROVINCE, 1978-80

	1978[1]	1979[2]	1980[3]
	(millions of dollars)		
Newfoundland	642.5	806.8	922.5
Prince Edward Island	165.5	164.5	169.5
Nova Scotia	998.9	1 122.4	1 215.3
New Brunswick	928.3	1 078.1	1 024.7
Quebec	8 527.3	9 395.0	9 590.9
Ontario	10 979.6	11 538.5	12 383.8
Manitoba	1 501.9	1 451.9	1 475.7
Saskatchewan	1 652.8	2 046.6	2 216.6
Alberta	7 411.5	9 051.5	11 251.7
British Columbia	4 933.0	5 297.4	6 645.5
Yukon and North-West Territories	448.8	418.3	540.3
Canada	38 190.1	42 371.0	47 436.5

Source: Statistics Canada.
[1] Actual. [2] Preliminary. [3] Revised intentions.

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.

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 t 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 sieve - the cut-off between commercial sand and gravel.

TABLE 2. CANADA, PRODUCTION (SHIPMENTS) SAND AND GRAVEL BY PROVINCES, 1977-79

	1977		1978		1979P	
	(000 tonnes)	($000)	(000 tonnes)	($000)	(000 tonnes)	($000)
Newfoundland	4 468	7,023	4 783	7,452	4 808	7,950
Prince Edward Island	865	1,864	981	2,068	998	2,200
Nova Scotia	9 012	18,214	8 917	19,852	9 072	20,500
New Brunswick	5 378	6,141	7 016	10,499	7 257	11,600
Quebec	74 423	69,586	78 913	78,138	71 101	70,880
Ontario	75 400	121,776	89 216	144,253	95 254	162,750
Manitoba	14 535	29,363	13 180	27,974	13 608	30,000
Saskatchewan	9 135	11,102	11 935	16,213	12 247	17,550
Alberta	23 900	45,658	20 898	46,422	23 587	55,900
British Columbia	45 789	54,154	36 253	63,989	37 195	69,700
Canada	262 905	364,881	272 092	416,860	275 127	449,030

Source: Energy, Mines and Resources Canada.
P Preliminary.

TABLE 3. PRODUCTION (SHIPMENTS) OF SAND AND GRAVEL BY USES AND BY AREAS, 1977 AND 1978

		Atlantic Provinces	Quebec	Ontario	Western Provinces	Canada
				(000 tonnes)		
Roads	1977	13 582	43 423	37 851	61 053	155 909
	1978	15 270	48 406	52 052	44 185	159 913
Concrete aggregate	1977	1 738	5 962	16 770	9 893	34 363
	1978	1 488	5 797	12 708	11 111	31 104
Asphalt aggregate	1977	2 793	3 963	6 493	7 227	20 476
	1978	3 255	3 231	6 880	11 980	25 346
Railroad ballast	1977	285	156	497	2 869	3 807
	1978	617	978	457	3 470	5 522
Mortar sand	1977	44	403	1 373	431	2 251
	1978	31	419	1 059	424	1 933
Backfill for mines	1977	155	16	989	189	1 349
	1978	88	672	1 536	348	2 644
Other fill	1977	965	6 368	9 620	8 494	25 447
	1978	812	5 015	11 868	8 768	26 463
Other uses	1977	161	14 132	1 807	3 203	19 303
	1978	136	14 395	2 656	1 980	19 167
Total sand and gravel	1977	19 723	74 423	75 400	93 359	262 905
	1978	21 697	78 913	89 216	82 266	272 092

Source: Energy, Mines and Resources Canada.

TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL, 1977-79

	1977		1978r		1979p	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
Sand and gravel						
United States	273 600	431,000	269 058	502,000	323 432	789,000
West Germany	-	-	-	-	36	7,000
France	126	11,000	18	1,000	85	6,000
St. Pierre and Miquelon	-	-	-	-	24	5,000
Australia	-	-	-	-	36	4,000
Other countries	19	2,000	140	16,000	27	3,000
Total	273 745	444,000	269 216	519,000	323 640	814,000
Imports						
Sand and gravel, nes						
United States	1 645 336	4,642,000	1 809 915	5,534,000	1 188 954	4,084,000
Belgium and Luxembourg	-	-	-	-	7 428	73,000
Netherlands	-	-	-	-	455	15,000
West Germany	327	1,000	1 020	2,000	5 060	8,000
Australia	-	-	54	12,000	16	3,000
Total	1 645 663	4,643,000	1 810 989	5,548,000	1 201 913	4,183,000

Source: Statistics Canada.
p Preliminary; r Revised; - Nil; nes Not elsewhere specified.

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 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

TABLE 5. CANADA, PRODUCTION (SHIPMENTS) OF SAND AND GRAVEL BY USES, 1977-1978

	1977	1978
	(000 tonnes)	
Roads - construction, maintenance, ice control	155 909	159 913
Concrete aggregate	34 363	31 104
Asphalt aggregate	20 476	25 346
Railroad ballast	3 807	5 522
Mortar sand	2 251	1 933
Backfill for mines	1 349	2 644
Other fill	25 447	26 463
Other uses	19 303	19 167
Total sand and gravel	262 905	272 092
$000	364 881	416 860

Source: Energy, Mines and Resources Canada.

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.

USES

The main uses for sand and gravel are: as fill, granular base and finish coarse 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-coarse 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, 1975-79

	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	377 677
1977	262 904 861	1 645 663	273 745
1978	272 091 925	1 810 989[r]	269 216[r]
1979P	275 127 000	1 201 913	323 640

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; [r] Revised.

Selenium and Tellurium[1]

D.A. CRANSTONE

Selenium

Selenium is a nonmetallic element whose chemistry is similar to that of sulphur. It has some of the properties of a metal and is sometimes referred to as a metal. Selenium occurs in minerals associated with copper, lead and iron sulphides. Commercial production is from electrolytic copper refinery slimes and from flue dusts from copper and lead smelters. Thus, selenium production is related to refined copper production and to the relative recovery rates of selenium. Producing countries include the United States, Canada, Japan, the U.S.S.R., Belgium, Sweden, Mexico, Yugoslavia, Finland, Peru, Australia and Zambia. A significant amount of selenium is also produced each year from secondary sources.

Production of selenium from blister copper treated at Canadian refineries plus refined selenium from domestic primary materials was 107 000 kilograms (kg) in 1979 compared with 122 405 kg in 1978 and 161 308 kg in 1977. However, substantial amounts of xerographic scrap and other selenium scrap are imported from the United States and other countries to be re-refined in Canada and re-exported. Because of this activity, Canada in 1979 was the non-communist world's largest producer of refined selenium, followed by Japan and the United States.

[1] This review was not published in 1978.

As shown in Table 1, production in 1978 and 1979 was below normal as a result of strikes at the Sudbury operations of Inco Limited and the Mines Gaspé Division of Noranda Mines Limited, both of which began in 1978 and continued into 1979.

Domestic consumption of selenium in 1979 was reported to be 15 772 kg compared with 14 364 kg in 1978 and 12 476 kg in 1977.

Most of Canada's selenium production is exported but exports vary widely from year to year, often differing significantly from refined production. The United States is Canada's major market, followed by the United Kingdom. These two countries together purchased 83 per cent of Canada's exports in 1978 and 88 per cent in 1979.

Canadian Copper Refiners Limited at Montreal East, Quebec, operates Canada's largest selenium recovery plant. This plant refines copper from the Noranda smelter of Noranda Mines Limited, the Murdochville smelter of Gaspé Copper Mines, Limited, (both in Quebec) and from the Flin Flon smelter of Hudson Bay Mining and Smelting Co., Limited in Manitoba. It produces commercial-grade (99.5 per cent) and high-purity (99.99 per cent) selenium and a variety of selenium compounds. Annual capacity is up to 186 600 kg of selenium in elemental form and in salts, depending on copper production and its selenium content. New emission control equipment was added in 1979 to meet the new air quality standards of the Montreal Urban Community, now among the most stringent in North America.

TABLE 1. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1977-79

	1977		1978		1979p	
	(kg)	($)	(kg)	($)	(kg)	($)
Production						
All forms[1]						
Quebec	92 659	3,711,137	71 805	2,708,581	174 305	5,529,732
Manitoba	11 856	474,830	15 480	583,913	20 354	645,725
Ontario	53 149	2,128,700	31 481	1,487,485	18 325	581,356
Saskatchewan	3 644	145,936	3 639	137,274	4 775	151,469
Total	161 308	6,460,603	122 405	4,917,253	217 759	6,908,282
Refined[2]	410 326	..	392 777	..	511 703	..
Exports						
United States	105 732	5,259,000	108 545	5,130,000	158 077	6,818,000
United Kingdom	75 841	3,270,000	91 943	3,832,000	95 481	3,789,000
Japan	9 843	558,000	23 496	875,000	8 890	471,000
French Oceania	-	-	-	-	4 491	179,000
Spain	-	-	7 076	191,000	6 169	169,000
Puerto Rico	816	44,000	1 406	76,000	2 676	159,000
Other countries	5 262	220,000	9 752	297,000	13 426	433,000
Total	197 494	9,351,000	242 218	10,401,000	289 210	12,018,000
Consumption[3]	12 476	..	14 364	..	15 772	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2] Refinery output from all sources, including imported materials and secondary sources. [3] Consumption (selenium content), as reported by consumers.
p Preliminary; - Nil; .. Not available.

The 67 200 kg-per-year selenium recovery plant of Inco Limited at Copper Cliff, Ontario treats tankhouse slimes from the company's Copper Cliff copper refinery and its Port Colborne, Ontario, nickel refinery and produces minus-200 mesh selenium powder (99.5 per cent Se). Production was interrupted by an 8½-month strike that began on September 20, 1978 and lasted until June 3, 1979.

Non-communist world production of selenium in 1979 was 1 531 000 kg compared with 1 373 007 kg in 1978 and 1 355 901 kg in 1977.

In the United States, primary selenium production in 1979 was 266 000 kg compared with 231 000 kg in 1978 and 226 000 kg in 1977. The United States imported 42 per cent of its requirements in 1977, 43 per cent in 1978 and 28 per cent in 1979. U.S. producer stocks rose from 146 500 kg at the end of 1977 to 230 000 kg at the end of 1978 and to 284 400 kg by the end of 1979, prompting some producers to lower their prices twice during 1979 (see Selenium Prices section).

USES

Selenium is used in the manufacture of glass, steel, electronic components, explosives, animal and poultry feeds, fungicides and pigments, and in xerography.

Elemental selenium is marketed in two grades; commercial, with a minimum content of 99.5 per cent Se; and high purity, with a minimum content of 99.99 per cent Se. Other forms include ferroselenium, nickel-selenium, selenium dioxide, barium selenite, sodium selenate, sodium selenite and zinc selenite. Consumption in the United States in both 1978 and 1979, as estimated by the United States Bureau of Mines, was: electronic and photocopier components, 35 per cent; ceramics and glass, 30 per cent; chemicals and pigments, 25 per cent and other uses, 10 per cent. U.S. apparent consumption in 1979 was 371 000 kg compared with 407 000 kg in 1978 and 395 000 kg in 1977.

TABLE 2. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1965, 1970, 1975-79

	Production			
	All forms[1]	Refined[2]	Exports[3]	Consumption[4]
	(kilograms)			
1965	232 274	233 416	204 660	7 206
1970	300 884	387 572	311 209	7 135
1975	182 385	342 392[r]	218 000	9 933
1976	109 649	226 373[r]	240 900	11 212
1977	161 308	410 326[r]	197 500	12 476
1978	122 405	392 777	242 200	14 364
1979[p]	107 000	511 703	288 000	15 772[p]

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2] Refinery output from all sources, including imported materials and secondary sources. [3] Exports of selenium, metal powder, shot, etc. [4] Consumption (selenium content), as reported by consumers.
[p] Preliminary; [r] Revised.

TABLE 3. NON-COMMUNIST WORLD REFINERY PRODUCTION OF SELENIUM, 1977-79

	1977	1978	1979[e]
		(kg)	
Japan	456 386	453 600[e]	453 600
Canada	410 326	392 777	511 700
United States	226 558	230 713	272 200
Mexico	50 000	80 000	81 600
Sweden	66 400	68 000[e]	68 000
Belgium[e]	60 000	60 000	59 000
Other countries	86 231	87 917	85 300
Total	1 355 901	1 373 007	1 531 400

Sources: U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 8; U.S. Bureau of Mines Mineral Commodity Summaries, January 1980; Energy, Mines and Resources Canada.
[e] Estimated.

TABLE 4. CANADA, INDUSTRIAL USE OF SELENIUM, 1977-79

	1977	1978	1979[p]
	(kg of contained selenium)		
By end-use			
Glass	8 371	10 369	9 618
Other[1]	4 105	3 995	6 154
Total	12 476	14 364	15 772

Source: Energy, Mines and Resources Canada.
[1] Steel, pharmaceuticals.
[p] Preliminary.

An important but declining use of selenium is in the production of rectifiers used in electroplating, welding, battery charging and other applications. Selenium is used in specialty transformers that vary in capacity from a fraction of a watt to 500 kilowatts. Xerography (electrostatic printing), a dry photocopying or photographing process, uses a large quantity of selenium. Selenium has largely been replaced in semiconductors by silicon.

The glassmaking industry is one of the major consumers of selenium. Small quantities added to a glass batch neutralize the greenish tinge imparted by iron impurities in glassmaking sand. Cerium is a competing product in this application. The addition of larger proportions of selenium imparts a brilliant ruby-red colour for uses such as in traffic and other signal lenses, automotive taillights, marine equipment, infrared equipment and decorative tableware; or "black", for use as the outer facing of high-rise office buildings.

Selenium has wide application in the chemical industry, the most important use being in the manufacture of the orange-red-maroon cadmium sulphoselenide pigments. These pigments have considerable light stability, maintain their brilliance and are resistant to heat and chemical action. Their most important application is in the expanding high-temperature, cured-plastic industry, but they are also used to colour ceramics, paints, enamels and inks.

In proportions ranging from 0.2 to 0.35 per cent, selenium imparts improved machinability to stainless steel without affecting its corrosion-resistant properties, and in lesser amounts improves the forging characteristics of steel. Small quantities of iron selenide, from 0.01 to 0.05 per cent, are used in steel castings to reduce pinhole porosity.

Finely ground elemental selenium and selenium diethyldithio-carbamate (selenac) are used in natural and synthetic rubber to increase the rate of vulcanization and to improve the aging and mechanical properties of sulphurless and low-sulphur rubber. Selenac is used in the manufacture of butyl rubber as an accelerator.

Selenium is used in the organic, chemical and pharmaceutical industries, in the manufacture of cortisone and nicotine acids, in the preparation of various proprietary medicines and shampoos for the control of dermatitis in human beings and animals, and in the control of selenium deficiency diseases in animals and poultry. Selenium is an essential element for normal physical development, and prevents white muscle disease in livestock and in poultry. Growing attention to this property of selenium should result in a large new market for it as an animal feed supplement. In the United States, the Food and Drug Administration has proposed that selenium be added to commercially prepared poultry and swine feed. Although an essential element to humans and livestock, selenium is highly toxic if consumed in more than trace quantities.

A small amount of selenium is used in the manufacture of delay-action blasting caps. Interest has been revived in the use of selenium in photogalvanic cells, which convert light energy to electrical energy. Silkscreen printing on glass has recently been used experimentally in Japan to prepare inexpensive selenium solar photogalvanic cells, but so far these printed cells can convert only about 5 per cent of the available solar energy into electrical energy; that is, a maximum of about 50 watts of electrical energy can be gathered per square metre of collector during exposure to solar radiation. Demand for selenium-tinted windows, which have a lower heat conductivity than conventional glass, is expected to grow.

OUTLOOK

Canadian production has been dropping because the average selenium content in Canadian ores is declining. Therefore, even though Canadian copper output is rising, selenium production is expected to continue to decline over the medium-term. However, production in 1980 should be higher than the strike-reduced levels of 1978 and 1979.

Increased recycling of xerographic drums is reducing demand for primary selenium. Prices are expected to remain weak in the short-to medium-term and producer stocks will continue to rise. The development of new uses could eventually strain the available supply but higher prices would encourage efforts to improve recoveries. Selenium tends to volatilize and be emitted as SeO_2 gas during copper smelting, and up to one-half of the selenium content in copper ores is lost in this way. Recovery of this lost selenium is technically feasible, but significantly higher selenium prices would be necessary to make such recovery economic.

PRICES

According to **Metals Week,** producer prices in 1978 and 1979 in United States currency, were as follows:

	($U.S./lb)
Commercial Grade Selenium	
Jan. 1/78 to Apr. 2/79	15.00
Apr. 3/79 to Oct.10/79	12.00-15.00
Oct. 11/79 to Dec. 31/79	10.00-15.00
High-purity Grade Selenium	
Jan. 1/78 to Apr. 2/79	18.00
Apr. 3/79 to Oct. 10/79	15.00-18.00
Oct. 11/79 to Dec. 31/79	13.00-18.00

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92804-4	Selenium	5%	10%	15%	5%

TARIFFS (Cont'd)

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					per cent				
92804-4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.9	9.2

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
					(per cent)					
420.50	Selenium dioxide	Remains free								
420.52	Selenium salts	Remains free								
420.54	Other selenium compounds	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.40	Selenium metal, unwrought, other than alloys, waste and scrap	Remains free								
632.88	Selenium metal alloys, unwrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Selenium metals, wrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.	1979	Base Rate	Concession Rate
28.04 C.11 Selenium	free	free	free

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979, Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 21, No. L335, 1978.

Tellurium

Tellurium, like selenium, is recovered in Canada from the tankhouse slimes from the two electrolytic copper refineries and the Port Colborne nickel refinery. It is refined by the same two companies, Canadian Copper Refiners Limited at Montreal East, Quebec, and Inco Metals Company at Copper Cliff (Sudbury) Ontario. Although more "metallic" than selenium, tellurium resembles selenium and sulphur in chemical properties and, like selenium, is a semiconductor.

Production of tellurium in all forms from Canadian ores in 1979 was 33 000 kg valued at $1,669,000 compared with 31 421 kg valued at $1,580,302 in 1978 and 35 116 kg valued at $1,414,931 in 1977. Tellurium output is related to selenium output because tellurium is a coproduct of selenium recovery. Refined output from all sources, including imported material, for the years 1979, 1978 and 1977 was 47 204 kg, 45 299 kg and 37 021 kg, respectively.

Canadian Copper Refiners has an annual capacity of up to 27 200 kg of tellurium in powder, stick, lump and dioxide forms. The Copper Cliff refinery has an annual capacity of up to 8 200 kg of tellurium in the form of dioxide.

USES

Tellurium supply is related to copper production but the nature of demand justifies only a low rate of recovery. Tellurium and

TABLE 5. CANADA, PRODUCTION AND CONSUMPTION OF TELLURIUM, 1965, 1970 AND 1975-79

	Production		Consumption
	All forms[1]	Refined[2]	Refined[3]
	(kilograms)		
1965	31 658	32 536	848
1970	26 459	29 317	399
1975	19 854	42 253	614
1976	48 698	53 141	589
1977	35 116	37 021	291
1978	31 421	45 299	x
1979[p]	33 000	47 204	x

Source: Energy, Mines and Resources Canada.
[1] Includes recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary materials. [2] Refinery production from all sources, including imported material and secondary sources. [3] Consumption (tellurium content), as reported by consumers.
[p] Preliminary; x Confidential.

many of its compounds are highly toxic and great care is required in their handling.

Most of the commercial-grade tellurium sold by the primary producers is in the form of slab, stick, lump, tablet and powder. It is also sold as copper-tellurium and iron-tellurium alloys.

Normal commercial grades of tellurium contain a minimum of 99 per cent or 99.5 per cent tellurium. Tellurium dioxide is sold in the form of minus 40 to minus 200-mesh powder containing a minimum of 75 per cent tellurium.

In the United States, consumption by major use in 1979 (1978) was estimated to be: iron and steel, 57 (77) per cent; chemical uses, 25 (5) per cent; nonferrous metal production, 14 (14) per cent; and other uses including rubber manufacturing, 4 (4) per cent.

The primary metal industries are by far the largest consumers of tellurium. When it is added to copper and to low-carbon and alloy steels, the machinability of these metals is greatly improved. In stainless steel castings it reduces or prevents pinhole porosity. A very small quantity of tellurium added to molten iron controls the chill depth of grey-iron castings. An alloy containing 99.5 per cent copper and 0.5 per cent tellurium is used in the manufacture of welding tips and communications equipment because it can be hot- or cold-worked, and the thermal and electrical conductivity of this alloy is only sightly less than that of copper. Addition of up to 0.1 per cent tellurium in lead forms an alloy that has better resistance to wear, vibration break-down and corrosion, and, because of these properties, the alloy is used to sheathe marine cables and to line tanks subject to chemical corrosion.

Tellurium, as a component of alloys containing gallium, bismuth and lead, is used in thermoelectric devices for the direct conversion of heat into electricity, and for cooling, as a result of its Peltier effect. A thermonuclear heart pacemaker that employs this principle is under development. In the device, nuclear power provides heat which a tellurium alloy converts to electrical energy. The minimum life of this experimental pacemaker is reported to be ten years.

Tellurium is used as a secondary vulcanizing agent in natural and synthetic rubber, in which it increases toughness and resistance to abrasion and heat. Such rubber is used for the jacketing of portable electric cable used in mining, dredging and welding, and for specialized conveyor belting. Tellurium is employed to eliminate porosity in thick rubber sections and as an accelerator for butyl applications.

TABLE 6. NON-COMMUNIST WORLD REFINERY PRODUCTION OF TELLURIUM, 1977-79

	1977	1978	1979[e]
		(kg)	
Japan	69 900	72 600[e]	77 100
Canada	37 021	45 299	47 200
Hong Kong	..	..	45 400
Fiji	..	22 700[e]	22 700
Peru	12 200	15 400	13 600
Total[1]	119 100	156 000	206 000

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979 and 1980; Energy, Mines and Resources Canada.
[1] Available data. United States withholds its figures to avoid disclosing company data, but accounted for 42 per cent of world output in 1975.
[e] Estimated; .. Not available.

Recently, tellurium has been used experimentally as a high-absorption-collector surface film for solar heat collector panels, where it results in higher absorption and lower re-emission of solar energy than can be obtained from other materials commonly used for this purpose.

In recent years there has been a sharp increase in the chemical uses of tellurium, especially in catalytic applications of tellurium dioxide in the processing of petrochemicals.

Some tellurium is consumed in glass and ceramic production to impart blue-to-brown coloration, in the preparation of insecticides and germicides, and in the manufacture of delay-electric blasting caps and of pigments.

OUTLOOK

Supply of tellurium is largely limited to that which is available from copper output and, as in the case of selenium, new copper production is increasingly derived from tellurium-poor ores. In the short-to medium-term, demand is expected to grow slowly and supply should be adequate to meet requirements. However, as the total available supply of tellurium is even more limited than that of selenium, significant new uses of tellurium, such as in solar collectors, could result in the higher prices that would justify a higher percentage recovery from tellurium-bearing ores.

PRICES

According to **Metals Week,** the 1978 and 1979 tellurium prices for slab in 150-pound lots, in United States currency were as follows:

	($U.S./lb)
Jan. 1/78 to Mar. 5/78	20.00
Mar. 6/78 to Dec. 31/79	20.00-23.00

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92804-5	Tellurium metal	5%	10%	15%	5%

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(per cent)				
92804.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.9	9.2

UNITED STATES

Item No.										
427.12	Tellurium salts				5.0					
		1979	1980	1981	1982	1983	1984	1985	1986	1987
421.90	Tellurium compounds	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.48	Tellurium metals, unwrought other than alloys, and waste and scrap	4.0	3.5	3.0	2.5	2.0	1.5	1.0	0.5	free
632.88	Tellurium metal alloys, unwrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Tellurium metal, wrought	9.0	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

TARIFFS (Cont'd)

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1979	Base Rate	Concession Rate
28.04 C.111	Tellurium metal	2.4%	2.4%	2.1%

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979, Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 21 No. L335, 1977; GATT Documents, 1979.

Silica

B.W. BOYD

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 1979 was 2.4 million tonnes, (t) slightly higher than in 1978 and considerably below the peak 2.9 million t produced in 1970.

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 1979, imports, nearly all from the United States, totalled 1.65 million t, an increase of 33 per cent over imports in 1978 reflecting a continuation of a trend to increased imports at the expense of domestic production.

PRINCIPAL PRODUCERS AND DEVELOPMENTS

Newfoundland. Newfoundland Enterprises Limited, a subsidiary of Erco Industries 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 150 000 t of silica annually.

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

TABLE 1. CANADA, SILICA PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979[P]	
	(tonnes)	($)	(tonnes)	($)
Production, quartz and silica sand				
By province				
Ontario	846 500	6,978,328	980 279	8,965,420
Quebec	684 190	9,174,468	606 998	8,927,703
Manitoba	348 134	2,122,147	269 908	2,598,824
Alberta	..	1,763,897	..	2,299,288
Newfoundland	..	742,502	..	1,710,233
Nova Scotia	..	480,000	..	1,088,000
New Brunswick	-	-	..	430,000
British Columbia	21 055	301,100	21 672	319,757
Saskatchewan	128 515	239,439	108 736	239,722
Total	2 245 136	21,801,881	2 368 497	26,578,947
By use				
Glass and fiberglass	505 422	8,209,400	..	..
Flux	239 811	1,680,618	..	..
Ferrosilicon	677 494	1,449,148	..	..
Other uses[1]	822 409	10,462,715	..	..
Total	2 245 136	21,801,881	2 368 497	26,578,947
Imports				
Silica sand				
United States	1 226 722	12,675,000	1 650 914	19,352,000
West Germany	90	3,000	353	20,000
France	-	-	36	10,000
Greece	-	-	453	5,000
United Kingdom	87	3,000	55	4,000
Sweden	-	-	79	3,000
South Africa	9 986	763,000	-	-
Belgium-Luxembourg	5 559	43,000	-	-
Total	1 242 444	13,487,000	1 651 890	19,394,000
Silex and crystallized quartz				
United States	1 945	186,000	1 241	175,000
United Kingdom	-	-	18	12,000
Brazil	10	9,000	-	-
Total	1 955	195,000	1 259	187,000
Firebrick and similar shapes, silica				
United States	5 076	1,585,000	3 848	1,106,000
West Germany	3	1,000	252	148,000
France	162	130,000	149	144,000
United Kingdom	1 672	165,000	560	50,000
Spain	-	-	55	27,000
Other countries	35	16,000	32	35,000
Total	6 948	1,897,000	4 896	1,510,000
Exports				
Quartzite				
United States	67 768	332,000	60 823	362,000
United Kingdom	7	3,000	-	-
Total	67 775	335,000	60 823	362,000

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.

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 operations in Quebec decreased for the second year in a row to 315 000 t, down 28 per cent from 1977. A 65 day strike at Saint-Canut and a subsequent strike at a major customer's plant caused the downturn in 1979 and expectations for 1980 are better. Installation of a primary dryer and a 1 000 short ton ore storage silo was nearly complete at year-end.

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 Couchette, Roberval produces about 15 000 t from vein quartz for Union Carbide's silicon plant at Chicoutimi.

S.K.W. Electro-Metallurgy Canada Ltd., operates a 52 000 tpy 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 tpy 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 tpy 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 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 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 tpy of washed lump silica and fine material. The Midland plant capacity is about 500 000 tpy 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.

In 1979, production increased to 573 000 t to set a new record for Indusmin's Ontario operations.

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 Limited's smelter at Thompson, Manitoba, for use as metallurgical flux. Inco now manages these facilities.

Manitoba's output declined in 1979 to 270 000 t after recovery to 348 000 t in 1978. Production and demand had been in excess of 450 000 t annually, earlier in the decade.

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 1979 was 109 000 t.

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, for products suitable for fibreglass manufacture, sand blasting and foundry use. Since operations started in 1971, capacity has tripled to more than 60 000 tpy. 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 1979 was 22 000 t.

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 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

TABLE 2. CANADA, SILICA PRODUCTION AND TRADE, 1970, 1975-79

Year	Production: Quartz and Silica Sand	Imports: Silica Sand	Imports: Silex or Crystallized Quartz	Exports: Quartzite	Consumption: Quartz and Silica Sand
			(tonnes)		
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	2 395 948r	1 337 138	863	47 944	3 077 594
1977	2 316 680	1 101 186	1 219	56 297	3 037 701
1978	2 245 136	1 242 444	1 955	67 775	2 987 735
1979p	2 368 497	1 651 890	1 259	60 823	..

Source: Statistics Canada.

p Preliminary; r Revised; .. Not available.

quartzitic pebbles are used as grinding media in the crushing of various nonmetallic ores.

Silica sand. Glass. High-purity, naturally occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass. Minor amounts of certain elements are particularly objectionable because they act as powerful colourants. For example, chromium should not exceed six parts per million and cobalt not over two parts per million. 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.

TABLE 3. CANADA, ESTIMATED CONSUMPTION OF SILICA, BY INDUSTRIES, 1977 and 1978

	1977	1978
	(tonnes)	
Foundry sand	549 089	818 602
Glass manufacture (including glass fibre)	886 356	748 305
Smelter flux[1]	875 221	677 494
Refractory brick mixes, cements	359 097	368 385
Artificial abrasives	129 056	170 142
Metallurgical	51 979	44 426
Chemicals	18 358	24 429
Gypsum products	7 759	27 147
Concrete products	8 440	5 072
Fertilizer, stock poultry feed	2 146	2 219
Other[2]	150 200	101 514
Total	3 037 701	2 987 735

Source: Statistics Canada for source data. Compiled by Energy, Mines and Resources Canada.

[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 and other minor uses.

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 constitutents 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 the 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 must be perfectly transparent and free from all impurties and flaws. The individual crystals should weigh 100 grams or more and measure at least five 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 for electronic use. Domestic requirements are met mainly by imports, chiefly from the United States, with minor amounts from Brazil. In Ontario, Comet Quartz Limited produced quartz for crystal growing in Europe.

OUTLOOK

Silica output and consumption in Canada had declined 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 brought a little recovery in 1979. 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.

Compared with 1970, total Canadian silica production is down 19 per cent in tonnage but has tripled in value by virtue of the change in product mix and price increases.

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. 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 the La Galette area northeast of Quebec City, the Madeleine 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.		
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

TARIFFS (Cont'd.)

		1979	1980	1981	1982	1983	1984	1985	1986	1987
					¢ per short ton					
513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide of iron	25	22	19	16	12	9	6	3	free

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated 1978, USITC Publication 843; U.S. Federal Register Vol. 44, No. 241.

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. The production of silicon metal, ferrosilicon and silicon carbide from silica ores requires large amounts of energy and therefore production plants are usually situated in areas with an abundant supply of electrical power. In Canada these silicon products are manufactured in plants in Quebec and southern Ontario.

CANADA

The three major producers of Canadian ferrosilicon, namely Chromasco Limited, Union Carbide Canada Limited and S.K.W. Electro-Metallurgy Canada Ltd., all operate plants located in Quebec.

In 1979 Chromasco Limited operated its Beauharnois, Quebec plant at full production capacity of 33 800 tonnes (t). The bulk of Chromasco's output is consumed at its Haley, Ontario plant in the production of magnesium.

Union Carbide Canada Limited (UCC), one of two domestic producers of both ferrosilicon and silicon metal, operates plants at Chicoutimi and Beauharnois, Quebec. Only ferrosilicon is produced at Chicoutimi, and during the year capacity production of 28 000 t was achieved. The Beauharnois plant produced only 8 000 t of ferrosilicon and 1 200 t of silicon metal because of a nine-month labour dispute.

S.K.W. Electro-Metallurgy Canada Ltd. (S.K.W. Canada) started production from its Bécancour, Quebec plant in 1976 and currently has an annual production capacity of 25 000 t of ferrosilicon and 25 000 t of silicon metal. S.K.W. Canada is 85 per cent owned by S.K.W. - Trostberg of West Germany and 15 per cent by A/S Ila Og Lilleby Smelterverker of Norway. Most of its production is exported to the United States, West Germany and Japan.

The availability of electrical energy also 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, with products shown in brackets, are: Canadian Carborundum Company, Limited, Shawinigan (SiC); Norton Company (SiC); Electro Refractories & Abrasives Canada Ltd., Cap-de-la-Madeleine (SiC); and Unicorn Abrasives of Canada Ltd., Arvida (Al_2O_3). 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., Thorold (Al_2O_3 and SiC). 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 the production of bonded abrasives such as abrasive wheels and coated abrasives such as sandpaper.

USES

Silicon metal is used principally as an alloying agent for aluminum. It increases fluidity and corrosion resistance as well as thermal and electrical conductivity. In addition, silicon metal reduces the specific density and thermal expansion of aluminum alloys. These alloys are used principally to make aluminum castings and contain on average about 6 per cent silicon. More than one-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 make silicon bronze, aluminum alloys for coating steel sheets, semiconductor electronic devices and silicon nitride (Si_3N_4).

TABLE 1. CANADA, FERROSILICON, SILICON CARBIDE AND SOME OTHER FERROALLOYS[1], EXPORTS AND IMPORTS, 1978 and 1979

	1978		1979P	
	(t)	($)	(t)	($)
Exports				
Ferrosilicon				
United States	48 296	21,196,000	31 550	14,806,000
Japan	5 542	3,691,000	5 553	4,583,000
West Germany	5 018	1,588,000	2 634	2,063,000
United Kingdom	721	239,000	310	208,000
Angola	142	18,000	307	92,000
Australia	122	106,000	132	88,000
Jamaica	-	-	33	37,000
Philippines	-	-	116	35,000
Other countries	305	215,000	98	50,000
Total	60 146	27,053,000	40 733	21,962,000
Silicon carbide, crude and grains				
United States	104 410	32,688,000	82 293	30,378,000
Japan	2 298	878,000	1 419	581,000
Taiwan	402	157,000	264	108,000
Philippines	-	-	199	82,000
Other countries	241	95,000	263	109,000
Total	107 351	33,818,000	84 438	31,258,000
Ferroalloys, nes				
United States	8 506	3,941,000	3 459	5,056,000
Japan	19	219,000	89	1,092,000
Netherlands	-	-	1 020	975,000
United Kingdom	1 212	256,000	2 330	596,000
Taiwan	62	46,000	21	294,000
Belgium and Luxembourg	-	-	10	140,000
Other countries	97	179,000	150	145,000
Total	9 896	4,641,000	7 079	8,298,000
Imports				
Ferrosilicon				
United States	8 669	6,349,000	17 776	12,031,000
Norway	649	548,000	1 452	1,412,000
France	476	366,000	228	269,000
Sweden	663	585,000	279	231,000
West Germany	21	38,000	48	84,000
Brazil	-	-	17	17,000
Venezuela	9	4,000	-	-
Total	10 487	7,890,000	19 800	14,044,000

TABLE 1. (cont'd)

	1978		1979P	
	(t)	($)	(t)	($)
Silicomanganese, including silico spiegel				
United States	6 309	2,902,000	12 079	7,054,000
Norway	5 779	2,412,000	6 776	3,551,000
Brazil	1 744	673,000	1 500	919,000
South Africa	507	721,000	1 521	822,000
Other countries	1 503	470,000	-	-
Total	15 842	7,178,000	21 876	12,346,000
Ferroalloys, nes				
United States	2 810	4,102,000	4 084	7,804,000
Brazil	775	6,204,000	1 034	4,879,000
France	1 369	1,769,000	1 751	2,734,000
United Kingdom	82	561,000	44	317,000
Dominican Republic	2 253	3,085,000	48	160,000
West Germany	12	31,000	78	119,000
Italy	-	-	18	47,000
Belgium and Luxembourg	7	67,000	16	26,000
Other countries	10 056	10,141,000	...	22,000
Total	17 364	25,960,000	7 073	16,108,000

Source: Statistics Canada.
[1] Other important ferroalloys are discussed in the manganese, nickel and titanium reviews for 1979.
nes Not elsewhere specified; - Nil; P Preliminary; ... Less than one tonne.

TABLE 2. FERROSILICON PRODUCTION AND TRADE, 1978P

	Production	Imports	Exports
		(t, gross weight)	
Austria	..	12 642	..
Belgium and Luxembourg	..	30 496	..
Brazil	60 290	..	..
Canada	99 880	9 131	45 490
France	236 029	..	78 631
West Germany	87 000	141 033	23 243
India	44 745	..	6 424
Italy	76 511	41 795	..
Japan	291 446	45 293	2 972
Norway	235 836	..	228 180
Republic of South Africa	100 000	..	..
Spain	67 077	..	17 126
Sweden	22 282	22 477	15 350
United Kingdom	-	92 904	1 480
United States	811 717	74 485	50 528
U.S.S.R.	300 000e	..	..
Yugoslavia	55 513	..	40 502

Sources: United States Bureau of Mines, Mineral Trade Notes, May 1979 for production; **Metal Bulletin Handbook,** 1979 for trade; Statistics Canada; Energy, Mines and Resources, Canada.
P Preliminary; .. Not available; e Estimated; - Nil.

TABLE 3. CANADA, CONSUMPTION, EXPORTS, IMPORTS AND PRODUCTION OF FERROSILICON, 1965, 1970, 1975-79

	Consumption[1]	Exports		Imports		Production[2]
	(t)	(t)	($)	(t)	($)	(t)
1965	30 672	42 115	4,706,724	5 678	1,799,546	67 109
1970	50 556	45 345	8,284,000	9 477	2,386,000	86 424
1975	54 904	29 029	8,075,000	26 353	15,665,000	57 580
1976	61 734	34 673	11,416,000	10 424	7,121,000	85 983
1977	63 521	45 490	17,225,000	9 131	5,552,000	99 880
1978	63 931	60 146	27,053,000	10 487	7,890,000	113 590
1979p	61 030	40 733	21,962,000	19 800	14,044,000	81 963

Source: Statistics Canada.
[1] Consumption as reported by consumers. [2] Consumption, plus net exports, equals derived production.
p Preliminary.

The iron and steel industry is the largest user of ferrosilicon and other silicon alloys such as silicocalcium, silicochrome and silicomanganese. Ferrosilicon functions primarily as a deoxidizer in molten steel. In addition, it is used as a graphite promoter during the production of carbon steels, as an additive to improve the electrical properties of electric steels and as a reducing agent in the manufacture of non-ferrous alloys. Carbon steel contains, on the average, 0.755 kilograms (kg) of silicon per t of steel and consumes about one-third of Canadian ferrosilicon production. Stainless steels and electric steels, which contain an average of 10 and 20 kg of silicon respectively per t of steel and other types of steel consume the remaining two-thirds. Ferrosilicon is also used in the silicothermic process for the production of other metals, but only small tonnages are required for this purpose.

OUTLOOK

The forecast for silicon metal and for ferrosilicon is based on the outlook for aluminum and steel respectively.

In the case of silicon metal, approximately 75 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 lightweight alloys.

Ferrosilicon demand is determined mainly by the iron and steel industry, and to some extent by manufacturers of magnesium and nickel in the silicothermic process. Slow production expansion is expected in the short-term for these industries and only moderate growth in the longer-term.

Potential areas for expanding consumption include the substitution of silicon for other metals in alloys, and for applications in solar energy collection systems and micro-electronics.

TABLE 4. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE SILICON CARBIDE, 1965, 1970, 1975-78

	(t)	($)
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
1978	106 763	38,763,000

Source: Statistics Canada.

TABLE 5. CANADA, EXPORTS OF SILICON CARBIDE, 1965, 1970, 1975-79

	(t)	($)
1965	82 465	12,243,784
1970	96 159	15,976,000
1975	78 615	17,441,000
1976	86 455	23,743,000
1977	86 016	28,511,000
1978	107 351	33,818,000
1979p	84 438	31,258,000

Source: Statistics Canada.
p Preliminary.

TABLE 6. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE FUSED ALUMINA, 1965, 1970, 1975-78

	(t)	($)
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
1978	154 303	49,916,000

Source: Statistics Canada.

TABLE 7. CANADA, EXPORTS OF CRUDE FUSED ALUMINA, 1965, 1970, 1975-79

	(t)	($)
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	167 344	48,830,000
1979p	183 127	55,138,000

Source: Statistics Canada.
p Preliminary.

PRICES

PRICES PUBLISHED BY **METALS WEEK** IN DECEMBER 1978 AND 1979

		1978	1979
		(¢ U.S.)	
Ferrosilicon, pound contained silicon fob shipping point freight equalized to nearest main producer, carloads lots lump bulk			
High-purity (% Si)			
	75	39.25-42.00	46.25
Regular	50	35.50-38.00	42.00
Silicon metal, pound contained silicon, fob shipping point, freight equalized to nearest main producer, carloads lots lump bulk			
(% max. Fe)	(% max. Ca)		
0.35	0.07	52.9	59.7
0.50	0.07	51.2	57.85-58.85
1.00	0.07	49.0	56.5

Prices published by **American Metal Market** in December 1978 and 1979

	1978	1979
	(¢ U.S.)	
SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, 15-ton lots, per pound of alloy	39.25	42.50
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	57.00	71.00
	($ U.S.)	
Electric furnace silvery pig iron, fob Keobuck, Iowa		
16% Si, per ton	178.00	210.00
20% Si, per ton	202.00	237.00

Prices published by **Industrial Minerals** in December 1979 and 1980

(tonnes, cif main European port)	(£)	
Fused alumina, 8-220 mesh, cif		
Brown, min. 94% Al_2O_3	315-325	315-325
White, min. 99.5% Al_2O_3	350-380	350-380
Silicon carbide, 8-220 mesh, cif		
Black, about 99% SC	560-580	560-580
Green, over 99.5% SC	710-730	710-730

fob Free on board; cif Cost, insurance and freight.

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%

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(cents)				
37502-1	0.75	0.75	0.75	0.74	0.73	0.73	0.72	0.71	0.70
37504-1	0.75	0.75	0.75	0.74	0.73	0.73	0.72	0.71	0.70
37505-1	2.5	2.5	2.5	2.4	2.3	2.3	2.2	2.1	2.0

TARIFFS (cont'd.)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(per cent)				
92804-1	15.0	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2
92815-4	15.0	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
606.42	Ferrosilicon chromium					10%				
519.21	Crude silicon carbide				remains free					
519.37	Silicon carbide in grains, ground, pulverized or refined					(¢/lb.)				
		0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
606.35	Ferrosilicon, containing 8-60% silicon				remains free					
606.36	Ferrosilicon, containing 60-80% silicon and over 3% calcium		¢/lb.							
		0.5	0.5	0.5	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
606.37	Other ferrosilicon containing 60-80% silicon		¢/lb.							
		0.5	0.5	0.5	1.6%	1.6%	1.6%	1.6%	1.5%	1.5%
606.39	Ferrosilicon containing 80-90% silicon		¢/lb.							
		1.0	1.0	1.0	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
606.40	Ferrosilicon containing over 90% silicon		¢/lb.							
		2.0	2.0	2.0	9.3%	8.6%	7.9%	7.2%	6.5%	5.8%
606.44	Ferrosilicon manganese		¢/lb.							
		.46 +3.5%	.46 +3.5%	.46 +3.5%	5.2%	5.0%	4.7%	4.4%	4.2%	3.9%

EUROPEAN ECONOMIC COMMUNITY (MFN):

Item No.		1979	Base Rate	Concession Rate
		(%)	(%)	(%)
28.13	Silicon dioxide	6.4	6.4	4.6
73.02	Ferrosilicon	10.0	10.0	6.2
	Ferrosilico manganese	5.5	-	-
	Ferrosilico-chrome	7.0	7.0	4.9

JAPAN

Item No.				
28.04	Silicon - single crystal	15.0	15.0	7.2
	- other	7.5	7.5	4.9
28.56	Silicon carbide	7.5	7.5	4.9
68.06	Abrasive paper	15.0	15.0	6.5
73.02	Ferrosilicon	5.0	5.0	3.7

Sources: The Customs Tariff and Amemdments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff Department of Finance, Ottawa, 1979, Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Customs Tariff Schedules of Japan, 1978; GATT Documents, 1979; Official Journal of the European Communities, Vol. 21, No. L335, December 1978.

Silver

J.J. HOGAN

Canada's primary production of silver is largely derived as a byproduct of base metal ores. Production in 1979 was estimated to be 1 184 000 kilograms (kg) compared with 1 266 927 kg in 1978. The decrease was mainly attributable to loss of production at two mines through labour strikes, and substantially lower production at a Northwest Territories silver producer. 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 Canada Ltd. and the copper-zinc-silver mines of Noranda Mines Limited in northwestern Ontario. The province accounted for about 37 per cent of Canada's total output.

The value of Canadian silver production in 1979 was $451.9 million compared with $251.4 million in 1978. A sharp rise in the average price of silver for 1979 and to a lesser extent a lower Canadian dollar in relation to its United States counterpart were responsible for the significant increase in the value of Canada's silver output.

Canada's exports of silver in ores and concentrates and as refined metal totalled 1 321 404 kg in 1979, 228 604 kg less than in 1978. The United States continued to be the major market for Canadian exports, accounting for 1 108 804 kg or about 84 per cent of Canada's total silver exports. Canada's imports of silver in ores and concentrates and as refined metal were 113 139 kg in 1979 compared with 210 616 kg in 1978. Imports of silver in ores and concentrates from countries other than the United States decreased substantially in 1979. Imports of refined silver were 36 564 kg in 1979, about the same as the previous year. The United States was the main source of refined silver imports.

Canadian consumption of silver for both industrial and coinage uses in 1979 was estimated at 251 985 kg compared with 329 320 kg in 1978, a decline of 23.5 per cent. There was a significant decline in the use of silver in sterling and silver alloys. The Royal Canadian Mint in 1979 consumed 10 658 kg of silver in the production of 826 695 silver dollar numismatic coins which commemorated the 300th Anniversary of Canadian Commercial Navigation (the ship Griffon) in the Great Lakes above Niagara Falls. Each coin contains 50 per cent silver and the weight of the contained silver is 11.66 grams (g).

DOMESTIC PRODUCTION

Mine Production

The principal source of silver was base-metal ores, which 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 1979" shows their approximate locations. The five 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; United Keno Hill Mines Limited in the Mayo district, Yukon Territory; and Mattabi Mines Limited in northwestern Ontario. These mines accounted for about 52 per cent of the Canadian silver production in 1979. The Cobalt district, once a major producer of silver, is now a relatively small silver producing district, accounting for only 3.3 per cent of Canada's 1979 output.

Metal Production

Production of refined silver in 1979 at six Canadian primary silver refineries was as shown in the accompanying listing.

Canadian Copper Refiners Limited at Montreal East, Quebec, was Canada's largest producer of refined silver, recovering it mainly from the treatment of anodes 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. 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.

	Production[1] Refined Silver (kilograms)	Annual[2] Rated Capacity (kilograms)
Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune, New Brunswick	96 327[3]	125 000
Canadian Copper Refiners Limited, Montreal East, Quebec	642 225	777 600
Canadian Smelting & Refining (1974) Limited Cobalt, Ontario	39 501	186 600[4]
Cominco Ltd., Trail British Columbia	311 097	373 200
Inco Metals Company Copper Cliff, Ontario	24 572[5]	..
Royal Canadian Mint Ottawa, Ontario	4 570[6]	217 705[7]

Sources: Company Reports; Royal Canadian Mint.

[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, 1979. [3] Bullion produced by Brunswick Mining and Smelting Corporation Limited was shipped to Canadian Copper Refiners Limited (CCR) for further refining and the 642 225 kg of silver reported as production for CCR includes all of that silver bullion produced by Brunswick and refined by CCR in 1979. [4] Up to this amount, depending on nature of material processed. [5] Silver delivered to market. [6] Silver derived from refining gold bullion. [7] Total capacity for producing refined gold and silver of which about 10 per cent is silver.

.. Not available.

TABLE 1. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979p	
	(kilograms)	($)	(kilograms)	($)
Production[1]				
By province and territories				
Ontario	443 071	87 906 253	438 000	166 985 000
British Columbia	229 001	45 434 389	233 000	88 882 000
New Brunswick	200 578	39 795 033	196 000	74 906 000
Yukon Territory	143 459	28 462 559	132 000	50 315 000
Northwest Territories	120 231	23 854 173	80 000	30 591 000
Quebec	77 590	15 394 028	60 000	23 077 000
Manitoba	28 739	5 701 868	27 000	10 221 000
Newfoundland	16 378	3 249 513	11 000	4 318 000
Saskatchewan	7 877	1 562 781	7 000	2 618 000
Alberta	3	592	-	-
Total	1 266 927	251 361 189	1 184 000	451 913 000
By source[2]				
Base-metal ores[3]	1 217 586	241 571 898	1 138 000	434 277 000
Gold ores	8 200	1 626 781	6 000	2 458 000
Silver-cobalt ores	41 007	8 136 030	39 000	15 100 000
Placer gold ores	134	26 480	1 000	78 000
Total	1 266 927	251 361 189	1 184 000	451 913 000
Refined silver[4]	1 026 998	..	949 778	..
Exports				
Silver in ores and concentrates				
United States	281 562	41 820 000	209 022	41 892 000
Japan	122 334	13 952 000	119 911	36 648 000
West Germany	35 293	2 103 000	41 505	6 185 000
U.S.S.R.	3 757	499 000	10 127	3 059 000
United Kingdom	12 854	1 481 000	8 940	2 194 000
Belgium-Luxembourg	8 666	710 000	9 087	1 835 000
Italy	9 031	742 000	9 410	1 599 000
Other countries	6 227	768 000	6 531	1 495 000
Total	479 724	62 075 000	414 533	94 907 000
Refined metal				
United States	1 025 270	202 156 000	899 782	346 900 000
Jamaica	1 416	283 000	1 457	512 000
Japan	543	97 000	1 446	374 000
Trinidad and Tobago	2 358	459 000	1 439	374 000
United Kingdom	22 801	4 451 000	1 286	356 000
Others	17 896	3 671 000	1 461	431 000
Total	1 070 284	211 117 000	906 871	348 947 000
Imports				
Silver in ores and concentrates				
United States	24 331	4 230 000	32 934	8 578 000
Other countries	150 284	22 619 000	43 641	15 964 000
Total	174 615	26 849 000	76 575	24 542 000

TABLE 1. (cont'd.)

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Imports (cont'd)				
Refined metal				
United States	30 098	4 573 000	32 648	4 272 000
United Kingdom	5 506	415 000	3 081	540 000
West Germany	119	41 000	275	113 000
Others	278	494 000	560	46 000
Total	36 001	5 523 000	36 564	4 971 000
Consumption, by use				
Sterling	69 938	..	35 799	..
Silver alloys	70 779	..	43 856	..
Wire rod	3 212	..	4 408	..
Others[5]	185 391	..	167 922	..
Total	329 320	..	251 985	..

Sources: Energy, Mines and Resources Canada; 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. [3] Includes mines which produce base-metals but are predominantly silver producers. [4] From all sources, domestic and imported materials of both primary and secondary origin. [5] Includes sheet, partial coinage and miscellaneous uses.
P Preliminary; - Nil; .. Not available.

TABLE 2. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970, 1975-79

	Production		Exports			Imports,	Consumption[3]
	All Forms[1]	Refined[2] Silver	In Ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
				(kilograms)			
1965	1 003 786	641 671	380 889	350 477	731 366	417 204	938 395
1970	1 376 354	955 668	678 676	752 689	1 431 365	134 347	187 679
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 684r	987 510	464 075	1 141 857	1 605 932	33 004	298 724
1978	1 266 927	1 026 998	479 724	1 070 284	1 550 008	36 001	329 320
1979P	1 184 000	949 778	414 533	906 871	1 321 404	36 564	251 985

Sources: Energy, Mines and Resources Canada; 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; r Revised.

WORLD PRODUCTION, CONSUMPTION AND ECONOMIC FACTORS

New production of silver in the non-communist world in 1979, as estimated by **The Silver Institute of Washington, D.C., U.S.A.** was 8 111.5 tonnes (t) or 56.9 t less than in 1978. Production of silver in the Eastern Bloc countries in 1979 was estimated to be 2 513 t compared with 2 510 t in 1978.

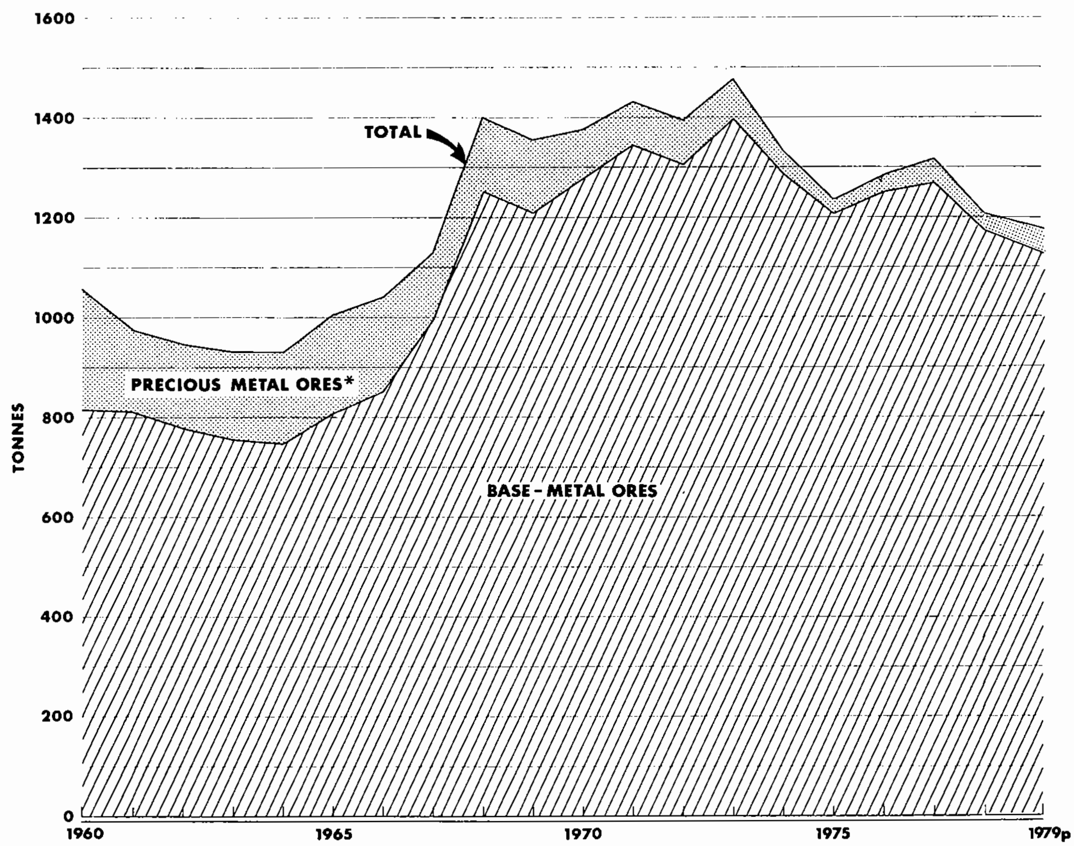
Based on preliminary figures, Canada was the fourth largest mine producer of silver in 1979, being surpassed by U.S.S.R., Mexico and Peru. The United States was also a substantial producer of silver. These five countries accounted for about 63 per cent of the world's total primary silver production.

In 1979, non-communist world consumption for both industrial and coinage uses, as estimated by Handy and Harman*, was 13 461.6 t compared with 13 483.4 t in 1978. The gap between primary production and consumption in 1979 was 5 350.1 t.

Substantial amounts of silver were consumed in the coinage sector of the silver industry. The Silver Institute in its publication **Modern Silver Coinage 1979,** reported that silver used in official coins was 759 313 kg compared with 954 402 kg in 1978. The leading consumers of silver in coinage in 1979 and the amount used were: France 235 048 kg, Mexico 155 884 kg,

* **The Silver Market 1979,** compiled by Handy & Harman, a leading United States refiner and fabricator of precious metals and a large consumer of silver.

PRIMARY SILVER PRODUCTION in CANADA by SOURCE



* Mostly from Silver-cobalt ores; some from Gold ores.
p Preliminary

Austria 119 799 kg, Federal Republic of Germany 114 473 kg and the U.S.S.R. 53 975 kg. These five countries accounted for over 89 per cent of the total silver usage in coinage. Included in Mexico's figure was 4 508 000 bullion coins (onza troy) which contain one troy ounce of fine silver. The onza troy coin does not carry a currency denomination but has a mark stating it contains one troy ounce of pure 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 platinium 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 five rubles each and the remaining 14 a face value of 10 rubles each. The five-ruble coin weighs 16.67 grams (g) and contains 15 g of silver, while 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 coins.

According to the United States Bureau of Mines, new production of silver in the United States in 1979 was 1 154.3 t, slightly lower than the 1 199.7 t produced in 1978. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 4 891.3 t and 5.2 t respectively, in 1979. Comparable figures for 1978 were 4 981.7 t and 1.4 t. The large deficit in requirements was met by imports, demonetized coinage, secondary silver derived from discarded jewellery, silverware and films, and withdrawals from existing stocks. Most of the requirements for United States coinage were obtained from Treasury stocks, balance in Bureau of Mint only, which declined slightly during 1979 to 1 212.7 t from 1 217.9 t in 1978. The General Services Administration (GSA) did not sell any silver from the nation's strategic and critical stockpile. The goal to eliminate stocks of silver, established late in 1976 by the U.S. Federal Preparedness Agency (FPA), remained unchanged at the end of 1979. The stockpile contained 4 338.9 t, all of which is surplus to the goal. None of this surplus silver, however, may be disposed of without Congressional approval. To date, bills introduced in Congress to dispose of this surplus have not received the necessary consensus.

Japan is the non-communist world's second-largest consumer of silver. Silver consumption in 1979 amounted to 2 037 t, an increase of 1.9 per cent over 1978. Japan did not use any silver in coinage.

Industrial consumption of silver in West Germany in 1979 amounted to 1 154 t, an increase of over 40 per cent from 1978.

Since August 26, 1976 all exports of Indian silver have been handled by the country's State Trading Corporation (STC). In 1979, effective February 20, the Government of India banned exports of silver in most of its forms. According to reports the suspension was made to enable India to assess the world silver situation. India has virtually no mine production of silver but the country has large stocks of above ground silver accumulated over the centuries. Varying estimates exist on the stocks but a reliable source has placed stocks in the range of 70 000 t. India, for a number of years, has been a major exporter of silver and shipments from this country have to a large extent offset the deficit between global production and consumption. Indian exports of silver in 1979 were estimated at about 855 t.

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 1979 amounted to 4.08 million contracts of 5,000 ounces each compared with 3.82 million contracts in 1978. The volume of silver traded on the Chicago Board of Trade in 1979 amounted to 2.72 million contracts of 5,000 ounces each compared with 2.66 million contracts in 1978. The volume of silver contracts traded on the Mid American Commodity Exchange at Chicago, in 1979, was 0.36 million contracts of 1,000 ounces each compared with 0.38 million contracts in 1978. Silver traded on the London Metal Exchange was 585.94 million troy ounces in 1979 compared with 430.53 million troy ounces in 1978.

Comex silver stocks at the end of 1979 were 74.81 million ounces compared with 58.23 million ounces at December 31, 1978. Chicago Board of Trade silver in storage at the end of 1978 and registered for delivery against futures' contracts was 58.32 million ounces compared with 59.89 million ounces in

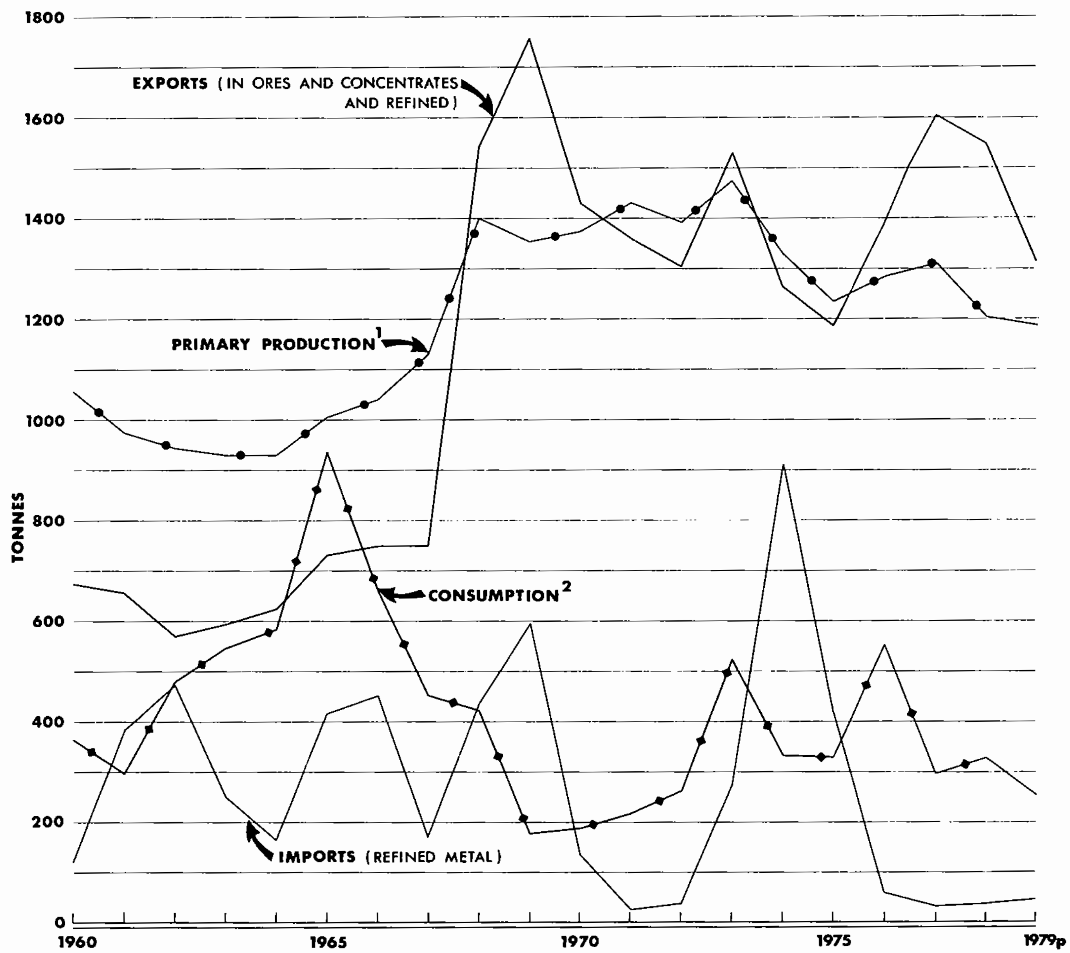
1978. Both figures for the Chicago Exchange are exclusive of some additional silver that may have been in stocks at such times, but not registered for future delivery. London Metal Exchange silver stocks at the end of 1979 were 13.10 million troy ounces compared with 22.96 million troy ounces at the end of 1978. United States industrial stocks* on December 31, 1979 were reported to be some 15.94 million ounces compared with 28.79 million ounces at the end of 1978.

* Refiners, fabricators and dealer stocks.

The U.S.S.R. was the world's largest silver producer in 1979. Output was estimated at 1 548.9 t. Most of the silver is recovered as a byproduct from lead-zinc-copper mining operations. Output of base-metal ores is increasing only at a low rate and production of silver from the U.S.S.R. is not expected to show any significant rise.

Mexico is a major world producer of silver, being surpassed by a small margin by the U.S.S.R. in 1979. Production in 1979 was estimated at 1 536.5 t. Much of the

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

silver production comes from mines in which silver is the main or most important metal. The present high silver price will lead to a significant increase in silver output because of expansion programs at present producers and new deposits being brought into production. An increase in exploration activity can be expected. After revisions to tax laws in 1978 no new mining or tax laws were introduced in 1979.

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 1979. At their five principal mining units, exploration was successful in adding to reserves. Silver output from these mines in 1979 was 224 754 kg compared with 211 960 kg in 1978. At Cuale, in the State of Jalisco, Fresnillo, construction work is under way on mill facilities to treat 1 000 tpd of silver-lead-zinc ores. Production is expected to begin in late 1980.

La Encantada Mining Group, Coahuila, Mexico, 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. de C.V., Mexico's largest mining company, increased exploration activity in 1979 with favourable results. Production from the three mines was 42 956 kg of silver.

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 tpd concentrator. Production was 156 155 kg of silver and 10 850 kg of gold in 1979. Underground drilling and development programs were successful in finding new ore. Higher silver prices have allowed lower grade material to be classed as ore resulting in a corresponding increase in reserves. Las Torres is owned 30 per cent by Lacana, 33 per cent by Penoles and 37 per cent by Compania Fresnillo, the operator of the project.

In December 1979, Placer Development Limited, a Canadian company, announced that the Zacatecas State silver-lead-zinc mine of Minera Real de Angles, S.A. de C.V., a Mexican company in which it has a 34 per cent interest, will be brought into production in 1982. Designed capacity of the concentrator is 10 000 tpd. Projected annual production is 225 000 kg of silver, 32 000 t of lead, 26 000 t of zinc and 415 t of cadmium. Ore reserves are estimated at 59 million t averaging 73 g of silver plus some lead and zinc. Partners in the venture with Placer are the Mexican government through Comision de Fomento Minero, and Minera Frisco, S.A. de C.V., each with a 33 per cent interest.

Peru is a major producer of silver and in 1979 ranked third in the world's silver producing countries, ahead of Canada and the United States. Silver output was 1 250.4 t. Empresa Minera del Centro del Peru S.A. (CENTROMIN-PERU), a Peruvian government company was the largest producer of silver in 1979 accounting for 801.9 t. Expansion programs under way are expected to increase silver output of CENTROMIN by about 14 per cent by 1983.

ASARCO Incorporated is the largest producer of silver in the United States. It operates two major silver producing mines in Idaho, the Galena and Coeur mines. Both these mines increased output slightly in 1979 and maintained reserves. ASARCO is bringing its silver-copper Troy mine in northwestern Montana into production. Construction of surface facilities and the driving of two entries to provide access to the orebody began in 1979. The mine is expected to be in production by mid-1981 with an annual output of 130 600 kg of silver and 18 100 t of copper contained in concentrates. Estimated cost of the project is $82.6 million.

Sunshine Mining Company's silver mine in Idaho is currently the largest silver producing mine in the United States. Production was down slightly in 1979 from the previous year. The company is sinking a new internal shaft. Expansion programs now under way should increase productive capacity by about 50 per cent.

Hecla Mining Company, a major producer of silver in the United States, operates silver mines in Idaho. The company is to spend $26 million to sink a new shaft from surface to an ultimate depth of 2 286 metres (m) at its Lucky Friday silver-lead mine. J.S. Redpath Corp., Temple, Arizona, an affiliate of J.S. Redpath Limited of North Bay, Ontario, has been selected to perform the design engineering for the project. Shaft sinking is expected to begin in early 1980. Tonnage of ore mined will be increased from 660 to 900 tpd when construction is completed.

TABLE 3. WORLD MINE PRODUCTION OF SILVER, 1978 AND 1979

	1978[1]		1979[2p]	
	(troy ounces)	(kilograms)	(troy ounces)	(kilograms)
U.S.S.R.	46 000 000[e3]	1 430 800[e3]	49 800 000	1 548 900
Mexico	50 779 000	1 579 400	49 400 000	1 536 500
Peru	37 045 000	1 152 200	40 200 000	1 250 400
Canada	40 732 000	1 266 900	38 068 000	1 184 000
United States	38 571 000	1 199 700	37 100 000	1 153 900
Australia	24 858 000	773 200	24 800 000	771 400
Poland	19 000 000[e]	591 000[e]	23 000 000	715 400
Japan	9 732 000	302 700	8 900 000	276 800
Chile	8 211 000	255 400	8 300 000	258 200
Bolivia	6 439 000	200 300	5 700 000	177 300
Sweden	5 800 000[e]	180 400[e]	5 700 000	177 300
Yugoslavia	5 112 000[3]	159 000[3]	5 200 000	161 700
Spain	3 093 000	96 200	3 400 000	105 800
Republic of South Africa	3 104 000	96 500	3 200 000	99 500
Zaire	4 390 000	136 500	2 900 000	90 200
South Korea	1 383 000	43 000	2 800 000	87 100
France	2 754 000	85 700	2 400 000	74 600
Morocco	3 189 000	99 200	2 400 000	74 600
Dominican Republic	1 844 000	57 300	2 300 000	71 500
People's Republic of China	990 000[e]	30 800[e]	2 000 000	62 200
Honduras	2 788 000	86 700	1 900 000	59 100
Philippines	1 637 000	50 900	1 800 000	56 000
Argentina	2 600 000[e]	80 900[e]	1 800 000	56 000
Greece	1 360 000	42 300	1 700 000	52 900
South West Africa	1 399 000	43 500	1 600 000	49 800
North Korea	1 600 000[e]	49 800[e]	1 500 000	46 700
German Democratic Republic	1 600 000[e]	49 800[e]	1 500 000	46 700
Papua New Guinea	1 708 000[e]	53 100[e]	1 400 000	43 500
Czechoslovakia	1 160 000[e]	36 100[e]	1 100 000	34 200
Italy	987 000[3]	30 700[3]	1 100 000	34 200
Romania	1 030 000[e]	32 000[e]	1 000 000	31 100
German Federal Republic	749 000	23 300	1 000 000	31 100
Bulgaria	900 000[e]	28 000[e]	800 000	24 900
Other countries	8 065 000	250 800	5 822 000	181 100
Total	340 609 000	10 594 100	341 590 000	10 624 600

Sources: Energy, Mines and Resources Canada; United States Department of the Interior, Bureau of Mines, Mineral Trade Notes for 1978; The Silver Institute of Washington, D.C., U.S.A. for 1979.

[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.

[p] Preliminary; [e] Estimated.

Australia is the world's sixth largest producer of silver, mostly as a byproduct or coproduct of base-metal ores. Silver produced in 1979 was approximately 771 366 kg, about 8 per cent higher than in 1978. The Mount Isa Mines Ltd. operations of M-I-M Holdings Ltd. in Queensland produced 471 218 kg of silver for the fiscal year ending June 30, 1979, over 60 per cent of Australia's output. The large lead-zinc-silver McArthur River deposit of M-I-M in the Northern Territory will not be developed until an economic metallurgical recovery process is developed.

TABLE 4. NON-COMMUNIST WORLD CONSUMPTION OF SILVER, 1978 AND 1979

	1978		1979P	
	(troy ounces)	(kilograms)	(troy ounces)	(kilograms)
Industrial uses				
United States	160 200 000	4 982 780	165 600 000	5 150 740
Japan	64 300 000	1 999 950	65 500 000	2 037 280
West Germany	26 400 000	821 130	37 100 000	1 153 940
Italy	41 800 000	1 300 130	33 000 000	1 026 410
United Kingdom	29 000 000	902 000	26 500 000	824 240
France	22 200 000	690 500	21 500 000	668 720
India	20 000 000	622 070	19 000 000	590 970
Canada	9 000 000	279 930	9 200 000	286 150
Mexico	5 800 000	180 400	6 200 000	192 840
Other countries	25 800 000	802 470	26 400 000	821 130
Total industrial uses	404 500 000	12 581 360	410 000 000	12 752 420
Coinage				
France	11 100 000	345 250	7 700 000	239 500
Austria	3 500 000	108 860	5 000 000	155 520
West Germany	3 600 000	111 970	3 700 000	115 080
Canada	300 000	9 330	300 000	9 330
United States	100 000	3 110	100 000	3 110
Other countries	10 400 000	323 480	6 000 000	186 620
Total coinage	29 000 000	902 000	22 800 000	709 160
Total consumption	433 500 000	13 483 360	432 800 000	13 461 580

Source: Handy & Harman, **The Silver Market, 1979.**

P Preliminary.

Australian Mining & Smelting Limited (AM&S), a wholly-owned subsidiary of Conzinc Riotinto of Australia Limited (CRA), operates two lead-zinc-silver mines in New South Wales. Production of silver in 1979 was 111 390 kg compared with 104 349 kg in 1978. The company also has a one-third interest in the Woodlawn zinc-lead-copper-silver mine in New South Wales which came into production in 1978. Metallurgical and mechanical problems adversely affected production levels in 1979. CRA is controlled by Rio Tinto Zinc Corporation Limited (RTZ). In 1978 RTZ reached an understanding with the Australian government whereby RTZ was prepared to lower its beneficial interest in CRA to 49 per cent over a period of time, by sales to Australian shareholders. At the end of 1979, its beneficial interest was 65.5 per cent.

A third large producer of silver in Australia is the lead-zinc-silver mine of North Broken Hill Ltd. at Broken Hill, New South Wales. For the fiscal year ending June 30, 1979 silver output was 103 492 kg, slightly higher than 1978 output.

Aberfoyle Ltd. in which Cominco Australian Pty. Ltd., a wholly-owned subsidiary of Cominco Ltd., has a 45 per cent interest, is bringing its Que River lead-zinc-silver mine in Tasmania into production. The ore will be treated at the Tasmanian concentrator of Electrolytic Zinc Company of Australasia Ltd., beginning in 1981. Ore will be mined at the rate of 150 000 to 200 000 tpy.

In Honduras, silver is recovered from mines that are operated primarily for their silver content. The El Mochito mine of Rosario Resources Corporation is one of the major silver producers. Production in 1979 amounted to 68 003 kg. An expansion program to enlarge the mining and milling facilities to 2 250 tpd from 1 100 tpd is expected to be completed in 1982. A new shaft is expected to be operational in the second half of 1980.

In the Republic of South Africa, the Black Mountain Mineral Development Company Limited brought its Broken Hill lead-zinc-copper-silver orebody, in northwestern Cape Province, into production in late 1979. Phelps Dodge Corporation of the United States holds 49 per cent of the shares and Gold Fields of South Africa Ltd. holds the remaining 51 per cent. Designed capacity of the concentrator is about 3 000 tpd. At full capacity annual production of silver is expected to be 120 000 kg.

In Chile, Compania Minera San Jose, Inc., a subsidiary of St. Joe Minerals Corporation of New York, is investing $80 million to bring its El Indio gold-silver-copper orebody into production in the Chilean Andes, some 500 km northwest of Santiago. Construction is underway on a 1 270 tpd concentrator which is scheduled for operation in 1981.

In November, 1979 the new ruling authority in Nicaragua nationalized the domestic mining industry. Mining in Nicaragua is relatively small, silver and gold being the most important metals.

In October 1979, Rosario Resources Corporation of New York and Simplot Industries Inc. of Boise, Idaho, sold the 27 per cent interest each held in Pueblo Viezo gold-silver open-pit mine of Rosario Dominicana S.A. to the Dominican Republic for $70 million. The Central Bank of the Dominican Republic had previously acquired a 46 per cent interest in the property. The mine has been a significant producer of both gold and silver and in 1978 silver output was 63 199 kg.

OUTLOOK

Canada's primary production of silver in 1980 is expected to be about 1 200 t, increasing to 1 300 t in 1981 and 1 400 t in 1982. A further increase in production to 1 500 t is expected by 1983, with output likely to stabilize at or near this figure thereafter.

For a number of years, Canada has 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 fourth place ranking in world output to the United States. Canada has always produced more than its requirements and has been a significant exporter of silver; its role in this capacity will continue. In 1979 Canada exported 907 t of silver and consumed only 256 t.

World consumption of silver in 1979, including coinage, was estimated at 13 462 t, about the same as in 1978. In the fourth quarter of 1979 consumption declined considerably and this decline will carry into 1980 because of the high price of silver. Sectors that will be affected the most are the sterling, electroplated ware and jewellery trades. Other applications may decline initially but because of the superiority of silver in its many applications and the fact that in many cases silver cost represents only a small fraction of total product cost, consumption should remain at a relatively high level. In the photographic industry silver is a major cost item but to date no satisfactory substitute has been developed and consumption in this field should continue at or near its present level.

In the past the normal supply-demand forces predominated in determining the price structure of silver. In 1979, especially in the latter part of the year, action by speculators and hoarders were largely responsible for sharp price movements. This group is expected to play a major role in determining future price levels.

It is difficult to assess the impact of higher silver prices on the silver supplies from secondary sources. Silver from industrial scrap, including photography, could increase because of improved methods and techniques of recovery. Restrictions placed on exports from India will reduce the silver available from that source. Silver from coins, silverware, heirlooms, etc. may or may not be available to the market, depending on whether the holders of these items sell to profit from the high price or retain them as a hedge against inflation.

World production of silver from base-metals will continue to increase in the short term because of new base-metal mines already under development and capacity expansion at existing mines. About 80 per cent of the world's silver mine output is derived as a byproduct of base-metal ores and any substantial increase in primary silver output will be heavily dependent on new base-metal developments. The price of silver will have a more direct impact on silver output from mines in which silver is the main metal. Output from this source should increase significantly in the medium to long term as new mines are brought into production and expansions take place at operating mines, mainly in Mexico, Central America and the western United States. The high silver price will enable some producing mines to treat lower grade ore and in the short-term output at these mines may remain static or perhaps decline slightly.

Over the years, there has been a substantial shortfall between non-communist world silver consumption and new production, which was balanced through above ground stocks. These stocks are still large but the recent sharp rise in the silver price will alter the trading pattern regarding the availability of the stocks to the market. The resolution of the demand-supply relationship in the short-term will be complex. The silver price at its present level will lead to increased silver output but only after a significant time period. The price trend is expected to be erratic in 1980 because of the many variables - the political and economic situation, supply, the actions of speculators, hoarders, and hedgers. Prices could retreat from year-end levels to somewhat below $U.S. 20/oz., but will have to remain close to that level to bring out new primary production. Any further deterioration in the world political and economic climate could force the price still further upwards to over $U.S. 30/oz.

CANADIAN DEVELOPMENTS

Atlantic provinces. Silver production in the Atlantic provinces, which is derived as a byproduct of base-metal ores, declined slightly in 1979 as all producers reported lower output. On October 1, 1979 Noranda Mines Limited acquired all of the shares of Heath Steele Mines Limited in exchange for all of the stock of Noranda Phosphate, Inc., owner of undeveloped phosphate land in Florida. Heath Steele has a 75 per cent interest in the Little River Joint Venture which operates a lead-zinc-copper-silver mine near Newcastle, New Brunswick. ASARCO acquired the 25 per cent interest in the Little River property held by Inco Limited. The expansion program under way at Brunswick Mining and Smelting Corporation Limited to increase the mine and mill capacity to 10 000 tpd is expected to be completed in the early part of 1981. Metallurgical test work is being done to improve silver recovery.

The two silver producers in Newfoundland, Consolidated Rambler Mines Limited and the Buchans zinc-lead-silver mine, a joint venture of ASARCO and The Price Company Limited, have limited ore reserves but both are carrying out exploration programs. ASARCO manages the Buchans operation.

Quebec. Silver output in Quebec, derived mostly as a byproduct from base-metal ores, was significantly lower in 1979 than in the previous year, mainly because of a labour strike at Gaspé Copper Mines, Limited and the closure of Manitou Barvue division of Louvem Mining Company Inc., which was a substantial producer of silver.

Effective December 31, 1978 Orchan Mines Limited merged with Noranda. This was followed by a merger of Mattagami Lake Mines Limited with Noranda which was completed during the year. The shaft at the Norita mine is being deepened for the mining of the lower "A" Zone and it is expected to be completed in 1980. The "A" Zone reserves are estimated to be about 1 900 000 t averaging 4.12 per cent zinc, 2.77 per cent copper and 32.9 g of silver per t. A ramp driven to explore the Mattagami Lake deposit at depth was completed and a deep diamond drill program was started.

In 1979 Louvem re-opened its Louvicourt mine in the Val d'Or area. Reserves are 730 000 t averaging 6.8 per cent zinc and 33.6 g of silver per t. The mine was closed in 1978 because of the depressed zinc market.

Selco Mining Corporation Limited, a company in which Selection Trust Limited has a 95.9 per cent interest, and Hudson's Bay Oil and Gas Company Limited entered into an agreement to bring Les Mines Selbaie project (formerly the Detour project) in northwestern Quebec into production at a rate of 1 500 tpd. Cost of the project has been estimated at $80 million. Selco has retained a two-thirds interest in the project and is the operator of the venture. Hudson's Bay Oil holds the remaining one-third interest. The mine is an underground operation and is scheduled to begin production during the second half of 1981. Reserves are estimated to be 3.8 million t averaging 3.6 per cent copper, 0.5 per cent zinc and 31.8 g of silver per t.

Ontario. Ontario was by far the leading silver-producing province or territory, with its output in 1979 accounting for 37 per cent of Canadian production.

The leading silver producing mine in Canada in 1979 was Texasgulf Canada Ltd.

TABLE 5. PRINCIPAL SILVER (MINE) PRODUCERS IN CANADA, 1979 AND (1978)

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)	
Newfoundland								
ASARCO Incorporated, Buchans	1 100 (1 100)	109.71 (104.91)	1.04 (1.04)	6.51 (6.07)	11.64 (10.78)	113 398 (183 251)	11 036 (16 757)	Known ore reserves limited.
Consolidated Rambler Mines Limited, Baie Verte	1 100 (1 100)	23.52 (26.47)	3.90 (4.70)	- (-)	- (-)	196 918 (287 874)	3 069 (4 557)	Ming ore zone expected to be mined in 1980.
New Brunswick								
Brunswick Mining and Smelting[1] Corporation Limited, Nos. 12 and 6 mines, Bathurst	9 050 (9 050)	94.97 (93.94)	0.31 (0.29)	3.61 (3.56)	8.93 (8.88)	2 971 516 (3 058 300)	194 995 (187 076)	Expansion program expected to be completed in early 1981.
Heath Steele Mines Limited, Newcastle	3 650 (3 650)	55.20 (77.49)	0.91 (1.03)	1.53 (1.53)	4.55 (4.43)	1 172 737 (1 137 767)	37 933 (46 593)	AMAX Inc. sold its interest in mine to Noranda.
Quebec								
Campbell Chibougamau Mines Ltd., Henderson and Cedar Bay, Chibougamau	3 650 (3 650)	7.54 (8.57)	1.17 (1.38)	- (-)	- (-)	396 822 (230 489)	2 028 (1 269)	-
Falconbridge Copper Limited, Lake Dufault Division, Millenbach mine and Norbec stockpile ore, Noranda	1 400 (1 400)	48.69 (43.54)	3.60 (3.36)	- (-)	4.90 (3.85)	419 827 (372 722)	17 610 (13 517)	Prepared Corbet mine for production.
Falconbridge Copper Limited, Opemiska Division, Perry, Springer and Cooke mines, Chapais	2 900 (2 900)	12.34 (14.06)	1.79 (1.99)	- (-)	- (-)	954 801 (967 823)	9 313 (11 155)	-
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	30 400 (30 400)	3.16 (3.19)	0.51 (0.51)	- (-)	- (-)	5 635 594 (7 985 273)	10 510 (15 263)	Strike settled in June 1979.

TABLE 5. (cont'd)

Company and Location	Mill Capacity (tonnes of ore/day)	Grade of Ore Milled: Silver (grams/tonne)	Copper (%)	Lead (%)	Zinc (%)	Ore Milled (tonnes)	Silver contained in concentrates produced (kilograms)	Remarks
Quebec (cont'd)								
Lemoine Mines Limited, (Patino, N.V.), Chibougamau	300 (350)	92.91 (94.63)	5.07 (4.97)	- (-)	11.61 (11.18)	108 267 (105 611)	8 907 (8 855)	
Louvem Mining Company Inc., (SOQUEM) Louvicourt	900 (900)	137.83 (87.77)	0.04 (0.15)	0.55 (0.29)	4.51 (5.33)	72 261 (248 073)	7 628 (16 680)	Reopened Louvicourt mine in 1979.
Madeleine Mines Ltd., Murdochville	2 250 ----------------	6.86 ----------------	0.98 Mine closed in 1978	-	-	297 853 ----------------	1 502 ----------------	Mine reopened in July 1979.
Mattagami Lake Mines Limited, Matagami	3 500 (3 500)	26.85 (32.57)	0.73 (0.52)	.. (..)	5.37 (7.56)	1 329 428 (878 484)	15 558 (12 567)	Merged with Noranda in 1979.
Noranda Mines Limited, (Orchan Division) Matagami	 (1 900)	Included in Mattagami Lake Mines figures for 1979 (34.29)	 (0.61)	 (-)	 (5.89)	 (368 602)	 (2 040)	
Patino Mines (Quebec) Limited, (Patino, N.V.) Chibougamau	2 700 (2 700)	9.50 (9.70)	1.64 (1.60)	- (-)	- (-)	606 995 (616 381)	4 105 (4 204)	
Ontario								
Agnico-Eagle Mines Limited, Cobalt district	350 (350)	156.69 (230.40)	.. (..)	- (-)	- (-)	41 799 (40 157)	5 827 (8 340)	Coniagas mine main source of ore.
Canadaka Mines Limited, Cobalt district	275 (275)	131.66 (166.97)	- (-)	- (-)	- (-)	38 919 (70 614)	4 648 (10 495)	
Falconbridge Copper Limited, Sturgeon Lake Joint Venture, Sturgeon Lake	1 100 (1 100)	169.71 (171.77)	2.17 (2.73)	1.23 (1.17)	8.70 (9.14)	373 953 (370 087)	52 721 (57 908)	Limited ore reserves.
Falconbridge Nickel Mines Limited, Ontario Mines, Sudbury district	11 200 (11 200)	.. (..)	.. (..)	- (-)	- (-)	1 500 190 (2 073 500)	.. (..)	

Inco Limited, Sudbury and Shebandowan, Ont., and Thompson, Man.	73 950 (73 950)	.. (..)	1.02 (1.07)	- (-)	- (-)	7 608 907 (9 160 940)	23 414[2] (34 458)[2]	Labour strike settled June 1979.
Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	97.71 (93.26)	0.55 (0.83)	0.77 (0.67)	6.91 (6.49)	945 015 (871 675)	73 085 (67 699)	Developing underground ore.
Noranda Mines Limited, Geco Division, Manitouwadge	4 550 (4 550)	58.97 (38.74)	1.82 (1.54)	0.11 (0.12)	3.24 (2.19)	1 475 841 (1 572 458)	65 668 (46 036)	Some higher grade pillar ore extracted.
Selco Mining Corporation Limited, South Bay Division Uchi Lake area	450 (450)	63.77 (75.77)	1.44 (1.43)	- (-)	10.75 (12.20)	132 923 (121 635)	6 514 (7 240)	Limited reserves.
Teck Corporation, Silverfields Division, Cobalt district	250 (250)	308.57 (342.86)	0.60 (0.60)	- (-)	- (-)	75 392 (77 247)	21 103 (24 510)	
Texasgulf Canada Ltd., Kidd Creek mine, Timmins	9 050 (9 050)	76.03 (102.7)	1.95 (1.87)	0.65 (0.77)	5.47 (6.43)	3 680 858 (3 002 148)	2 241 109 (262 725)	Constructing copper smelter and preparing No. 2 mine for production.
Union Minière Explorations and Mining Corporation Limited, Thierry mine, Pickle Lake area	3 650 (3 650)	8.23 (8.23)	1.15 (1.29)	- (-)	- (-)	956 291 (836 119)	5 482 (4 365)	
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake districts	7 700 (7 700)	18.61 (20.57)	2.23 (2.26)	0.16 (0.43)	2.95 (3.16)	1 700 822 (1 679 000)	20 573 (24 541)	Snow Lake concentrator completed.
Inco Limited, Thompson	(Output included with company's listing for Ontario)							
Sherritt Gordon Mines Limited, Fox mine, Lynn Lake	2 600 (2 600)	.. (..)	1.19 (1.24)	- (-)	1.82 (1.73)	772 500 (874 933)	2 943[e] (4 234)[e]	
Sherritt Gordon Mines Limited, Ruttan mine, Ruttan	9 050 (9 050)	.. (..)	1.39 (1.15)	- (-)	1.17 (1.53)	2 094 159 (2 307 069)	9 703[e] (13 097)[e]	Some ore coming from underground operations.

TABLE 5. (cont'd)

Company and Location	Mill Capacity (tonnes of ore/day)	Grade of Ore Milled: Silver (grams/ tonne)	Copper (%)	Lead (%)	Zinc (%)	Ore Milled (tonnes)	Silver contained in concentrates produced (kilograms)	Remarks
British Columbia								
Afton Mines Ltd., Dominion pit, Kamloops	6 350 (6 350)	4.90 (4.97)	1.06 (1.01)	- (-)	- (-)	2 822 528 (2 456 770)	9 242 (8 067)	First full year of operation successfully completed.
Bethlehem Copper Corporation, Highland Valley	18 150 (18 150)	.. (..)	0.41 (0.41)	- (-)	- (-)	6 536 861 (6 490 760)	6 957 (8 512)	
Brenda Mines Ltd., Peachland	27 000 (21 750)	.. (..)	0.14 (0.16)	- (-)	- (-)	9 075 720 (9 995 801)	5 752 (7 104)	Short strike.
Cominco Ltd., Sullivan mine, Kimberley	9 075 (9 075)	63.77 (62.06)	- (-)	5.33 (4.64)	3.73 (3.31)	2 047 726 (2 107 876)	117 131 (115 483)	Major modifications of metal-lurgical plants at Trail.
Dankoe Mines Ltd., Keremeos	150 (150)	250.29 (286.29)	.. (..)	.. (..)	.. (..)	25 536 (28 677)	6 088 (7 520)	Completed a 1 220 metre drive.
Gibraltar Mines Ltd., McLeese Lake Cariboo district	36 300 (36 300)	.. (..)	0.42 (0.38)	- (-)	- (-)	10 446 035 (5 135 682)	.. (..)	Strike settled in February 1979.
Lornex Mining Corporation Ltd., Highland Valley	43 500 (43 500)	.. (..)	0.43 (0.45)	- (-)	- (-)	16 126 103 (15 927 148)	17 625 (18 341)	To increase production by 68 per cent by 1981.
Newmont Mines Limited, Similkameen Division, Princeton	19 150 (19 150)	0.62 (1.37)	0.44 (0.41)	- (-)	- (-)	7 034 952 (6 826 464)	4 155 (4 314)	Developing Copper Mountain open-pit.
Noranda Mines Limited, Granisle mine Babine Lake	14 300 (14 300)	.. (..)	0.45 (0.41)	- (-)	- (-)	4 382 909 (4 549 288)	5 154[e] (5 181)[e]	Mine purchased by Noranda in 1979.
Northair Mines Ltd., Alta Lake	250 (250)	26.33 (70.63)	0.50 (0.20)	0.91 (1.30)	1.50 (1.96)	91 587 (93 397)	2 020 (5 656)	Extensive exploration and development program.
Silvana Mines Inc., Silmonac mine, Slocan district	100 (100)	478.63 (508.80)	- (-)	4.89 (5.81)	4.51 (4.34)	19 625 (15 966)	8 996 (7 792)	Underground development program.

Teck Corporation, Beaverdell mine, Beaverdell	100 (100)	320.23 (323.66)	- (-)	0.28 (0.35)	0.63 (0.60)	33 662 (35 280)	9 533 (11 211)	Considering deeper exploration.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	34 450 (34 450)	.. (..)	0.45 (0.40)	- (-)	- (-)	13 339 997 (14 200 278)	11 207 (10 145)	
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	4 650 (4 650)	4.46 (4.11)	0.37 (0.35)	- (-)	- (-)	1 009 247 (889 933)	3 346 (2 744)	
Western Mines Limited, Buttle Lake, Vancouver Island	900 (900)	131.31 (139.89)	1.32 (1.25)	1.37 (1.33)	8.45 (8.24)	266 877 (269 035)	31 074 (33 620)	
Yukon Territory								
Cyprus Anvil Mining Corporation, Faro	9 050 (9 050)	25.03 (19.89)	- (0.20)	3.26 (3.17)	5.28 (5.14)	2 823 031 (3 280 660)	61 494 (49 905)	
United Keno Hill Mines Limited, Elsa	450 (450)	818.40 (1224.69)	- (-)	3.00 (5.50)	- (0.79)	112 783 (81 721)	78 931 (90 735)	
Hudson Bay Mining and Smelting Co., Ltd. Whitehorse Copper Division, Whitehorse	2 250 (2 250)	7.20 (7.82)	1.12 (1.40)	- (-)	- (-)	829 221 (782 984)	5 254 (6 134)	
Northwest Territories								
Echo Bay Mines Ltd., Port Radium	100 (100)	1748.57 (2170.29)	0.74 (0.83)	- (..)	- (..)	36 083 (34 232)	61 903 (72 853)	Mining leased Contact mine.
Nanisivik Mines Ltd., Strathcona Sound, Baffin Island	1 350 (1 350)	66.17 (61.71)	- (-)	1.39 (1.44)	12.92 (13.24)	615 459 (574 314)	34 015 (30 489)	
Terra Mining and Exploration Limited, Silver Bear mine and Norex Joint Venture Mine, Camsell River area	200 (200)	421.71 (1385.14)	1.03 (0.29)	.. (..)	.. (..)	31 020 (33 433)	12 471 (145 871)	Actively engaged in exploratory work.

Sources: Company reports and technical press.

[1] All statistical data, including mill capacity represents combined results for No. 12 and No. 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 (tonnes)	Indicated Ore Reserves (tonnes)	Average Grade and Deposit: Silver (grams/tonne)	Copper (%)	Lead (%)	Zinc (%)	Remarks
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. No work done on the property in 1979.
Noranda Mines Limited, Les Mines Gallen, Northwestern Quebec	1981	9 100	1 630 000	24.0	0.15	-	5.4	Deposit also contains 1.03 g gold per tonne.
Noranda Mines Limited, Barvue zinc-silver property Barraute township	..	..	3 629 000	37.3	-	-	3.5	
Noranda Mines Limited, P.D. prospect, La Gauchetiere township, Matagami area	1982	..	1 402 000	17.1	1.1	-	4.9	Phelps Dodge option.
Selco Mining Corporation Limited, Les Mines Selbaie project, Brouillan township	1981	1 500	3 800 000	31.8	3.6	-	0.5	Hudson's Bay Oil and Gas Company Limited entered into an agreement with Selco to bring property into production.
Selco Mining Corporation Limited, A-1 zone orebody, Brouillan township	..		32 114 000	35.7	0.39	-	2.3	High capital costs required to bring property into production - feasibility studies continuing.
Ontario								
Noranda Mines Limited, Lyon Lake Division, Sturgeon Lake	1980	900	3 579 000	117.2	1.24	0.63	6.53	Underground mine.
Noranda Mines Limited, "F" Group Mine, Sturgeon Lake	1981	..	572 000	61.70	0.98	0.49	8.1	Development began in 1979.

British Columbia								
Equity Silver Mines Limited, Sam Goosly Southern Tail deposit, north-central British Columbia	1980	4 500	6 800 000	131.0	0.48	-	-	Leaching plant to be in operation in 1981.
Equity Silver Mines Limited, Sam Goosly Main Zone deposit, north-central British Columbia	..	..	21 200 000	98.4	0.35	-	-	
Noranda Mines Limited, Goldstream River property, Revelstoke	..	..	3 600 000	21.0[e]	3.6	-	2.6	Necessary government approval to develop property expected in 1980.
Yukon Territory								
Hudson Bay Mining and Smelting Co., Limited, Tom claims, MacMillan Pass on Canol Road	..	..	7 800 000	94.0	-	8.2	8.4	Development extended West zone.

Sources: Company reports, technical press; estimates by Energy, Mines and Resources Canada.

[e] Estimated; - Nil; .. Not available.

The total silver contained in concentrates at its Kidd Creek property, near Timmins, was 216 713 kg compared with 243 403 kg in 1978. Although tonnage milled in 1979 increased by over 22 per cent over the previous year, silver output declined by 11 per cent. Work continued on the $140 million mine-mill expansion program and the $280 million copper and refinery complex. Development work at the No. 2 mine is scheduled for completion by the end of 1981 and at that time, the mill is expected to be operating at its rated capacity of about 4 500 000 tpy. The 59 000 tpy copper smelter and refinery were 70 per cent complete by the end of 1979. It is expected that the smelter and refinery will be in full operation by mid-1981. Included in the new copper refinery complex are plans for a silver refinery. According to Texasgulf, the proven and probable ore reserves at its Kidd Creek property at the end of 1979 are estimated at 91.6 million t averaging 5.13 per cent zinc, 2.82 per cent copper, 0.18 per cent lead and 66.2 g of silver per t.

In the Cobalt district the silver-bearing ores are mined primarily for the recovery of silver. This year (1979) marks the 75th anniversary of the discovery of silver in the Cobalt district of Ontario in 1904. Mine production of silver reached an all-time high of 980 002 kg (31,507,791 ounces) in 1911. Today the district is a relatively small producer. In 1979 the silver output from the three producers was estimated to be 22 844 kg compared with 43 345 kg in 1978. The high silver price will enable the silver producers to mine ore that was marginal in the past. The recovery of cobalt from these ores is being investigated. The silver-containing ores and concentrate produced in the Cobalt area are processed at the silver refinery of Canadian Smelting & Refining (1974) Limited at Cobalt. This hydrometallurgical plant was designed to treat the high-arsenic ores and concentrates produced by the Cobalt area mines.

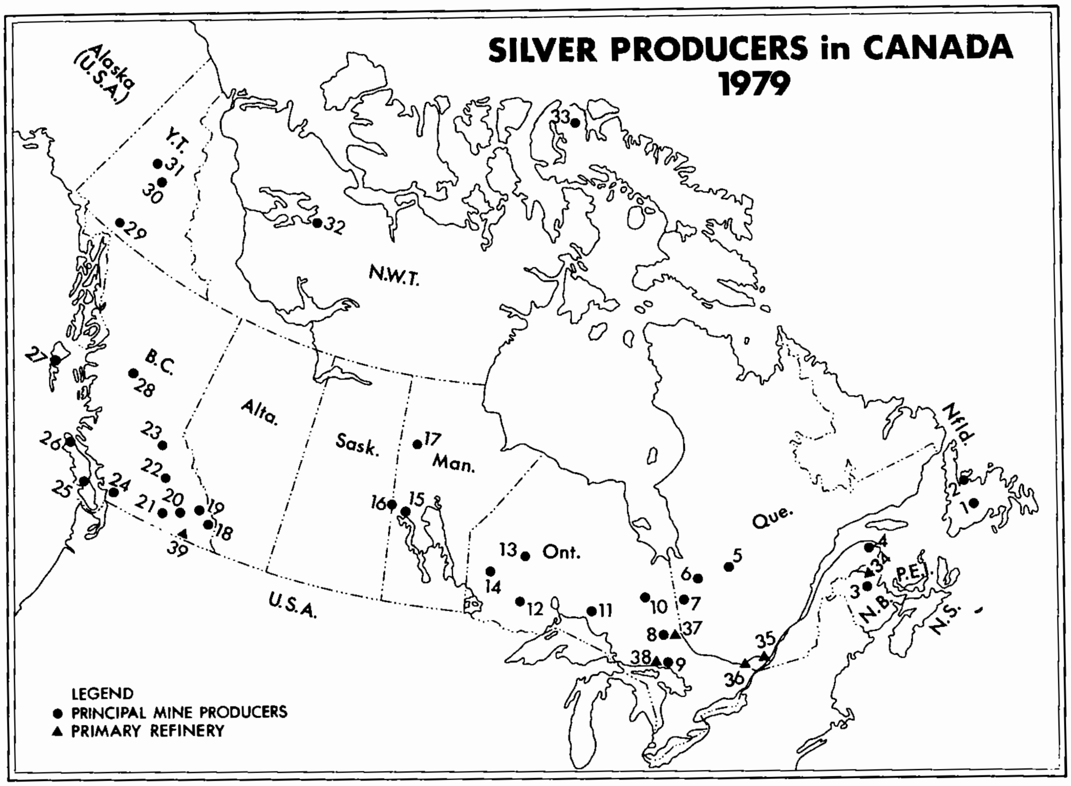
The copper-lead-zinc mines in the Sturgeon Lake area of Ontario are substantial producers of silver. The Sturgeon Lake Joint Venture, managed by Falconbridge Copper Limited, carried out an extensive exploration program on its property with little success. Ore reserves are limited and are expected to be exhausted in late 1980 or early 1981. Mattabi Mines Limited, in which Noranda has a 60 per cent interest, expects to deplete ore being mined by open-pit in early 1981. At this time ore will come from underground operations. Mattabi was one of the major producers of silver in Canada in 1979, accounting for 65 939 kg.

Noranda is preparing the Lyon Lake Division property in Sturgeon Lake for production in mid-1980 at a rate of 900 tpd. The "F" Group mine is being prepared for production in 1981. Both properties contain significant amounts of silver.

Manitoba - Saskatchewan. In 1979 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. Hudson Bay's new $33 million, 3 450 tpd Snow Lake concentrator, built adjacent to the Stall Lake mine, was officially opened in June 1979. It treats ore mined in the Snow Lake area which formerly had been shipped to the company's concentrator at Flin Flon. Significant quantities of byproduct silver were derived from the Fox and Ruttan copper-zinc mines operated by Sherritt Gordon Mines Limited at Lynn Lake and Ruttan, Manitoba, respectively.

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 concentrator in 1979 was slightly lower than in 1977 but silver output was up moderately because of the mining of higher grade silver-containing lead ore.

Ores 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 amounted to an estimated 24 617 kg. The geological characteristics of these deposits makes it difficult to develop proven ore reserves and over the years reserves have been low. Dankoe completed a 1 220 m drive and was developing the levels between 518 m and 670 m for production. The underground development program was assisted by a $144,000 grant from the British Columbia government under its Accelerated Mine Development Program. The mill's capacity is 410 tpd but it is operating at a rate of 130 tpd. Silvana carried out an extensive drifting and diamond drilling program at its property to increase output and develop ore reserves. At Beaverdell,



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)
4. Gaspé Copper Mines, Limited
   Madeleine Mines Ltd.
5. Campbell Chibougamau Mines Ltd.
   Falconbridge Copper, Limited
   Opemiska Division
   Patino Mines (Quebec) Limited,
   Patino, N.V.
6. Noranda Mines Limited
   (Orchan and Mattagami Lake
   Limited Division)
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. Dankoe Mines Ltd.
    Teck Corporation
    (Beaverdell mine)
22. Afton Mines Ltd.
    Bethlehem Copper Corporation
    Lornex Mining Corporation Ltd.
23. Gibraltar Mines Ltd.
24. Northair Mines Ltd.
25. Western Mines Limited
26. Utah Mines Ltd.
27. Wesfrob Mines Limited
28. Noranda Mines Limited
    Granisle mine
29. Hudson Bay Mining and Smelting Co., Ltd.
    Whitehorse Copper Division
30. Cyprus Anvil Mining Corporation
31. United Keno Hill Mines Limited
32. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited
33. Nanisivik Mines Ltd.

Primary refineries
(numbers refer to numbers on the map)

34. Brunswick Mining and Smelting Corporation Limited, Smelting Division
35. Canadian Copper Refiners Limited
36. Royal Canadian Mint
37. Canadian Smelting & Refining (1974) Limited
38. Inco Limited
39. Cominco Limited

Teck Corporation is considering an underground exploration program to investigate the deeper parts of the mine.

On November 30, 1979 Noranda bought the assets of the Zapata Grandby Corporation which included the open-pit Granisle copper mine. Noranda formed the Babine Division which includes the Granisle mine and the nearby open-pit Bell Copper mine. Esso Resources Canada Limited obtained control of the former Granduc Copper mine near Stewart. The company is rehabilitating the mine and mill for a projected resumption of operations in the latter part of 1980 at a rate of 3 600 tpd.

In 1979 Placer Development Limited acquired control of Equity Mining Corporation's Sam Goosly silver-copper property 37 km south of Houston, British Columbia. Under an agreement, Placer acquired a 70 per cent interest in Equity Silver Mines Limited, a company formed to take over the ownership of the mine. Placer has the responsibility for bringing the mine into production and for its operation. Designed capacity of the concentrator is 4 500 tpd. Estimated cost of the project is $107 million of which $37.5 million was expended by the end of 1979. Redesign of the leaching plant substantially increased the overall construction costs and delayed the start up of this section of the recovery plant. Operation of the concentrator is expected to begin in the latter part of 1980 and of the leaching plant in the first half of 1981. There are two separate zones on the property but the smaller zone, the Southern Tail, is being prepared for production. Reserves are estimated at 6.8 million t. Silver production is expected to be over 170 000 kg annually, making Equity one of the major silver producers in Canada. The mine is also expected to produce 6 400 t of copper and 1 700 t of antimony per year.

Yukon Territory. Mine production of silver in the Yukon in 1979 declined mainly because of lower production from the mines of United Keno Hill Mines Limited in the Elsa district.

Cyprus Anvil Mining Corporation has added considerably to its reserves in the Faro district through its acquisition of properties of Kerr Addison Mines Limited and Canadian Natural Resources Limited and Vangorda Mines Limited, a 70 per cent owned subsidiary of Kerr Addison. The newly acquired Grum, Vangorda and Swim deposits will add significantly to the life of the Faro community. A feasibility study is under way on development of these properties and a development plan could be decided by mid-1980.

Northwest Territories. Lower output in 1979 at the two silver producing properties in the Great Bear Lake district was responsible for a sharp decrease in silver production which amounted to 80 000 kg compared with 120 231 kg in 1978. Echo Bay Mines Ltd., the largest silver producer in the Territories, rehabilitated the Contact Lake mine, located about 23 km southeast of Echo Bay's plant site at Port Radium, and brought it into production. The property is under lease from Ulster Petroleums Ltd. Production from the mines operated by Terra Mining and Exploration Limited declined significantly in 1979, amounting to about 12 440 kg compared with 46 665 kg in 1978. Considerable exploration work was carried out in search for new ore.

SILVER PRICES, 1979
MONTHLY AVERAGES

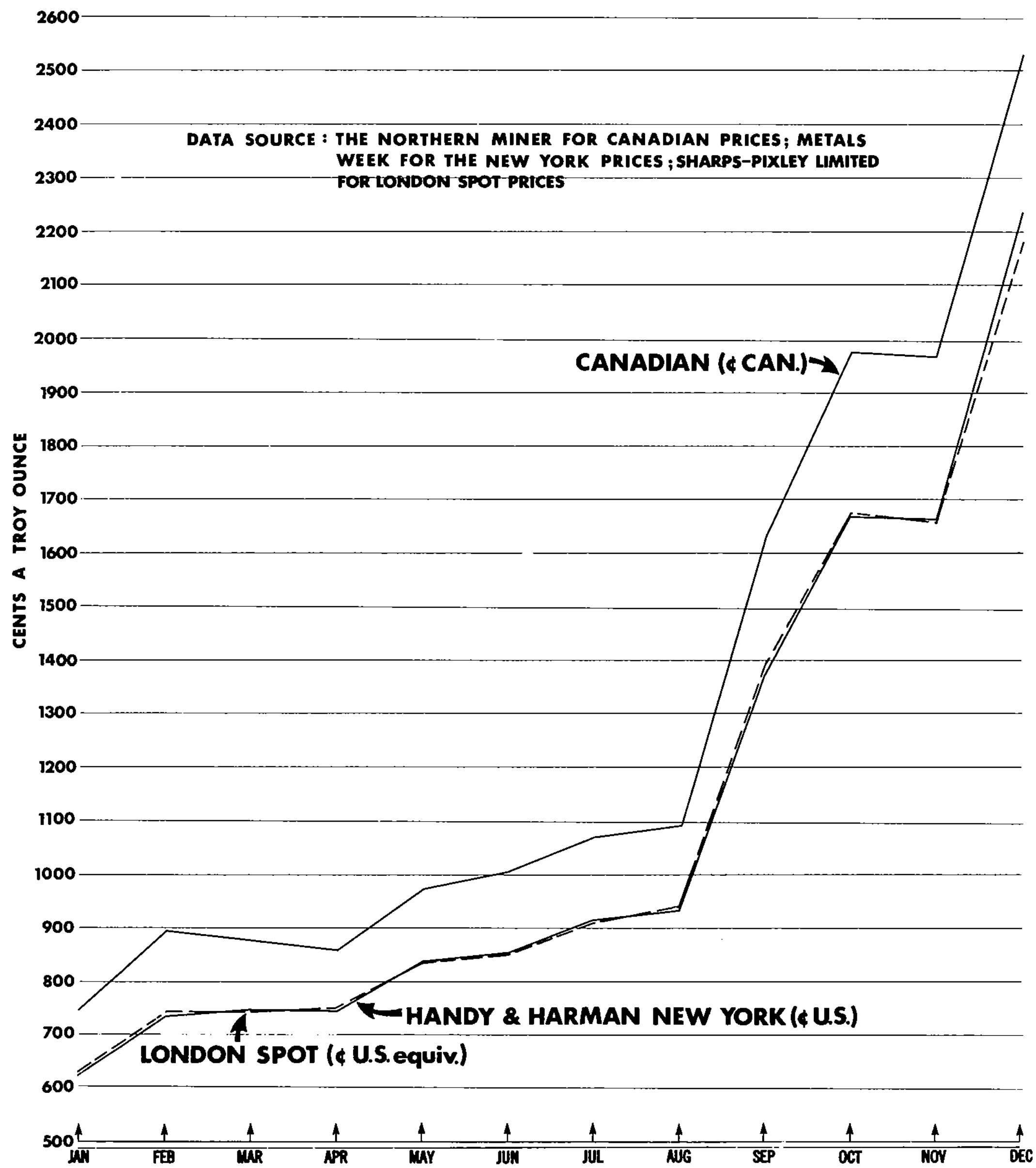


TABLE 7. UNITED STATES CONSUMPTION OF SILVER BY END-USE[1], 1978 and 1979

	1978[2]		1979[2]	
	(kilograms)[3]	(%)	(kilograms)[3]	(%)
Electroplated ware	226 247	4.5	250 850	5.1
Sterling ware	557 001	11.2	407 082	8.3
Jewellery	210 446	4.2	166 653	3.4
Photographic materials	1 999 922	40.1	2 052 145	42.0
Dental and medical supplies	63 233	1.3	71 383	1.5
Mirrors	57 915	1.2	57 542	1.2
Brazing alloys and solders	341 734	6.9	339 401	6.9
Electrical and electronic products:				
Batteries	187 523	3.8	142 547	2.9
Contacts and conductors	956 618	19.2	1 042 153	21.3
Bearings	11 602	0.2	10 326	0.2
Catalysts	254 955	5.1	175 330	3.6
Coins, medallions and commemorative objects	84 819	1.7	145 440	3.0
Miscellaneous[4]	29 673	0.6	30 419	0.6
Total net industrial consumption	4 981 688	100.0	4 891 271	100.0
Coinage	1 400		5 225	
Total consumption	4 983 088		4 896 496	

Sources: United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys, "Gold and Silver in December 1979" for 1978 statistics and "Gold and Silver in March 1980" for 1979 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.

USES

There was no marked change in the pattern of silver usage in industrial applications in 1979 from the previous year. The major uses of silver are the photographic industry, electric and electronic industries, sterlingware, electroplate ware, brazing alloys and solders. In 1979 silver emerged as an important metal in the speculative field, as a hedge against inflation and in hoarding. Speculation will continue to be a major factor in determining silver price and in the amount of silver removed or made available to the market.

Silver is used in a myriad of applications and research is going on continuously for new uses. The silver chapter of the Canadian Minerals Yearbook 1977 detailed the many uses of silver.

PRICES

Silver, gold and platinum experienced phenomenal increases in prices in 1979. The opening silver price as quoted by Handy & Harman of New York for the year 1979 was $U.S. 5.966 per troy ounce and the closing quote and high for the year was $U.S. 28.00 per ounce, an increase of over 360 per cent. Purchases of silver for speculative or hoarding purposes and for hedging against inflation were largely responsible for the spectacular price increases. Other factors affecting the market performance of the metal were currency uncertainties, restrictions on the amount of silver made available by India, and economic and political events or announcements. In the latter part of the year the takeover of the United States Embassy in Iran by Iranian students and the holding of United States citizens as hostages, and the movement of U.S.S.R. troops into Afghanistan were major factors in the accelerated price increases.

The silver price started its significant upward trend in 1979 in the second half of January as a result of tensions in Iran and Vietnam and reached the $U.S. 7.00 plateau in early February. The temporary suspension of exports of silver by India on February 20 had a bullish effect on the market, increasing the price to $7.92 per ounce. The price was comparatively stable for March and April. In May the silver price increased to over $8.00 per ounce, reaching a high of $8.77 toward the end of the month. The effects of a possible oil shortage on the economy was the main reason for the price rise. The price was comparatively stable until mid-July, moved moderately upwards in July and August, and began a sharp upward movement in September on speculative action such as reports that a major bullion dealer who had a long position in the futures market was to take delivery of silver in December. Much buying took place to cover short positions in the futures market by operators who had sold short and being unable to cover their positions on the futures market were forced to purchase silver on the London bullion market. The strong market action continued into the first part of October, forcing the silver price up to $18.00 per ounce. Action by the commodity exchanges in increasing margin requirements and restrictions on buying futures contracts helped to stabilize the market. Prices for November were stable until the latter part of the month when prices again began an upward trend. Action by speculators and adverse political and military action in the Middle East caused the silver price to increase sharply to close at the year's high of $28.00 per ounce.

TABLE 8. ANNUAL AVERAGE SILVER PRICES: CANADA, UNITED STATES AND UNITED KINGDOM, 1970-1979

		United States	United Kingdom	
	Canada	Handy & Harman, New York	London Spot	London Spot
	($Can.)	($U.S.)	(pence)[2]	($U.S. equiv.)[3]
		(per troy ounce)		
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
1979	12.974	11.094	519.607	11.026

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 & Harman's daily quotation during July and August for a total of 22 days. [2] 1971-79 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.**

The average silver price for the year 1979 as quoted by Handy & Harman of New York was $11.09 per ounce. The London spot silver prices which closely paralled the United States price averaged 519.26 pence ($U.S. 11.02) per ounce.

In 1979 the Canadian silver price closely followed its United States counterpart, with the essential difference being the currency exchange differential. The average Canadian silver price (Handy & Harman) in 1979 was $417.35 per kg ($12.98 Cdn. per troy ounce) compared with $198.53 per kg ($6.175 per ounce) in 1978.

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	free	free	25	free
36100-1	Silver leaf	12.5	20	30	12.5
36200-1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	17.5	22.5	45	15

M.F.N. Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
	(per cent)								
36100-1	20.0	18.9	17.8	16.7	15.7	14.6	13.5	12.4	11.3
36200-1	22.5	21.1	19.6	18.2	16.8	15.3	13.9	12.4	11.0

UNITED STATES

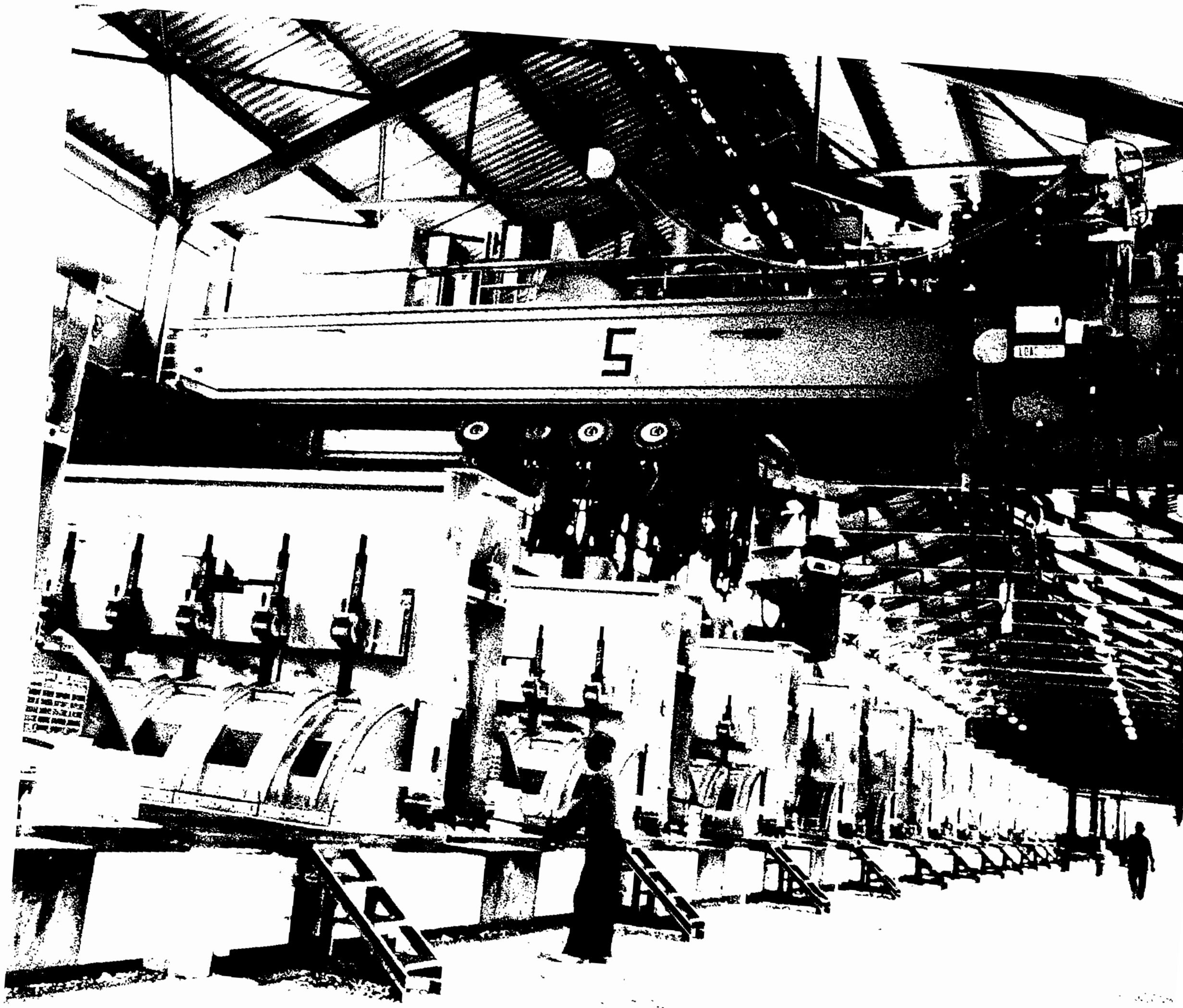
Item No.		
601.39	Precious metal ores, silver content	Free
605.20	Silver bullion, silver dore and silver precipitates	Free
605.70	Precious metal sweepings and waste and scrap, silver content	Free
644.56	Silver leaf	2.5¢ per 100 leaves

		1979	1980	1981	1982	1983	1984	1985	1986	1987
		(per cent)								
420.60	Silver compounds	5.0	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
605.46	Platinum-plated silver, unwrought or semimanufactured	16.0	14.9	13.9	12.8	11.8	10.7	9.6	8.6	7.5
605.47	Gold-plated silver, unwrought or semimanufactured	25.0	23.1	21.3	19.4	17.5	15.6	13.8	11.9	10.0
605.48	Other unwrought or semimanufactured silver	10.5	9.9	9.4	8.8	8.3	7.7	7.1	6.6	6.0
605.65	Rolled silver, unworked or semimanufactured	10.5	9.9	9.4	8.8	8.3	7.7	7.1	6.6	6.0

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1979 (%)	Base Rate (%)	Concession Rate (%)
28.49	Colloidal silver, almalgams, salts and other compounds of silver			
A.	Colloidal silver	8.0	8.0	5.3
B.	Amalgams of silver	8.0	8.0	5.3
C.	Salts and other compounds, inorganic or organic of silver	9.6	9.6	6.0
71.05	Silver, including silver gilt and platinum-plated silver, unwrought or semi-manufactured			
A.	Unwrought	Free	Free	Free
B.	Bars, rods, wire and sections, plates, sheets, strips	2.0	2.0	1.8
C.	Tubes, pipes and hollow bars	3.5	3.5	2.9
D.	Foil of a thickness, excluding any backing, not exceeding 0.15 mm	6.5	6.5	5.0
E.	Powder, purls, spangles, cuttings and other forms	5.0	5.0	3.8
71.06	Rolled silver, unworked, or semi-manufactured			
A.	Unworked	5.0	5.0	3.8
B.	Semi-manufactured	6.5	6.5	4.6
71.08	Rolled gold on silver, unworked or semi-manufactured	3.5	3.5	2.9
71.10	Rolled platinum or other platinum group metals on silver, unworked or semi-manufactured	3.5	3.5	2.9
71.11	Silversmiths sweepings, residues and other waste and scrap	Free	Free	Free
71.12	Articles of jewellery and parts thereof, of silver or rolled silver			
A.	Of silver	4.5	4.5	3.5
B.	Of rolled silver	9.0	9.0	5.8
71.13	Articles of silversmiths wares and parts thereof, of silver, other than above			
A.	Of silver	7.5	7.5	3.0
B.	Of rolled silver	5.0	5.0	3.8
71.14	Other articles of silver or rolled silver			
A.	Of silver	7.5	7.5	5.1
B.	Of rolled silver	6.0	6.0	4.4

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 21, No. L335, 1978; GATT Documents, 1979.
nop Not otherwise provided for.



A worker tends one of the 64 electrolytic reduction units in a potline at the new Grande-Baie smelter of the Aluminum Company of Canada, Ltd. (Alcan), 30 kilometres from Jonquière, Québec. Still under construction, this plant embodies the newest technology in aluminum production. (Alcan photo)

Sodium Sulphate

G.S. BARRY

Sodium sulphate is an industrial chemical used principally in the manufacture of pulp and paper by the "kraft" process, and in the manufacture of 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 in several alkaline lakes in Saskatchewan and Alberta. Eight plants produced natural sodium sulphate in Canada during 1979; one closed in 1978. Byproduct sodium sulphate was recovered at one rayon plant and at three paper mills in Ontario.

In the United States, natural and byproduct sodium sulphate production is split almost evenly. Natural sodium sulphate is produced in California, Texas and Utah. The Kerr-McGee Corporation, which produces sodium sulphate from brines at Searles Lake, California, completed a major expansion program increasing their production capability by 136 000 tonnes per year (tpy). However, a delay in startup along with run-in difficulties resulted in lower output of soda ash, sodium sulphate and other salts than was originally anticipated.

In Europe, sodium sulphate is almost entirely produced as a byproduct of chemical processes.

PRODUCTION AND DEVELOPMENTS IN CANADA

Shipments of natural sodium sulphate from Canadian producers increased by 17.1 per cent to 442 646 tonnes (t) in 1979, but were still much below the record level of 638 000 t in 1974. The unit value of shipments increased from $51.52 in 1978 to $68.93 per t in 1979, reflecting improved demand from the pulp and paper and detergent industries. Production in 1979 was recorded at 438 540 t.

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 inflow is greater than outflow. 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 ($Na_2SO_4.10H_2O$). The cycle has been

TABLE 1. CANADA, SODIUM SULPHATE PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979[p]	
	(tonnes)	($)	(tonnes)	($)
Production				
Shipments	376 563	19,299,566	452 000	26,156,000
Imports				
Total salt cake and Glauber's salt				
United Kingdom	14 562	570,000	19 181	639
United States	10 616	545,000	816	197
Belgium and Luxembourg	-	-	-	-
West Germany	-	-	-	-
Total	25 178	1,115,000	19 997	836,000
Exports				
Crude sodium sulphate				
United States	129 029	7,833,000	191 412	13,104,000
Philippines	-	-	1 290	147,000
Other countries	-	-	568	72,000
Total	129 029	7,833,000	193 270	13,323,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[p] Preliminary; - Nil.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1979

	Plant Location	Source Lake	Annual Capacity (tonnes)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	75 000
Saskatchewan			
Francana Minerals Ltd.	Grant	Snakehole	63 000
Francana Minerals Ltd.	Hardene	Alsask	42 500
Midwest Chemicals Limited	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals	Chaplin	Chaplin	90 000
Saskatchewan Minerals	Bishopric[1]	Frederick	45 000
Saskatchewan Minerals	Fox Valley	Ingebrigt	135 000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	45 400
Total			695 500

Sources: Company reports.
[1] Closed at end of June 1977; to be reopened in April 1980.

repeated year after year, resulting in thick deposits of hydrous sodium sulphate, accompanied by other salts and mud. 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 re-dissolved 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.

TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION 1965, 1970 AND 1975-79

	Production[1]	Imports[2]	Exports	Consumption
	(tonnes)			
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	256 385
1976	460 193	29 266	146 396	265 608
1977	394 795	34 639	117 027	254 872
1978	376 563	25 178	129 029	227 766
1979P	452 000	19 997	193 270	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake.
P Preliminary; .. Not available.

Deposits in Saskatchewan have been identified that contain, in total, approximately 90 million t of anhydrous sodium sulphate. Of this amount, a total of about 51 million t is in 21 individual deposits, each containing more than 500 000 t of sodium sulphate. One deposit in Alberta contains 2.7 million t of Na_2SO_4. Production currently takes place on the following lakes (with reserves, in million of tonnes, in brackets): Whitehorse Lake (6.5), Horseshoe Lake (3.7), Frederick 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 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. After the crystal bed has become frozen, harvesting is carried out by 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 air-cooled crystallizer at the plant, where sodium sulphate is separated from other insoluble salts. At the Chaplin Lake plant, after precipitation in the brine reservoir the water is drained back into the lake, permitting mechanical harvesting of the precipitate. Removal of the crystallized sodium sulphate usually takes place in the coldest months of January and February. The processing method at Alberta Sulphate Limited's plant at Horseshoe Lake combines dredging and solution mining. Crystallizers are used mainly to separate mud from salt cake.

Processing of a 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

TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION, 1977-79

	1977	1978	1979
	(tonnes)		
Pulp and paper	199 678	176 074	..
Soaps	37 029	33 786	..
Glass and glass wool	8 920	17 410	..
Other products[1]	9 245	9 496	..
Total	254 872	236 766	..

Source: Statistics Canada, breakdown by Energy, Mines and Resources Canada.
[1]Colours, pigments, feed supplements and other minor uses.
.. Not available.

paper industry, contains a minimum of 97 per cent Na_2SO_4. Detergent-grade material analyzes up to 99.7 per cent Na_2SO_4. Uniform grain size and free-flow characteristics are important in handling and use.

Of the eight plants in the prairie provinces, three are capable of producing detergent-grade sodium sulphate. Each of the three plants has the capacity to produce 80 per cent or more of its output as a high-grade product.

Byproduct recovery. Courtaulds (Canada) Inc. produces approximately 20 000 t 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 68 000 t of salt cake in 1979 (54 000 t in 1978) as a byproduct of paper manufacturing. The capacity of the plant is 77 000 tpy. The Great Lakes Paper Company Limited at Thunder Bay produces salt cake for internal consumption (about 11 000 tpy in 1979) and is expanding capacity to over 20 000 tpy by mid-1980. At a late date, driers could be installed permitting production of salt cake for sale.

CONSUMPTION AND TRADE

The three principal consumers of sodium sulphate are 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 and reduction of usage per unit of output, consumption of salt cake declined between 1974 and 1978. The detergent market, however, remained strong. In 1979 North American markets had a remarkable recovery.

TABLE 5. CANADA, RAILWAY TRAIN LOADINGS OF SODIUM SULPHATE, 1978 AND 1979

	1978	1979
	(tonnes)	
Nova Scotia	-	..
New Brunswick	260	..
Quebec	699	..
Ontario	32 786	..
Manitoba	-	..
Saskatchewan	320 644	..
Alberta	38 916	..
British Columbia	60 909	..
Canada	454 214	..

Source: Statistics Canada.
- Nil; .. Not available.

Canadian exports of sodium sulphate in 1979 were 193 270 t, an increase of 50 per cent from the 128 663 t exported in 1978. Production delays at the California plant greatly improved this export picture. Almost 60 per cent of exports to the United States are detergent grade. Imports in 1979 decreased by 20 per cent to 19 997 t, compared with 1978. Almost all imports were from the United Kingdom, as the U.S. ceased to be a significant supplier.

OUTLOOK

Outlook for sales in 1980 remains as strong as that of 1979, but full production at facilities in the United States in the early 1980s may result in substantially reduced export opportunities for Canada. Despite the current two-year improvement in the overall demand, U.S. commodity experts still predict an average decline in demand of 2 per cent per year for the 1980's.

PRICES

Canadian prices of sodium sulphate, as quoted in "Canadian Chemical Processing Newsletter", March 3, 1980.

	($ Cdn. per t)
Sodium sulphate (salt cake)	
Regular, bulk, carlots, fob works	55.00
Detergent grade bulk, carlots, fob works	66.00

United States prices as quoted in "Chemicals Marketing Reporter", December 31, 1979.

	($ 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

The Tokyo Round of Multilateral Trade Negotiations under the General Agreement on Tariffs and Trade (GATT) that was convened in 1973, were brought to a successful conclusion in 1979. The negotiations resulted in the signing of a number of so-called non-tariff Agreements that are intended to liberalize world trade and a reduction in Most-Favoured Nation (MFN) tariffs on most industrial products. For most items, the tariff reductions will be phased in over the 8-year period January 1, 1980 to January 1, 1987. Selected tariff items from Canada's four-column tariff schedule and some MFN reductions by Canada and the USA are presented below showing the tariffs for 1979 and the full phase-in period. For the European Economic Community and Japan, only the tariff applicable for 1979, the base rate for the tariff reductions (i.e. the previously bound MFN tariff), and the concession rate are presented (i.e. for most items January 1, 1987).

Canada: Customs Tariffs, 1979

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
21000-1	Natural sodium sulphate	10.0	15.0	25.0	10.0

MFN reductions (%) under GATT, effective January 1 of year given

1979	1980	1981	1982	1983	1984	1985	1986	1987
15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

United States: Custom Tariffs

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
421.42	Crude sodium sulphate	Remains free								
421.44	Anhydrous (per ton)	39¢	39¢	38¢	37¢	36¢	36¢	35¢	34¢	33¢
421.46	Crystallized	3%	3%	3%	2.9%	2.8%	2.7%	2.7%	2.6%	2.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20, No. L289, 1977; GATT Documents, 1979.

Stone

D.H. STONEHOUSE

CANADIAN INDUSTRY

Production of stone of all types in Canada in 1979 decreased 10.2 per cent to 110 million tonnes (t), while the unit value of production increased by over 11 per cent. 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. There are, however, periodic surges of interest in Canadian stone for building uses, particularly Canadian black granites. 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

TABLE 1. CANADA, TOTAL PRODUCTION (SHIPMENTS) OF STONE, 1977-79

	1977		1978		1979P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
By province						
Quebec	78 425 530	176,818,607	76 218 682	198,504,209	63 251 049	185,072,776
Ontario	28 869 133	77,884,277	33 815 562	94,517,217	33 439 385	102,095,244
British Columbia	3 938 003	11,166,228	3 433 566	11,996,038	4 353 417	14,929,542
New Brunswick	3 091 665	9,541,779	3 121 279	9,897,442	3 122 185	9,913,820
Manitoba	3 022 867	11,303,411	2 678 311	8,628,186	1 923 781	7,100,466
Nova Scotia	1 974 215	6,919,179	1 980 332	6,245,093	2 181 372	7,682,578
Newfoundland	616 780	2,205,701	654 895	2,163,560	1 262 033	2,922,962
Alberta	224 409	728,128	241 181	792,524	185 958	990,314
Canada	120 162 602	296,567,310	122 143 808	332,744,269	109 719 180	330,707,702
By use						
Building stone						
Rough	320 673	2,889,799	524 115	3,185,951	..	..
Monumental and ornamental stone	23 661	1,640,633	24 663	1,779,410	..	..
Other (flagstone, curbstone, paving blocks, etc.)	23 238	888,738	31 901	1,252,980	..	..
Chemical and metallurgical						
Cement plants, foreign	1 205 482	1,285,616	1 219 039	1,994,429	..	..
Lining, open-hearth furnaces	34 536	62,302	31 370	71,683	..	..
Flux in iron and steel furnaces	421 467	1,524,365	413 868	1,670,474	..	..
Flux in nonferrous smelters	84 306	218,203	42 752	189,272	..	..
Glass factories	277 828	2,085,426	257 949	2,360,198	..	..
Lime kilns, foreign	332 317	819,818	342 283	925,854	..	..
Pulp and paper mills	308 668	1,881,921	310 305	2,212,908	..	..
Sugar refineries	35 280	164,807	27 864	160,240	..	..
Other chemical uses	826 105	3,475,959	1 072 155	4,333,833	..	..
Pulverized stone						
Whiting (substitute)	19 533	670,922	27 167	1,043,623	..	..
Asphalt filler	31 035	166,079	25 371	245,989	..	..
Dusting, coal mines	3 538	56,400	3 674	60,300	..	..
Agricultural purposes and fertilizer plants	717 431	4,802,926	966 298	7,037,548	..	..
Other uses	57 094	478,630	60 494	357,441	..	..

Crushed stone for						
Manufacture of artificial stone	9 579	168,064	17 669	220,212	..	..
Roofing granules	230 288	7,478,853	274 119	9,640,539	..	..
Poultry grit	33 588	430,779	50 395	628,824	..	..
Stucco dash	32 119	1,157,871	22 561	1,026,687	..	..
Terrazzo chips	9 919	344,895	4 361	141,134	..	..
Rock wool	-	-	-	-	..	..
Rubble and riprap	41 639 851	65,201,294	40 430 659	79,388,652	..	..
Concrete aggregate	12 368 628	34,562,618	12 373 703	35,384,224	..	..
Asphalt aggregate	5 470 040	15,020,731	6 622 217	18,852,198	..	..
Road metal	25 382 239	69,476,894	24 536 390	69,034,613	..	..
Railroad ballast	5 570 667	17,590,395	3 396 582	12,589,742	..	..
Other uses	24 693 492	62,022,372	29 033 884	76,955,311	..	..
Total	120 162 602	296,567,310	122 143 808	332,744,269	109 719 180	330,707,702

Source: Statistics Canada.

P Preliminary; - Nil; .. Not available.

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 buoyant and continuing market for cement and clinker would be necessary to suport 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.

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 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]. 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.

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. 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 t, nearly 90 per cent of the Canadian total.

Sandstone. There are far fewer sandstone-producing operations in Quebec than there

TABLE 2. CANADA, PRODUCTION (SHIPMENTS) OF LIMESTONE, 1977 and 1978

	1977		1978	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Newfoundland	453	1,410	537	1,619
Nova Scotia	193	1,532	203	1,711
New Brunswick	752	3,600	679	3,651
Quebec	27 821	79,116	24 320	72,092
Ontario	27 126	64,742	31 620	78,555
Manitoba	1 147	2,669	1 462	3,818
Alberta	88	536	74	523
British Columbia	2 581	6,788	2 644	8,977
Canada	60 161	160,393	61 539	170,946
	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	279 771	1,187,173	475 140	1,262,518
Monumental and ornamental	915	77,567	816	33,000
Other (flagstone, curbstone, paving blocks, etc.)	8 221	257,533	10 341	365,602
Chemical and metallurgical				
Cement plants, foreign	1 205 482	1,285,616	1 219 039	1,994,429
Lining, open-hearth furnaces	34 536	62,302	31 370	71,683
Flux, iron and steel furnaces	421 467	1,524,365	413 868	1,670,474
Flux, nonferrous smelters	84 306	218,203	42 620	187,556
Glass factories	277 828	2,085,426	257 949	2,360,198
Lime kilns, foreign	332 317	819,818	342 284	925,854
Pulp and paper mills	301 999	1,815,540	301 901	2,128,969
Sugar refineries	35 280	164,807	27 864	160,240
Other chemical uses	826 105	3,475,959	945 756	4,210,580
Pulverized stone				
Whiting substitute	19 533	670,922	27 167	1,043,623
Asphalt filler	25 092	140,597	25 371	245,989
Dusting, coal mines	3 538	56,400	3 674	60,300
Agricultural purposes and fertilizer plants	633 842	4,291,258	883 069	6,458,033
Other uses	53 653	404,927	50 507	268,190
Crushed stone for				
Artificial stone	1 379	53,200	934	29,625
Roofing granules	41 327	209,392	57 060	279,321
Poultry grit	32 978	416,808	44 316	554,311
Stucco dash	26 445	1,097,430	22 561	1,026,687
Rubble and riprap	692 890	1,849,022	2 090 668	5,658,137
Concrete aggregate	10 661 288	28,313,202	10 575 756	28,581,483
Asphalt aggregate	3 673 566	9,616,631	5 230 634	14,459,441
Road metal	19 831 967	52,065,162	19 255 874	52,530,204
Railroad ballast	2 618 317	5,732,379	1 059 234	2,824,352
Other uses	18 037 193	42,501,203	18 143 602	41,555,230
Total	60 161 235	160,392,842	61 539 375	170,946,029

Source: Statistics Canada.

TABLE 3. CANADA, PRODUCTION (SHIPMENTS) OF MARBLE, 1977 and 1978

	1977		1978	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Quebec	390	1,783	380	1,972
Ontario	7	279	2	91
Canada	397	2,062	382	2,063
	(tonnes)	($)	(tonnes)	($)
By use				
Chemical process stone				
Flux in nonferrous smelters	-	-	133	1,716
Pulp and paper mills	6 669	66,381	8 404	83,939
Pulverized stone				
Agricultural purposes and fertilizer plants	83 589	511,668	83 229	579,515
Other uses	3 441	73,703	9 987	89,251
Crushed stone				
For manufacture of artificial stone	8 200	114,864	16 735	190,587
Stucco dash	5 674	60,441	-	-
Terrazzo chips	9 919	344,895	4 361	141,134
Concrete aggregate	69 803	366,566	50 663	316,803
Asphalt aggregate	15 702	68,468	13 363	76,596
Road metal	79 847	225,064	78 571	256,499
Roofing granules	-	-	1 412	21,800
Poultry grit	-	-	5 543	60,957
Rubble and riprap	-	-	9 427	19,385
Other uses	114 062	230,171	100 701	225,119
Total	396 906	2,062,221	382 529	2,063,301

Source: Statistics Canada.

- Nil.

TABLE 4. CANADA, PRODUCTION (SHIPMENTS) OF GRANITE, 1977 and 1978

	1977		1978	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Newfoundland	6	61	9	94
Nova Scotia	...	23	1	14
New Brunswick	1 664	4,158	2 037	5,225
Quebec	48 200	88,921	49 331	117,236
Ontario	1 720	12,404	2 055	15,427
Manitoba	1 876	8,635	1 216	4,810
British Columbia	1 357	4,378	790	3,019
Canada	54 823	118,580	55 439	145,825

TABLE 4. (Cont'd.)

	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	14 787	852,766	26 935	1,165,570
Monumental and ornamental	22 746	1,563,066	23 804	1,743,381
Other (flagstone, curbstone, paving blocks, etc.)	3 885	295,564	13 277	619,869
Pulverized stone				
Asphalt filler	5 943	25,482	-	-
Crushed stone for				
Roofing granules	188 961	7,269,461	215 646	9,339,418
Poultry grit	610	13,971	536	13,556
Rubble and riprap	40 870 680	63,188,390	37 961 828	72,899,983
Concrete aggregate	1 258 859	4,351,695	1 381 531	5,044,447
Asphalt aggregate	1 164 027	3,402,219	1 116 987	3,447,052
Road metal	3 975 761	12,512,090	4 013 543	12,706,117
Railroad ballast	2 135 298	9,079,012	1 978 317	8,274,637
Other uses	5 180 980	16,025,909	8 707 045	30,571,100
Total	54 822 537	118,579,625	55 439 449	145,825,130

Source: Statistics Canada.

- Nil; ... Figure too small to be expressed.

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 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 t. 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

TABLE 7. CANADA, PRODUCTION (SHIPMENTS) OF STONE BY TYPES, 1970, 1975-78

	1970		1975		1976		1977		1978	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Granite	4 388 270	15,231,891	11 469 656	34,912,787	24 690 983	68,557,352	54 822 537	118,579,625	55 439 449	145,825,130
Limestone	52 522 637	67,563,790	72 284 032	152,521,587	57 793 004	146,699,824	60 161 235	160,392,842	61 539 375	170,946,029
Marble	56 096	350,903	356 111	1,842,715	398 317	1,974,468	396 906	2,062,221	382 529	2,063,301
Sandstone	2 112 794	4,133,708	3 753 357	10,880,645	3 693 917	11,298,041r	3 834 010	13,336,685	4 196 987	13,019,751
Shale	180 087	695,458	1 550 450	2,566,306	1 299 715	2,108,777	947 914	2,195,937	585 468	890,058
Slate	-	-	-	-	-	-	-	-	-	-
Total	59 259 884	87,975,750	89 413 606r	202,724,040	87 875 936	230,638,462	120 162 602	296,567,310	122 143 808	332,744,269

Source: Statistics Canada.

- Nil; r Revised.

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.

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 principle 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.

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.

TABLE 8. CANADA, STONE EXPORTS AND IMPORTS, 1977-79

	1977		1978		1979P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
Building stone, rough	13 494	1,447,000	17 471	975,000	6 377	769,000
Crushed limestone, limestone refuse	1 502 492	3,251,000	1 710 349	4,011,000	2 296 295	5,639,000
Stone crude, nes	182 047	683 000	294 049	656,000	296 121	1,817,000
Natural stone, basic products	..	1,731,000	..	3,730,000	..	6,909,000
Total		7,112,000		9,372,000		15,134,000
Imports						
Building stone, rough	13 756	1,226,000	11 022	893,000	10 803	1,032,000
Crushed limestone, limestone refuse	2 922 684	8,611,000	2 873 601	9,961,000	3 215 717	12,227,000
Crushed stone including stone refuse, nes	69 225	3,459,000	59 648	3,201,000	79 329	3,640,000
Stone crude, nes	6 469	488,000	6 591	699,000	6 802	545,000
Granite, rough	22 156	1,686,000	17 063	1,544,000	22 662	2,306,000
Marble, rough	7 665	1,153,000	5 937	1,307,000	8 694	1,622,000
Shaped or dressed granite	..	842,000	..	1,080,000	..	1,549,000
Shaped or dressed marble	..	1,526,000	..	1,442,000	..	1,602,000
Natural stone basic products	..	960,000	..	1,078,000	..	1,788,000
Total		19,951,000		21,205,000		26,311,000

Source: Statistics Canada.

P Preliminary; nes Not elsewhere specified; .. Not available.

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.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminium oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Limestone is used in the metallurgical industries as a fluxing material where it combines with impurities in ore to form a fluid slag that can be separated from molten metal. Calcium limestones are used in open-hearth steel manufacture, whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron in blast furnaces.

Limestone is used extensively as a filler or an extender and, where quality permits, as whiting. In such applications both physical and chemical properties are important. Specifications vary widely but, in general, a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture the material may be used as a pigment extender.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley Industries Limited.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded on barges of up to 20 000 t 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 its silica for these uses.

TABLE 9. CANADA, VALUE OF CONSTRUCTION BY PROVINCE, 1978-80

	1978[1]	1979[2]	1980[3]
	(millions of dollars)		
Newfoundland	642.5	806.8	922.5
Prince Edward Island	165.5	164.5	169.5
Nova Scotia	998.9	1,122.4	1,215.3
New Brunswick	928.3	1,078.1	1,024.7
Quebec	8,527.3	9,395.0	9,590.9
Ontario	10,979.6	11,538.5	12,383.8
Manitoba	1,501.9	1,451.9	1,475.7
Saskatchewan	1,652.8	2,046.6	2,216.6
Alberta	7,411.5	9,051.5	11,251.7
British Columbia	4,933.0	5,297.4	6,645.5
Yukon and Northwest Territories	448.8	418.3	540.3
Canada	38,190.1	42,371.0	47,436.5

Source: Statistics Canada.

[1] Actual; [2] Preliminary; [3] Forecast.

TABLE 10. CANADA, VALUE OF CONSTRUCTION BY TYPE, 1978 and 1979

	1978[1]	1979[2]
	(millions of dollars)	
Building construction		
Residential	13,780	14,153
Industrial	1,563	1,945
Commercial	3,856	4,825
Institutional	1,682	1,966
Other building	1,353	1,549
Total	22,234	24,438
Engineering construction		
Marine	223	250
Highways, airport runways	3,035	3,428
Waterworks, sewage systems	1,804	1,956
Dams, irrigation	148	189
Electric power	3,855	4,073
Railway, telephones	1,442	1,663
Gas and oil facilities	3,336	4,197
Other engineering	2,113	2,177
Total	15,956	17,933
Total construction	38 190	42 371

Source: Statistics Canada.

[1] Actual; [2] Preliminary.

Note: Data for the forecast year 1980 is not available by type of construction.

TABLE 11. CANADA, VALUE OF CONSTRUCTION WORK PERFORMED, BY PRINCIPAL TYPES OF CONSTRUCTION, BY INDUSTRY, 1977-1980

Industry	1977[1] Building	1977[1] Engineering	1977[1] Total	1978[1] Building	1978[1] Engineering	1978[1] Total	1979[2] Building	1979[2] Engineering	1979[2] Total	1980[3] Total
				(millions of dollars)						
Agriculture and fishing	552	301	853	637	346	983	751	408	1,159	1,279
Forestry	21	129	150	17	132	149	26	165	191	193
Mining, quarrying and oil wells	352	2,890	3,242	205	3,372	3,577	319	4,416	4,735	6,820
Construction	147	2	149	157	2	159	177	2	179	194
Manufacturing	1,389	800	2,189	1,294	807	2,101	1,575	698	2,273	2,596
Utilities	558	5,420	5,978	754	5,866	6,620	914	6,280	7,194	8,245
Trade	467	20	487	494	22	516	558	24	582	659
Finance, insurance and real estate	1,695	313	2,008	1,876	428	2,304	2,533	449	2,982	3,395
Commercial services	406	5	411	457	13	470	542	11	553	656
Housing	13,126	-	13,126	13,780	-	13,780	14,153	-	14,153	14,377
Institutional services	1,400	17	1,417	1,417	11	1,428	1,630	24	1,654	1,860
Government departments	1,194	4,599	5,793	1,146	4,957	6,103	1,260	5,456	6,716	7,163
Total	21,307	14,496	35,803	22,234	15,956	38,190	24,438	17,933	42,371	47,437

Source: Statistics Canada.

[1] Actual; [2] Preliminary; [3] Forecast.
- Nil.
Note: Data for the forecast year is not available by principal type of construction.

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, nor 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		free		
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

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			%		
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

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1979	1980	1981	1982	1983	1984	1985	1986	1987
					%				
30515-1	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0
30520-1	7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30525-1	7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30530-1	7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30605-1	7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30610-1	12.5	11.9	11.4	10.8	10.3	9.7	9.1	8.6	8.0
30700-1	17.5	16.4	15.4	14.3	13.3	12.2	11.1	10.1	9.0
30705-1	17.5	16.4	15.4	14.3	13.3	12.2	11.1	10.1	9.0
30710-1	17.5	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
30715-1	17.5	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
30800-1	17.5	16.9	16.3	15.6	15.0	14.4	13.8	13.1	12.5

UNITED STATES

Item No.		
513.61	Granite, not manufactured, and not suitable for use as monumental, paving or building stone	free

TARIFFS (Cont'd.)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
514.91	Quartzite, whether or not manufactured						free			
515.41	Stone, other, not manufactured and not suitable for use as monumental, paving or building stone						free			
513.21	Marble chips and crushed	5.0%	4.4%	3.8%	3.1%	2.5%	1.9%	1.3%	0.6%	free
514.11	Limestone, crude, not suitable for use as monument-as, paving or building stone, per short ton	10¢	free	free	free	free	free	free	free	free
515.11	Roofing slate	12.5%	11.8%	11.0%	10.3%	9.6%	8.8%	8.1%	7.3%	6.6%

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated 1978, USITC Publication 843; U.S. Federal Register Vol 44, No. 241.

Sulphur

B.W. BOYD

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 one-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 54.9 million tonnes (t) in 1979, was only 2 per cent higher than in 1978, but was in line with the long-term 4 per cent annual growth rate established over the past 20 years.

World sulphur consumption, on the other hand, rose an estimated 5 per cent to a new high of 55.5 million t. Western world consumption exceeded production for the second year in succession as an era of tight supply became established.

Canada's total elemental sulphur sales in 1979, a record 6.7 million t, were 17 per-cent greater than in 1978. Sulphur stock-piles on the prairies were reduced from 20.88 million t at year-end 1978 to 20.57 million t at year-end 1979.

THE CANADIAN 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 tpy of liquid sulphur dioxide is produced from smelter gases. In 1979, over 90 per cent of Canadian sulphur shipments were in elemental form, nearly all from sour natural gas produced 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 natrual 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, these vast sources of sulphur will be tapped in the future at a rate proportional to their development as sources of energy.

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

TABLE 1. CANADA, SULPHUR SHIPMENTS AND TRADE, 1978 and 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Shipments				
Pyrite and pyrrhotite[1]				
Gross weight	9 203	..	31 000	..
Sulphur content	4 602	72,466	15 500	275,000
Sulphur in smelter gases[2]	676 278	11,649,197	605 000	12,675,000
Elemental sulphur[3]	5 752 208	101,392,000	6 718 000	145,072,000
Total sulphur content	6 433 088	113,113,663	7 338 500	158,022,000
Imports				
Sulphur, crude or refined				
United States	8 005	957,000	1 687	583,000
West Germany	62	17,000	12	9,000
France	63	9,000	-	-
Total	8 130	983,000	1 699	592,000
Exports				
Sulphur in ores (pyrite)				
United States	..	57,000	..	281,000
Total	..	57,000	..	281,000
Sulphuric acid and oleum				
United States	205 166	4,062,000	139 426	3,086,000
Other countries	...	1,000	1	2,000
Total	205,166	4,063,000	139 427	3,088,000
Sulphur, crude or refined, nes				
United States	1 181 552	20,253,000	1 239 262	26,600,000
South Africa	459 695	18,432,000	480 048	23,018,000
Brazil	402 977	12,874,000	424 225	17,025,000
Australia	442 855	17,067,000	343 352	14,969,000
South Korea	267 114	10,990,000	274 540	12,956,000
Italy	296 867	8,312,000	291 840	12,245,000
People's Republic of China	205 236	8,917,000	244 138	11,974,000
India	147 299	6,219,000	241 174	11,149,000
New Zealand	260 047	8,888,000	247 564	10,385,000
Morocco	117 480	4,611,000	205 759	9,726,000
Taiwan	307 979	14,885,000	192 332	9,481,000
Tunisia	94 745	3,906,000	141 899	8,142,000
Netherlands	97 772	3,445,000	151 192	5,810,000
Belgium-Luxembourg	108 393	4,251,000	101 381	5,379,000
Other countries	594 535	20,833,000	576 100	27,452,000
Total	4 984 546	163,883,000	5 154 806	206,311,000

Sources: Statistics Canada; Energy, Mines and Resources 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; ... Amount too small to be expressed; - Nil.

TABLE 2. CANADA, SOUR GAS SULPHUR EXTRACTION PLANTS, 1979

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
Bonanza Oil and Gas Limited	Kirkwall		0.5
CDC Oil and Gas Limited	Brazeau River		42
Canadian Superior Oil Ltd.	Harmattan-Elkton	53	490
Canadian Superior Oil Ltd.	Lonepine Creek	12	157
CanDel Oil Ltd.	Minnehik-Bruce Lake		45
Chevron Standard Limited	Kaybob South	19	3 521
Chevron Standard Limited	Nevis	7	260
Esso Resources Canada	Joffre		17
Esso Resources Canada	Quirk Creek	9	300
Esso Resources Canada	Redwater	3	33
Gulf Canada Limited	Nevis	3-7	295
Gulf Canada Limited	Pincher Creek	10	160
Gulf Canada Limited	Rimbey	1-3	333
Gulf Canada Limited	Strachan	10	943
Home Oil Company Limited	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	Edsen	2	284.5
Hudson's Bay Oil and Gas	Hespero (Sylvan Lake)	1	16
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	Zama		74
J.S.E. Enterprises Ltd.	Acadia		0.2
Mobil Oil Canada, Ltd.	Wimborne	14	168
Petro-Canada	Gold Creek		43
Petrofina Canada Inc.	Wildcat Hills	4	177
Petrogas Processing Ltd.	Crossfield (Balzac)	31	1 687
Saratoga Processing Company	Savannah Creek (Coleman)	13	389
Shell Canada Limited	Burnt Timber Creek	8-5	497
Shell Canada Limited	Innisfail	14	163
Shell Canada Limited	Jumping Pound	3-5	511
Shell Canada Limited	Rosevear	8	153
Shell Canada Limited	Simonette River	15	267
Shell Canada Limited	Virginia Hills		9
Shell Canada Limited	Waterton	18-25	3 066
Steelman Gas Limited	Steelman, Sask.	1	7
Suncor Inc.	Rosevear	8	84
Texaco Exploration Company	Bonnie Glen		15
Texasgulf Inc.	Okotoks	36	459
Texasgulf Inc.	Windfall	16	1 175
Westcoast Transmission	Fort Nelson, B.C.		1 100
Westcoast Transmission	Pine River, B.C.		1 055
Westcoast Transmission	Taylor Flats, B.C.	3	325
Western Decalta Petroleum	Turner Valley	4	24
Total (daily rated capacity December 31, 1979)			28 189

Sources: Compilation by **Oilweek**; "H_2S in Raw Gas" figures from Alberta Energy Resources Conservation Board publications.

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:

$$2H_2S + 3O_2 \qquad 2H_2O + 2SO_2$$

$$2H_2S + SO_2 \qquad 2H_2O + 3S$$

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 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. The Procor G.X. dry-granulation process is a Canadian forming technology adopted in 1978 by Shell Canada Limited at Harmattan and by Texasgulf Inc. at Windfall, Alberta. Gulf Canada Resources Inc. has been constructing, for service by early 1980, a prilling tower based on Polish technology.

Declining production has led to the development of sulphur melters to reclaim sulphur from vatted storage. Melting, for producing liquid sulphur for shipment, and some ripping and loading of bulk sulphur accounted for a net 300 000 t reduction in stockpiles in 1979.

In 1979, 50 sour gas sulphur plants were operating, including one in Saskatchewan and three in British Columbia, with a combined daily capacity of 28 189 t, slightly higher than in 1978. Production of elemental sulphur from natural gas in Alberta, as reported by the Alberta Energy Resources Conservation Board, was 5 934 000 t in 1979, down 8 per cent from 1978. Production in British Columbia was 131 147 t, and in Saskatchewan 116 t. A further 214 000 t were produced at oil sands plants in Alberta, and 32 000 t from oil refining in Alberta and Ontario.

Alberta sulphur sales were a record 6 175 000 t in 1979, up 9 per cent from 1978. The value of sales increased 42.5 per cent to $142 million. Alberta inventories stood at 20 094 000 t at December 31, 1979. British Columbia and Saskatchewan elemental sulphur sales were 151 411 t and 2 440 t, respectively, and inventories were 12 650 t and 2 200 t.

Canadian elemental sulphur production capacity, having doubled between 1968 and 1972, reached a plateau in 1973 from which output has declined by 1 million t. Seven plants are scheduled for completion in 1979 (Table 3).

Higher gas prices and federal and provincial incentives have stimulated exploration, especially in the foothills belt where most sour gas sulphur occurs, and 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 mid-80s.

A number of pollution abatement guidelines for natural gas plants were laid down in November 1971 by the Alberta government. These include: mandatory stack clean-up facilities and recovery

TABLE 3. PROPOSED NEW SULPHUR CAPACITY FOR 1980

Operating Company	Location	Proposed Daily Rated Capacity
	(all in Alberta)	(tonnes)
Czar Resources	Leahurst-Gadsby	2
Dome Petroleum	Brazeau-Elk River	15
Dome Petroleum	Cranberry	319
Dome Petroleum	Pembina-Alder	4
Norcen Energy	Ferrier	120
PanCanadian	Countess	14
PanCanadian	Morley	18

Source: **Oilweek.**

efficiencies between 97 and 99 per cent, depending on acid gas quality, for plants rating over 1 016 tpd; minimal stack clean-up, or equipment with efficiency between 94 and 98 per cent, for plants rated between 406 tpd and 1 016 tpd; 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. Revised guidelines for new plants and expansions are planned for 1980.

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 Prince Rupert, British Columbia; Churchill, Manitoba; Thunder Bay, Ontario and Quebec City, Quebec.

Athabasca oil sands. The Athabasca oil sands constitute a vast deposit of relatively unconsolidated sandstone impregnated with bitumen, covering some 80 000 km^2 of northeastern Alberta. The estimated 300 billion barrels of recoverable oil in the formation contain about 2 billion t 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 t of sulphur daily. Twinning of the sulphur unit to permit the expanded production required was completed in 1977. In August 1979, GCOS and Sun Oil Company amalgamated to form Suncor Inc.

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 t.

A third project, Alsands, is under consideration and would, if approved, increase the sulphur production capacity of oil sands projects by 100 000 t to 200 000 t annually at the initial stages and by 350 000 t when complete. A heavy oil project at Cold Lake has a proposed capacity of about 140,000 barrels per day of heavy oil, which would indicate sulphur production capacity of about 350 000 tpy. These last two projects are not likely to be operating at capacity before 1985.

Sulphur production from tar sands plants in 1979 totalled 214 000 t, which was more than double the production in 1978. Most of this production has been put into vatted storage, although small shipments

TABLE 4. CANADA, PRINCIPAL SULPHUR OPERATIONS BASED ON SMELTER GASES, 1979

Operating Company	Plant Location	Raw Material	Annual Capacity 100% H_2SO_4	Annual Capacity Approx. S equiv.
			(tonnes)	
Brunswick Mining and Smelting Corp. Ltd.	Belledune, N.B.	SO_2lead-zinc	124 000	42 000
Allied Chemical	Valleyfield, Que.	SO_2zinc conc.	140 000	47 000
Canadian Electrolytic Zinc	Valleyfield, Que.	SO_2zinc conc.	120 000	40 000
Canadian Industries[1]	Copper Cliff, Ont.	SO_2pyrrhotite	900 000	300 000
Cominco[1]	Trail, B.C.	SO_2lead-zinc	440 000	145 000
	Kimberley, B.C.	SO_2pyrrhotite	280 000	92 000
Texasgulf Canada Ltd.	Timmins, Ont.	SO_2zinc conc.	205 000	70 000
Gaspé Copper Mines	Murdochville, Que.	SO_2copper	245 000	82 000
Falconbridge Nickel Mines Limited	Falconbridge, Ont.	SO_2pyrrhotite	420 000	140 000
Total			2 874 000	958 000

Sources: Company data.
[1]Does not include 85 000 t sulphur content in liquid SO_2 production.

have been trucked to the railroad at Lynton, Alberta and shipped south from there.

Oil refineries. Some crude oils contain as much as 5 per cent sulphur, either as hydrogen sulphide or in other compounds, but 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. The total sulphur output from refineries in 1979 was an estimated 240 000 t and this recovery represents 30 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 "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 t by 1990 and 5 million t by the end of this century. Although coal in western Canada is low in sulphur (less than 0.5 per cent), 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 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.

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 the gas. 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 t (85 000 t 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, $H_2S_2O_7$).

The largest H_2SO_4 plant complex in Canada is that of Canadian Industries Limited (CIL) at Copper Cliff, Ontario. The

TABLE 5. CANADA, SULPHUR SHIPMENTS AND TRADE, 1970, 1975-79

	Shipments				Imports	Exports	
	Pyrites[1]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites[2]	Elemental Sulphur
	(tonnes)				(tonnes)	($)	(tonnes)
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	4 602	676 278	5 752 208	6 433 088	8 130	57,000	4 984 546
1979P	15 500	605 000	6 718 000	7 338 500	1 699	281,000	5 154 806

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1]See footnotes for Table 1. [2]Quantities of pyrites exported not available. PPreliminary.

TABLE 6. CANADIAN EXPORT MARKETS FOR SULPHUR, 1979

Country or Area	Exports	Per cent of Total
	(million tonnes)	
United States	1.24	24.0
Europe	.77	15.0
South Africa	.48	9.3
Brazil	.42	8.2
Australia	.34	6.6
South Korea	.27	5.2
New Zealand	.25	4.8
People's Republic of China	.24	4.7
India	.24	4.7
Others	.90	17.5
Total	5.15	100.0

Source: Energy, Mines and Resources Canada.

company operates three acid plants that have a combined annual capacity of 900 000 t of H_2SO_4 based on SO_2 gas from Inco Limited'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; Chicago, Illinois; Cleveland, Ohio; and River Rouge, Michigan.

The total production in 1979 of sulphur contained in smelter gases was 605 000 t, down 18 per cent from the last year of "normal" operations, 1977, because of strikes at Copper Cliff, Ontario. A strike at Inco Limited began in September 1978 and continued to June 1979; followed by a strike at CIL which continued into August 1979.

Subsidiaries of Noranda Mines Limited produce smelter acid at three localities: Gaspé Copper Mines, Limited's 245 000 tpy plant at Murdochville, Quebec; Brunswick Mining and Smelting Corporation Limited's 125 000 tpy plant at Belledune, New Brunswick; and Canadian Electrolytic Zinc Limited's zinc concentrate roasting facility at Valleyfield, Quebec, with a capacity of 120 000 tpy. Expanded zinc capacity at the latter is idle in the face of soft markets. A proposed new copper smelter and associated 100 000 tpy sulphuric acid installation to be built at Noranda, Quebec has been shelved for the time being.

TABLE 7. CANADA SULPHUR CONSUMPTION 1965, 1970, 1975-79

	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	699 895[r]	1 434 990[r]
1978	677 261	806 676	1 483 937
1979[p]	604 660	..	..

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 Energy, Mines and Resources Canada. [p] Preliminary. .. Not available; [r] Revised.

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 tpy 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 tpy. 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 an 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 tpy. An expansion plan intended to raise acid output to 400 000 t by 1978 was delayed for two years and a second stage to raise capacity to 560 000 t has been shelved. A proposed associated phosphate fertilizer works has also been deferred.

TABLE 8. CANADA, ESTIMATED CONSUMPTION OF SULPHUR[1] BY INDUSTRY, 1976-78

	1976	1977[r]	1978
		(tonnes)	
Fertilizers	239 211	318 951	304 738
Pulp and paper	265 869	261 186	256 148
Chemicals	105 448	85 389	106 340
Foundry	2 606	3 540	5 220
Rubber products	2 137	2 975	5 120
Other industries[2]	35 761	27 854	129 110
Total	651 032	699 895	806 676

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[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.
[r] Revised.

Falconbridge Nickel Mines Limited's new $95 million electric smelter and associated 1 180 tpd acid plant operated through the year and compensated in part for the production lost at Copper Cliff.

Shipments of acid and oleum to the United States in 1979 dropped 32 per cent to 45 590 t 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.

*Obtained by multiplying H_2SO_4 tonnage by 0.327.

Conversion to elemental sulphur feed at acid plants has resulted in a drastic reduction in pyrite usage.

Small tonnages of pyrite are produced by Noranda and exported to the United States. In addition, over one-third of the sulphuric acid produced at Kimberley, British Columbia, by Cominco is based on pyrite.

CANADA CONSUMPTION AND TRADE

In 1979, Canadian consumption of sulphur in all forms, as reported by consumers, amounted to about 1.5 million t.

Canada remains the largest exporter of elemental sulphur, having shipped 5 154 806 t in 1979. From the outset, the United States has been the principal destination for Canadian sulphur and presently accounts for about 24 per cent of Canadian exports. Sales to the U.S. were unchanged from 1978 at 1.2 million t, while shipments to Europe were up 6 per cent from those of 1978, to 773 260 t. This is 80 per cent of the peak reached in 1974. Asian sales increased slightly to a record 1 033 762 t, reflecting stronger markets in India and South Korea. Australasia's Canadian purchases, totalling 590 919 t, were down 17 per cent from 1978.

Canadian sales to Africa and South America (mainly South Africa and Brazil) increased by 17 per cent and 5 per cent, respectively, to reach new records of 942 000 t and 563 000 t.

TABLE 9. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1965, 1970, 1975-79

	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	3 260 846	107 766	205 166	3 163 446
1979P	3 685 919	172 891	139 427	3 719 383

Source: Statistics Canada.
PPreliminary.

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 weak 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 the sudden turnaround inevitable. 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 1979.

The country which produces the most sulphur is the United States, at 12 101 000 t in 1979. Over one-half of its production, 6 357 000 t of elemental sulphur, is voluntary coming from Frasch-type mines located around the Gulf of Mexico. Recovery from natural gas and oil refining accounts for another 4 070 000 t and is also in elemental form. Remaining production of 1 674 000 t is byproduct recovery, mainly as sulphuric acid and sulphur dioxide. Production in 1979 was 1 638 000 t less than apparent consumption, and with exports running at close to 2 million t, importation of 2.5 million t, mainly from Canada and Mexico, was required.

Mexican sulphur production, which is 95 per cent elemental, increased 11.6 per cent from the 1978 level to 2 230 000 t. Domestic consumption, which has grown rapidly during this decade, was about 0.9 million t in 1979. Exports were 1.2 million t, 8 per cent lower than in 1978 and well below the peak year 1974. The United States is the principal destination of Mexican sulphur.

Production of elemental sulphur in 1979 from the Lacq sour natural gas field in France was 2 million t, a production plateau first reached in 1969.

Elemental sulphur production from sour gas and oil refineries in the northern part of the Federal Republic of Germany (West Germany) increased 22 per cent to over 1 million t after two years of production at 850 000 tpy.

Polish production, at 4.9 million t was down 8 per cent from the record production in 1978 and exports fell by 10 per cent to 3.9 million t.

Iraq became a significant producer of elemental sulphur in 1973. Capacity is reported to have reached 1 million tpy, but no major expansion to the estimated 762 000 t output is expected until improvements to upgrade rail transport capability to the Persian Gulf port of Umm Qasr, 725 km to the south, are 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 only 244 000 t during 1979.

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 the world industrial demand, it seems inevitable that the current shortage will deepen over the next few years and prices will escalate sharply. This outlook is based on the view that non-market 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 39 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 t and output in 1979 was 7 per cent less than that figure. Several of the major plants are recycling operations, ie., 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

TABLE 10. CANADA, AVAILABLE DATA ON CONSUMPTION OF SULPHURIC ACID BY INDUSTRY, 1977 AND 1978

	1977[r]	1978
	(tonnes-100% acid)	
Industrial chemicals	1 910 364	2 185 631
Smelting and refining	260 683	285 787[e]
Pulp and paper mills	227 316	253 421
Uranium ore processing	165 639	198 993
Mining[e]	49 895	49 900
Miscellaneous chemicals	34 000	77 113
Soaps and cleaning compounds	21 759	22 850
Petroleum refineries	18 218	22 463
Plastics and synthetic resins	16 302	16 699
Iron and steel mills	10 592	9 486
Wire and wire products	6 464	9 247
Miscellaneous electrical products	5 616	5 352
Mixed fertilizers	5 421	1 107
Metal stamping, pressing and coating	4 097	3 936
Motor vehicle parts and accessories	2 455	2 900
Miscellaneous industries[1]	20 071	9 132
Total	2 758 892	3 154 017

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; [r]Revised.

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 t.

Estimates of annual production of sulphur from tar sands by 1985 is 400 000 t and sulphur produced from smelter gases is expected to reach 1 million t contained in sulphuric acid by that year. 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 1979 was 20 per cent below the 1974 record of 8.0 million t. 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 8 remain in operation. It now seems optimistic to expect much more than 5.0 million t of annual output by 1985. Increased shipments from stocks, as prices rise, will have reduced these by as much as 2 million t by the end of 1980. Sulphur produced from oil, gas, pyrite and smelters could expand to 7.0 million t 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 U.S. operators. Except for the all-time high of 2.3 million t in 1974, production has varied between 1.2 and 1.8 million t for much of the 25-year Frasch 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 t by 1985.

Poland's Frasch production may reach 6 to 7 million t, and the output from new Middle East producers - sour gas and Iraqi Frasch - could rise to 3.0 million t by 1985. However, rapid consumption growth in the Communist bloc and in the Middle East will assuage 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 factors, 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 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 t of H_2SO_4 are needed to produce 1 t 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 t of sulphuric acid per t of uranium produced, plus additional acid indirectly in

TABLE 11. WORLD PRODUCTION OF SULPHUR IN ALL FORMS, 1978

	Elemental	Other[1]	Total
	(000 tonnes)		
United States	9 703	2 160	11 863
U.S.S.R.	3 800	7 000	10 800
Canada	5 752	681	6 433
Poland	5 325	335	5 660
Japan	1 104	1 623	2 727
France	2 060	159	2 219
Mexico	1 816	176	1 992
West Germany	855	709	1 564
Spain	13	1 277	1 290
Italy	70	570	640
Iran	542	-	542
South Africa	28	481	509
Finland	5	349	354
East Germany	80	274	354
Sweden	18	294	312
Other countries	2 188	4 320	6 508
Total	33 359	20 408	53 767

Source: British Sulphur Corporation Limited, Statistical Supplement, January-February 1980.

[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.

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 t. By the year 2000, annual requirements are expected to exceed 2 million t. Ore and tailings leaching in base-metal production and anticipated developments in hydrometallurgy are other consumption areas with high growth potential. Several new applications for elemental sulphur, based on useful physical 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 **CPI Management Service** , December 3, 1979	$
Sulphur, elemental, fob producing point, carload, per long ton	25.00-30.00
Sulphuric acid, fob plants, East, 66^{o} Be, tanks, per tonne	67.10
United States prices in U.S. currency, quoted in **Engineering and Mining Journal,** January 1980	$ U.S.
Sulphur elemental	
U.S. producers, term contracts fob vessel at Gulf ports, Louisiana and Texas, per long ton	
Bright	89.50
Dark	88.50
Export prices, ex terminal Holland, per long ton	
Bright	102.50
Dark	106.50
Mexican export, fob vessel, per long ton	
Bright	63.00
Dark	63.00

fob Free on board.

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

TARIFFS (concl'd)

CANADA (cont'd)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
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

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
92808-1	15.0	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free

UNITED STATES

Item No.		
418.90	Pyrites	free
415.45	Sulphur, elemental	free
416.35	Sulphuric acid	free

		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
422.94	Sulphur dioxide	6.0	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2

Sources: The Customs Tariff and Amendments, Revenue Canada, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated 1978, USITC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Tin

G.E. WITTUR and J.J. HOGAN

Canada is a relatively small producer of tin. Production of tin in concentrates and lead-tin alloy in 1979 was 362 tonnes (t) valued at $7,022,000 compared with 360 t in 1978 valued at $5,099,216. The tin in concentrates is exported for smelting. Mine production is not sufficient to support a domestic smelter.

Canadian industrial requirements of tin are met mainly by imports. These totalled 4 689 t in 1979 valued at $81,102,000 compared with 4 809 t in 1978 valued at $69,012,000. Malaysia is Canada's main source of tin and most of the tin destined for this country is brought into New York because of economic factors, then transshipped by truck from New York to Toronto, Hamilton and Montreal, the major centres of tin consumption. As a result, Statistics Canada's method of defining country of origin shows the United States (Table 1) as the source of most Canadian tin imports. Malaysia makes small direct shipments to Canada, as does Singapore, Bolivia, Thailand and other countries.

Canada also imports relatively small tonnages of tinplate and other tin products from the United States and elsewhere. Most tin metal scrap and tinplate scrap is exported, mainly to the U.S., as facilities for secondary metal recovery in Canada are 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 automobile radiators and scrap plumbing and are reconstituted, but statistical data on the amount of tin solder recovered are not available.

Metal Recovery Industries Ltd. of Hamilton, Ontario recovers a secondary tin product by de-tinning industrial scrap. Small quantities of municipal scrap are also processed. The tin is recovered as potassium stannate and sold to the electroplating industry.

Two Canadian mining operations produce a small amount of tin concentrates. By-product tin is recovered by Cominco Ltd. from the milling of the Sullivan Mine lead-zinc ores at Kimberley, British Columbia. Besides the tin concentrate produced, Cominco also recovers about 600 t of a lead-tin alloy each year from the treatment of lead bullion dross in the indium circuit at 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 a special research grade tin (99.999 per cent) and "Tadanac" high-purity tin (99.9999 per cent).

Texasgulf Canada Ltd. recovers some tin in concentrate from its Kidd Creek base-metal operation at Timmins, Ontario.

Tin is present in small quantities in several other sulphide deposits in Canada but its recovery is not economic.

On the horizon, the most promising tin prospect is the newly discovered deposit (1979) of Shell Canada Resources Limited, a subsidiary of Royal Dutch/Shell Group, near

TABLE 1. CANADA, TIN PRODUCTION, IMPORTS AND CONSUMPTION, 1978 AND 1979

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Production				
Tin content of tin concentrates and lead-tin alloys	360	5,099,216	362	7,022,000
Imports				
Blocks, pigs, bars				
United States	3 726	53,875,000	3 091	56,277,000
United Kingdom	8	131,000	526	9,311,000
Singapore	173	2,399,000	255	4,465,000
Bolivia	246	3,503,000	410	4,128,000
Netherlands	...	1,000	85	1,553,000
Thailand	-	-	75	1,411,000
Other countries	655	9,103,000	247	3,957,000
Total	4 809	69,012,000	4 689	81,102,000
Tinplate				
United States	1 156	832,000	1 291	1,039,000
United Kingdom	274	364,000	198	343,000
Hong Kong	-	-	5	4,000
Total	1 430	1,196,000	1 494	1,386,000
Tin, fabricated materials, nes				
United States	255	769,000	311	1,452,000
United Kingdom	34	71,000	40	137,000
Hong Kong	3	5,000	79	8,000
Other countries	28	42,000	4	7,000
Total	320	887,000	434	1,604,000
Exports				
Tin in ores, concentrates and scrap				
United States	301	863,000	637	4,637,000
Mexico	501	2,376,000	25	315,000
Belgium-Luxembourg	-	-	2	32,000
United Kingdom	124	488,000	2	14,000
Other countries	17	73,000	46	12,000
Total	943	3,800,000	712	5,010,000
Tinplate scrap				
United States	2 396	184,000	2 863	237,000
Singapore	519	108,000	-	-
Total	2 915	292,000	2 863	237,000
Reported Consumption				
Tinplate and tinning	2 465	..	2 306	..
Solder	2 021	..	1 955	..
Babbit	204	..	199	..
Bronze	73	..	55	..
Other uses (including collapsible containers, foil, etc.)	159	..	160	..
Total	4 922	..	4 675	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; nes Not elsewhere specified; .. Not available; ... Figure too small to be expressed.

TABLE 2. CANADA, TIN PRODUCTION, EXPORTS, IMPORTS AND CONSUMPTION, 1970, 1975-79

	Production[1]	Exports[2]	Imports[3]	Consumption[4]
		(tonnes)		
1970	120	268	5 111	4 565
1975	319	1 052	4 487	4 315
1976	274	777[r]	4 224	4 849
1977	328	876	5 028	5 286
1978	360	943	4 809	4 922
1979P	362	712	4 689	4 675

Sources: Statistics Canada; Energy, Mines and Resources 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 80-85 per cent.
P Preliminary; [r] Revised.

East Kemptville, Yarmouth County, Nova Scotia. Geological evaluation, including diamond drilling, is being carried out and tin mineralization has been indicated over a length of four kilometres (km).

Higher tin prices also encourages greater interest in tin exploration in other parts of Canada, especially in northern British Columbia and the Yukon.

The multi-mineral Fire Tower Zone deposit of Brunswick Tin Mines Limited in southwestern New Brunswick contains 0.04 per cent tin. Brunswick Tin and Billiton Exploration Canada Limited are bringing this deposit into production for the recovery of tungsten and molybdenum but the low tin content cannot be economically recovered. A second multi-mineral zone occurs about one-half mile to the north and contains an estimated 2.4 million t grading 0.42 per cent tin as well as some tungsten, molybdenum, bismuth and zinc. This property could be developed at a later date.

Consumption of tin reported in Canada peaked at nearly 5 300 t in 1977 but has since declined, reaching 4 675 t in 1979.

The principal use of tin in Canada is in the production of tinplate, which consumes nearly half of the total. 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 1979, 2 306 t of tin were used to produce approximately 444 700 t of tinplate.

Dofasco and Stelco each operate three electrolytic tinplate lines. Stelco's third line, with an annual capacity of 175 000 t of tinplate, can be converted to produce other types of coatings, notably chromium. Dofasco's third line is also a dual-purpose unit and these units give tinplate producers flexibility in the face of higher prices for tin.

The second-largest use for tin is in the manufacture of solders, which absorb about 2 000 tpy of tin. Important Canadian tin solder producers are: The Canada Metal Company, Limited, Federated Genco 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.

THE FIFTH INTERNATIONAL TIN AGREEMENT

Tin is the only metal for which there is an international agreement between consuming and producing countries. The Fifth International Tin Agreement (ITC), which came into force in July 1, 1976, is effective until June 30, 1981. It is designed primarily to limit price fluctuations of tin through the mechanism of a buffer stock and export controls, to help increase export earnings from the commodity and to secure an adequate supply of tin at prices acceptable to consumers and remunerative to producers.

Producer and consumer members form separate groups in the Council and each

TABLE 3. ESTIMATED WORLD[1] PRODUCTION OF TIN-IN-CONCENTRATES, 1969, 1978 AND 1979

	1969	1978	1979[P]
		(tonnes)	
Malaysia	73 325	62 650	62 995
Thailand	21 092	30 186	33 962
Bolivia	30 047	30 881	29 337[e]
Indonesia	16 542	27 410	28 817
Australia	8 128	11 716	11 997
Brazil	2 385	6 500[e]	7 400[e]
Zaire	6 647	3 450[e]	3 300[e]
Nigeria	8 741	2 935	2 750[e]
South Africa	1 822	2 887	2 693
United Kingdom	1 648	2 802	2 337
Total, including countries not listed	179 500	197 300	201 700

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.
[P] Preliminary; [e] Estimated.

group has an equal number of votes in the governing body. There are seven producer members: Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and the Republic of Zaire. Brazil and China, two substantial producers of tin, are not members of ITC but there is a possibility that Brazil could join the Sixth International Tin Agreement. China is not expected to join the next agreement. Canada was a signatory to the Fifth Agreement and is one of the 23 consumer members. In 1979 Canada has 29 votes out of a total of 1,000 in the consumer group. The United States has 265 votes, followed by Japan with 164 votes.

After prolonged discussions the ITC reached an agreement in July on new operating price ranges for the buffer stock manager. The floor price was adjusted upwards from M$1,350/picul (133.3 /picul) to M$1,500/picul and the ceiling from M$1,700 to M$1,950/picul. The buffer stock of the ITC was exhausted in January 1977 and the ITC has not entered the market since then as the price ranges laid down by the ITC for tin purchases remained below the market price.

WORLD DEVELOPMENTS

Total non-communist world output of tin-in-concentrates in 1979, as reported by the ITC, was 202 400 t compared with 197 400 t in 1978, an increase of 2.5 per cent.

Non-communist world production of primary tin metal in 1979 was 204 000 t and from recycled tin metals 9 400 t, for a total output of 213 400 t. Total production in 1978 was 202 200 t. Consumption of tin metal from both sources in 1979 was 195 800 t compared with 193 000 t in 1978. Taking into account trade with the communist bloc, the surplus in the supply-demand balance was about 7 000 t. The United States did not make any sales from its stockpile in 1979.

On January 2, 1980, the President of the United States signed the Strategic and Critical Materials Transaction Authorization Act of 1979 which authorized the disposal of

TABLE 4. ESTIMATED WORLD[1] PRODUCTION OF PRIMARY TIN METAL, 1969, 1978 AND 1979

	1969	1978	1979[P]
		(tonnes)	
Malaysia	88 487	71 953	73 068
Thailand	22 402	28 945	33 058
Indonesia	7 762	25 830	26 645[e]
Bolivia	86	16 181	18 405[e]
Brazil	2 269	8 354	9 939[e]
United Kingdom	26 399	8 445	8 154
Australia	4 227	5 129	5 423
United States	351	3 873	4 656
Spain	2 101	4 575	4 412
Singapore	-	1 500[e]	4 000[e]
Nigeria	8 981	2 984	2 858
West Germany	1 469	3 241	2 488
Belgium	4 515	3 295	2 165
Total, including countries not listed	180 600	192 300	202 600

Source: International Tin Council, Statistical Bulletin.
[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
[P] Preliminary; [e] Estimated.

materials determined to be excess to the current requirements of the National Defence Stockpile. Negotiations had been going on for some time and agreement was reached in December. Terms of the Act call for the sale of 35,000 long tons of tin which includes 5,000 long tons to be made available to the International Tin Council buffer stock. Some of the primary tin producing countries expressed opposition to the Act when it was under discussion, fearing it would depress the tin price.

Malaysia is the world's largest tin producing country and in 1979 output was 62 995 t, more than 31 per cent of total non-communist world production. Initiatives by the tin-mining industry in Malaysia have resulted in the government establishing a new tax structure that will go into effect on January 1, 1980. The main feature of the tax revision will be that export duties will be calculated on a cost-plus formula on a production cost of M$1,100 per picul. The tax assessment would be on a sliding scale with the maximum rate set at 50 per cent. Recent changes in Malaysian corporate law require a minimum of 30 per cent Malaysian interest in foreign controlled companies. The two tin smelters are foreign controlled and will have to change their ownership structure.

Bolivia has long been the world's second-largest tin producing country but it was surpassed in 1979 for the first time by Thailand. Most of Bolivia's tin comes from underground operations and increasing cost of wages and supplies make it difficult for the country's tin mines to remain profitable.

Offshore dredging units in Indonesia are expected to come on stream in 1980 and could increase annual tin production to more than 30 000 t. Thailand is also increasing its tin output and should maintain its position as the second-largest producer. Thai Pioneer Enterprises has signed a contract with Lurgi Chemie und Hüttentechnik GmbH of West Germany for a new tin smelter with an annual capacity of 5 000 t. The estimated cost of the plant is $9.2 million and it is expected to be in operation in late 1980. The plant will be some 40 km north of Bangkok.

The Peoples Republic of China is a substantial producer of tin. The country has two tin smelters in the southwest, with a reported, combined annual capacity of 35 000 t. A major tin mine is being developed in the southern Guangxi province which will have an annual output of 4 000 t as well as appreciable amounts of zinc, lead and antimony. The International Tin Council estimated China's tin output at 20 000 t in 1979. China's exports of tin have declined since 1975 and exports were only about 2 000 t in 1979.

Rio Tinto Zinc Corporation Limited (RTZ) acquired control of the Wheal Jane and Mount Wellington tin mines in Cornwall, United Kingdom, and decided to reopen both these mines. According to reports RTZ estimated the overall cost to acquire the properties and rehabilitate the mines at about $19.5 million. The mines are expected to be in full production in early 1981.

In Australia, Renison Limited, a subsidiary of Consolidated Gold Fields Limited, is increasing its plant capacity by 35 per cent to 850 000 tpy. Cost of the project is $20 million and it is expected to be completed in late 1980. The Renison mine is one of the world's major underground operations and has ample reserves.

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 (m). Suction dredges are also used, but in most places they are less efficient than the bucket-line method. Other methods are gravel pumping, hydraulic methods 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 gram (g) per m^3 of sand (approximately 1 800 kilograms (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 blocs, notably The People's Republic of China and the U.S.S.R., are also important producers of tin from lode mines. 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, but higher tin prices could permit the mining of lower-grade deposits. Silver, tungsten, bismuth and lead are common byproducts of lode mines. Cassiterite is 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. However, mill recoveries of tin from lode deposits often are quite low by base-metal standards and some 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.

USES

The major use of tin is in tinplate and tinning, which account for over 40 per cent of the world's consumption. The manufacture of solders is the second-largest use of tin, accounting for about 26 per cent of the world's total. Tin is also used in the manufacture of babbit, bronze and brass alloys, and in the chemical industry.

The Tin Review of 1978 gives a more-detailed description of the many uses of tin.

PRICES

Table 5 lists monthly tin prices in 1979. Tin prices rose sharply after 1973, when the average N.Y. composite price was $U.S. 2.27 a pound, and reached an average of $7.09 in November 1978. In 1979, prices were comparatively stable for the first eight months, but then rose significantly during the last four months. The possibility of sales by the United States from its tin stockpile might have affected the market in the latter part of the year, but political events in Bolivia, monetary uncertainties, and probably general speculative activity generated by action in the precious metal field, resulted in continued price strength.

OUTLOOK

In the short-to medium-term the supply and demand for tin is expected to be in close balance. Overhanging the market is the excess tin stocks in the United States strategic stockpile. At the end of 1979 the stockpile contained 184 795 t while the goal was 29 957 t, leaving a surplus of 154 838 t of tin. The United States government authorized the sale of 35 000 t of tin from this surplus by the General Service Administration (GSA). It is expected that sales from this surplus will be made in such a manner as to be the least disruptive to the market. The price is expected to remain comparatively stable.

Negotiations on a Sixth International Tin Agreement will be held in 1980, with the new agreement scheduled to replace the Fifth Agreement on July 1, 1981. Initial proposals by some member countries suggest that producers will press for mandatory joint producer-consumer financing of the buffer stock, a continuation of the existing export control mechanism, and revision of the voting distribution. Consumers are expected to press for a larger buffer stock provision and less reliance on export controls.

TABLE 5. TIN PRICES, 1979

	N.M. Can. ¢/lb	Metals Week N.Y. Composite U.S. ¢/lb	Metals Week N.Y. Dealer U.S. ¢/lb	Metals Week Penang Market Malaysia U.S. Equiv. ¢/lb
January	822.23	684.23	643.27	608.79
February	868.27	720.08	685.22	645.29
March	880.17	741.80	713.86	665.55
April	852.25	735.91	691.62	659.46
May	865.38	740.77	695.00	663.01
June	891.77	753.92	707.86	677.48
July	892.37	759.52	708.33	679.99
August	896.05	739.52	687.39	659.36
September	862.60	761.95	721.63	677.66

TABLE 5. (Cont'd.)

	N.M. Can. ¢/lb	Metals Week N.Y. Composite U.S. ¢/lb	Metals Week N.Y. Dealer U.S. ¢/lb	Metals Week Penang Market Malaysia U.S. Equiv. ¢/lb
October	929.08	781.40	749.77	694.08
November	954.23	799.63	766.32	704.69
December	982.66	827.95	788.75	732.57
Average	889.75	753.89	711.45	672.33

Sources: **Metals Week; Northern Miner (N.M.)** for Canada.

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%	17 1/2%	30%	10%
34200-1	Phosphor tin	5%	7 1/2%	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%	12 1/2%	25%	8%
43220-1	Manufactures of tin plate	15%	17 1/2%	30%	11 1/2%

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
33507-1	15.0	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
33910-1	17.5	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
34200-1	7.5	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
38203-1	12.5	12.5	12.5	11.8	11.0	10.3	9.5	8.8	8.0
43220-1	17.5	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2

UNITED STATES

Item No.		
601.48	Tin ore and black oxide of tin	free
622.02	Unwrought tin other than alloys of tin	free
622.04	Unwrought tin, alloys of tin	free
622.10	Tin waste and scrap	free

TABLE 1. CANADA, TITANIUM PRODUCTION AND TRADE, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Titanium dioxide, slag	..	88,155,899	..	66,595,000
Imports				
Titanium dioxide, pure				
United States	3 601	4,218,000	3 768	5,111,000
West Germany	1 400	1,543,000	2 521	2,685,000
France	20	18,000	1 626	1,707,000
United Kingdom	831	1,027,000	1 183	1,607,000
Other countries	743	744,000	670	791,000
Total	6 595	7,550,000	9 768	11,901,000
Titanium dioxide, extended				
United Kingdom	286	348,000	1 146	1,331,000
United States	135	228,000	189	370,000
France	20	21,000	179	168,000
Switzerland	1	3,000	1	3,000
West Germany	56	47,000	-	-
Total	498	647,000	1 515	1,872,000
Titanium metal				
United States	569	6,882,000	655	16,100,000
United Kingdom	43	947,000	55	1,358,000
Belgium-Luxembourg	7	328,000	5	395,000
Other countries	22	345,000	10	160,000
Total	641	8,502,000	725	18,013,000
Exports[1] to the United States				
Titanium metal, unwrought including waste and scrap	293	882,784	302	1,368,000
Titanium metal, wrought	481	3,744,965	426	3,799,000
Titanium dioxide	15 642	13,847,302	17 970	16,948,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[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.

Canada Inc. at Tracy, Quebec. Together these two companies produce about 72 000 t of TiO_2 pigment per year and supply approximately 90 per cent of the 60 000 t of annual Canadian consumption.

WORLD DEVELOPMENTS

Australia remained the world's largest source of titanium minerals in 1979, producing some 280 000 t of rutile and 1.2 million t of ilmenite. In the Republic of South Africa, production at Richards Bay Iron & Titanium (Pty.) Ltd. (QIT owns 31.8 per cent) was expected to reach its annual capacity of 400 000 t of titanium slag production by the end of the year.

Sierra Rutile Ltd. in Sierra Leone began to produce rutile in July from the Mogbwemo deposit, located 130 km south of Freetown. The company estimates that rutile shipments were 32 000 t in 1979 and expects to operate at its annual capacity production rate of 900 000 t in 1980.

TABLE 2. CANADIAN TITANIUM PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970, 1975-79

	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	1 809 990	850 000	6 595	498	7 093	..	34
1979p	1 004 260	671 500	9 768	1 515	11 283	..	23

Sources: Energy, Mines and Resources Canada; Statistics Canada; 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 contents.
p Preliminary; .. Not available.

TABLE 3. TITANIUM SLAG AND IRON PRODUCTION, QIT-FER ET TITANE INC., 1965, 1970, 1975-79

	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	850 000	595 000
1979p	1 004 260	671 500	339 660

Source: Kennecott Copper Corporation Annual Report.
p Preliminary.

PROCESSING AND USES

Nearly 90 per cent of all 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 which is then clarified to remove insoluble heavy metals and impurities. After cooling, the iron is precipitated in the form of hydrated iron sulphate and the remaining 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 chloride process, rutile is chlorinated in the presence of carbon to produce titanium tetrachloride. The tetrachloride is separated from other chloride products by distillation, and then vaporized and oxidized to produce titanium dioxide and chlorine. The chlorine is recovered and recycled.

More than one-half of the 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

TABLE 4. SALIENT TITANIUM STATISTICS, UNITED STATES, 1978 AND 1979

	Ilmenite		Rutile		Titanium[1]	
	1978	1979[e]	1978	1979[e]	1978	1979[e]
			(tonnes)			
Production	535 239	499 000	..	-	..	..
Imports	415 491[2]	408 000[2]	263 084	274 000	1 339	2 200
Consumption	835 517[2]	880 000[2]	238 590	254 000	18 011	21 800
Price/pound	..	..	..	..	$3.28	$3.98
Price/ton	$50.00[3]	$50.00[3]	$340.00[4]	390.00[4]	..	..

Source: U.S. Bureau of Mines, **Mineral Commodity Summaries**, January 1980.
[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 or not applicable; - Nil.

TABLE 5. CONSUMPTION OF TITANIUM CONCENTRATE IN THE UNITED STATES, BY PRODUCTS, 1978

	Ilmenite[1]		Titanium Slag		Rutile	
Product	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
			(tonnes)			
Pigments	708 730	424 028	116 869	82 999	190 276	177 292
Welding-rod coatings	(2)	(2)	..	..	8 146	7 645
Alloys and carbides	(2)	(2)	(3)	(3)	(2)	(2)
Miscellaneous[4]	10 023	7 292	..	..	40 335	37 490
Total	718 753	431 320	116 869	82 999	238 757	222 427

Source: U.S. Bureau of Mines, **Mineral Industry Surveys**, Third Quarter, 1979.
[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 fibres and titanium metal.
.. Not available or not applicable.

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 and the sponge metal is compacted and melted into metal ingots. The production of titanium sponge metal requires approximately 2.2 kg of rutile, 3.5 kg of chlorine, 1.3 kg of magnesium or 2.1 kg of sodium, 0.3 kg of petroleum coke and 8 495 cubic centimetres (cm^3) of inert gas, as well as about 465 mega joules (MJ) of energy per kg of sponge metal; included is the energy needed to produce the magnesium and chlorine. An additional 49 to 61 MJ per kg of titanium ingot (United States Bureau of Mines (USBM) data) are required for the conversion of sponge metal to titanium ingot.

OUTLOOK

Very little change is expected in the short- to medium-term for titanium dioxide pigments. The major consuming industries, namely those producing paints, paper and plastics, will likely continue to experience slow growth. The demand for titanium metal 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 outpaced the growth in supply, and in 1979 the backlog in deliveries was two years.

Most of the major titanium metal manufacturers are expanding production capacity in response to the increased demand and, while the present shortage of titanium metal will continue into 1980, these expansion programs should provide adequate capacity to satisfy demand by 1981.

TABLE 6. PRODUCTION OF ILMENITE CONCENTRATE BY COUNTRIES, 1977-79

	1977	1978[p]	1979[e]
	(000 tonnes)		
Australia	1 082	1 259	1 143
Norway	828	767	771
Canada[1]	692	850	672
United States	579	535	499
U.S.S.R.[e]	400	408	..
Malaysia	154	187	..
India[e]	136	143	146
Finland	125	132	-
Republic of South Africa	-	91[e]	299
Sri Lanka	34	33	-
Other countries	13	774	780
Total	4 043	4 114	4 115

Sources: U.S. Bureau of Mines, **Minerals Yearbook Preprint,** 1977; **Mineral Industry Surveys** 1978[p]; U.S. Bureau of Mines, **Mineral Commodity Summaries,** January 1980.
[1]Titanium slag containing 70-71% TiO_2.
[p] Preliminary; [e] Estimated; .. Not available; - Nil.

TABLE 7. PRODUCTION OF RUTILE BY COUNTRIES, 1977-79

	1977	1978[p]	1979[e]
	(tonnes)		
Australia	326 618	265 624	280 000
United States	..	..	-
U.S.S.R.[e]	27 215	29 937	..
India[e]	5 988	7 260	9 000
Sri Lanka	978	11 497	..
Brazil	128	132	..
Republic of South Africa	-	18 000[e]	42 000
Other countries	-	141	44 000
Total	360 927	332 591	375 000

Sources: U.S. Bureau of Mines, **Minerals Yearbook Preprint,** 1977; **Mineral Industry Surveys** 1978[p] and U.S. Bureau of Mines, **Mineral Commodity Summaries,** January 1980.
[p] Preliminary; [e] Estimated; .. Not available; - Nil.

TABLE 8. UNITED STATES TITANIUM METAL DATA, 1975-79

	1975	1976	1977	1978	1979
			(tonnes)		
Sponge metal					
Imports for consumption	3 801	1 613	2 165	1 339	2 257
Industry stocks	5 143	3 281	3 217	2 397	1 955
Government stocks (total inventory)[1]	28 750	29 328	29 328	29 330	29 330
Consumption	15 990	12 079	14 729	18 011	21 715
Scrap metal					
Consumption	7 544	8 356	9 878	11 174	12 688
Stocks	5 563	5 229	6 193	5 849	6 108
Ingot[2]					
Production	23 188	19 608	23 861	28 472	33 679
Consumption	22 213	19 055	22 898	27 892	32 151
Stocks	936	1 661	1 722	1 955	1 652
Net shipments of mill products[3]	14 177	13 152	14 031	16 010	19 471

Source: U.S. Bureau of Mines, **Mineral Industry Surveys,** final 1978, fourth quarter 1979, and U.S. Bureau of Mines, **Mineral Yearbook Preprint** 1975-1977.
[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.

PRICES

Prices of selected titanium commodities, in United States currency, 1979

	($)
Titanium ore, fob cars Atlantic and Great Lake ports[1]	
Rutile, 96%, per short ton, delivered within 12 months	425.00-450.00
Ilmenite, 54%, per long ton, shiploads	55.00
Slag, 70%, per long ton, fob Quebec	110.00
Titanium metal, sponge, per lb, max.	
115 Brinell, 99.3% 500-lb lots[1]	3.98
Mill products, per lb delivered, 4,000-lb lots[1]	
Billet, Ti - 6AL-4V (8 in. diameter, rotating grade)	5.24-7.13
Bar, Ti - 6AL-4V (2 in. diameter, random lengths)	8.17-10.73
Titanium dioxide, anatase, dry milled, Canadian prices[2]	
Bags, carlots, delivered East, per kg.	1.190
Bags, carlots, rutile, per kg.	1.312

[1] **Metals Week,** December 28, 1979. [2] **CPI Management Service,** December 3, 1979.

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 in Canadian manufactures (expires June 30, 1980)	7.5%	7.5%	25%	5%

TARIFFS (cont'd)

CANADA (cont'd)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
37506-1	Ferrotitanium	free	5%	5%	free
92825-1	Titanium oxides	free	12.5%	25%	free
93207-6	Titanium whites, not including pure titanium dioxide	free	12.5%	25%	free

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
37506-1	5.0	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
92825-1	12.5	12.2	11.9	11.6	11.3	10.9	10.6	10.3	10.0
93207-6	12.5	12.2	11.9	11.6	11.3	10.9	10.6	10.3	10.0

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
						(%)				
422.30	Titanium compounds	7.5	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
473.70	Titanium dioxide	7.5	7.3	7.1	6.9	6.8	6.6	6.4	6.2	6.0
601.51	Titanium ore			remains free						
606.46	Ferrotitanium and ferro-silicon titanium	5.0	5.0	5.0	4.8	4.6	4.4	4.1	3.9	3.7
629.12	Titanium metal, waste and scrap[1]	18.0	16.7	15.3	14.0	12.6	11.3	9.9	8.6	7.2
629.14	Titanium metal, unwrought	18.0	18.0	18.0	17.5	17.0	16.5	16.0	15.5	15.0
629.20	Titanium metal, wrought	18.0	18.0	18.0	17.5	17.0	16.5	16.0	15.5	15.0

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979, Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

[1] Duty on waste and scrap temporarily suspended.

Tungsten

D.G. LAW-WEST

CANADIAN DEVELOPMENTS

Canada Tungsten Mining Corporation Limited (Cantung), the only producer of tungsten concentrates in Canada, completed an expansion program early in July and operated at full capacity for most of the second half of 1979. The doubling of mill capacity to 1 000 tonnes per day (tpd) of ore required additions of equipment and alterations in both the mine and the mill. In 1979 Cantung produced 327 508 metric ton units (mtu) of tungsten trioxide (WO_3), an increase of 12 per cent from 1978. This increase was achieved despite a 19.4 per cent decline in the mill feed grade. At the same time, tungsten recovery increased by nearly 1 per cent to 87 per cent. The expansion makes Cantung one of the largest and most efficient tungsten mines in the western world.

Canada is to have a second tungsten producer by mid-1982. Brunswick Tin Mines Limited and Billiton Canada Ltd. formed a joint venture to bring the Mount Pleasant tungsten-molybdenum deposit in New Brunswick into production. Billiton is committed by the agreement to spend $80 million on mine and mill development. The mine will have a capacity of 650 000 tpy of ore which will be processed in a new 2 000 tpd mill. Annual output is projected to be about 1 800 t of contained WO_3 and 600 t of molybdenum sulphide (MoS_2). Billiton will manage the project and market the output. After Billiton has recovered its costs, all profits will be shared by the two companies.

During 1979, AMAX Inc. continued evaluation work on its Mactung deposits which are located on the Yukon-Northwest Territory boundary. The company is expected to announce development plans in the near future.

INTERNATIONAL DEVELOPMENTS

In the United States, Utah International announced plans to open the Springer tungsten mine, formerly known as the Sutton mine, near Tungsten, Nevada. In addition to the mine, Utah is building a 725 000 kilogram (kg) per year ammonium paratungstate (APT) plant on the site. The integrated operation is expected to begin production in mid-1982, and to have a 13-year operating life.

AMAX Tungsten division of AMAX Inc. also announced plans for the construction of an APT plant. The project, an addition to the existing molybdenum conversion plant at Fort Madison, Iowa, is scheduled for start-up in the fall of 1981.

In March, 1979 the United States government announced that tungsten ore and ferotungsten had been added to the General System of Preference (GSP) list. These commodities will be allowed to enter the United States duty free when they originate in developing countries, and providing that imports from any one country do not exceed $37.2 million in value or more than 50 per cent of total United States imports of the product during a calendar year.

TABLE 1. CANADA, TUNGSTEN PRODUCTION, IMPORTS AND CONSUMPTION, 1978 AND 1979

	1978		1979P	
	(kilograms)	($)	(kilograms)	($)
Production[1] (WO_3)	2 885 619	..	3 275 082	..
Imports				
Tungsten in ores and concentrates				
United States	1 200	8,000	11 000	242,000
Total	1 200	8,000	11 000	242,000
Ferrotungsten[2]				
United Kingdom	24 000	434,000	21 000	425,000
United States	2 000	49,000	7 000	171,000
France	46 000	777,000	-	-
Other countries	1 000	44,000	-	-
Total	73 000	1,304,000	28 000	596,000
Tungsten carbide powder				
United States	248 000	6,379,000	389 000	10,238,000
United Kingdom	12 000	413,000	33 000	558,000
Other countries	107 000	2,724,,00	90 000	3,683,000
Total	367 000	9,516,000	512 000	14,479,000
	(number)	($)	(number)	($)
Tungsten carbide rotary rock drill bits				
United States	1 638	4,961,000	1 955	7,567,000
Other countries	5 568	56,000	1 259	233,000
Total	7 206	5,017,000	3 214	7,800,000
Tungsten carbide percussion rock drill bits				
Ireland	..	..	98 028	1,921,000
United States	94 673	1,153,000	29 577	1,184,000
Other countries	45 753	748,000	4 362	112,000
Total	140 426	1,901,000	131 967	3,217,000
Tungsten carbide tools for metal work				
United States	..	4,181,000	..	5,327,000
Other countries	..	2,788,000	..	3,912,000
Total	..	6,969,000	..	9,239,000
Consumption (W content)	(kilograms)		(kilograms)	
Tungsten metal and metal powder	242 269	..	193 963	..
Other tungsten products[3]	145 877	..	186 266	..
Total	388 146	..	380 229	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments. [2] Gross weight. [3] Includes tungsten ore, tungsten carbide and tungsten wire.

P Preliminary; .. not available; - nil.

The Central Tasmanian Tungsten Pty. Ltd. is reopening a wolframite mine in Tasmania, Australia. The company is owned equally by Buka Minerals N.L., Triako Mines N.L. and the French government-owned Serem. Production is expected by early 1980 at a monthly rate of 2 200 t of ore.

Thailand tungsten production declined drastically during 1979 as reserves at the Khao Soon mine became depleted. The easily won ore at the mine had allowed a very large production rate which had placed the country among the largest of the world tungsten producers.

Anschutz Mining Corp., (a subsidiary of the Anschutz Corporation) which leases the Chicote Grande wolframite mine in Bolivia, announced plans to triple the production of concentrate to 30 t a month by the end of 1979.

China, a major seller from time to time on the world tungsten market, announced early in 1979 that a new wolframite mine and mill project would be established in southern Kiungsi province. The ore reserves were reported to contain 118 000 t of tungsten. However, production capacity was not announced.

USES

Tungsten materials can be divided into several major classes, depending on uses; these include tungsten carbides; tungsten-bearing steels, superalloys and nonferrous alloys, mill products made essentially from pure metal, and chemicals.

Tungsten carbide (WC) is one of the hardest materials known and is the preferred metalworking material for cutting edges of machine tools that are subject to intense wear and abrasion, and as a metal surface 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 for machining steel, cast iron and nonferrous metals, and for shaping in the woodworking and plastics industries. Cemented tungsten carbide is also 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 cemented tungsten carbides is lowered, thereby, producing grades better suited to the machining of specific products, particularly those of 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. Tungsten-bearing steels are used for the same applications as carbides, especially where lower operating temperatures are encountered, although tungsten is also used in some stainless steels for application in high-temperature environments.

Tungsten is an important constitutent in a wide variety of superalloys and nonferrous alloys. Tungsten-containing superalloys are being used increasingly in high-temperature applications and 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 or "Stellite" superalloys. While only small amounts of tungsten are currently used in the nickel and iron-base superalloys, several companies are developing new superalloys containing larger amounts of tungsten, a factor which could expand the market for tungsten.

Mill products made from pure or substantially pure tungsten metal powder are used in significant quantities by the electric industries. The most important properties of tungsten in its metallic form are its high-melting point, low-vapour pressure, 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.

Discs cut from tungsten rods are used as electrical contacts to improve resistance to heat deformation resulting from sparking and

TABLE 2. CANADA, TUNGSTEN PRODUCTION, TRADE AND CONSUMPTION, 1965, 1970, 1975-79

	Production[1] WO$_3$ content	Imports: Tungsten Ore[2]	Imports: Ferro-tungsten[3]	Consumption W content
	(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	1 000	45 359	451 336
1976	2 168 153	-	77 111	337 345
1977	2 284 409	-	103 000	449 365
1978	2 885 619	1 200	73 000	388 146
1979P	3 275 082	11 000	28 000	380 229

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of scheelite (WO$_3$ content); [2] W content; [3] Gross weight.
P Preliminary; - Nil.

associated high temperatures. Pure tungsten contacts are used principally in ignition circuits of automobiles and aircraft. However, the trend to electronic ignition systems without tungsten contacts has resulted in a decline in its use 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 both fluorescent lamps and vacuum tubes. The overall demand for tungsten wire is increasing in response to the upward trend in the manufacture of lamps and new uses such as de-icing and defogging elements 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.

TABLE 3. WORLD TUNGSTEN PRODUCTION IN ORES AND CONCENTRATES, 1977-79

	1977	1978	1979e
	(tonnes of contained tungsten: W content)		
Austria	390	-	-
Czechoslovakia	80e	80e	80
France	654	608	520
Portugal	997	1 088	1 370
Spain	327	350	320
Sweden	205	580	580
Turkey	6	9	10
U.S.S.R.	8 200e	8 500e	8 500
Total Europe	10 859	11 215	11 380
Canada	1 812	2 288	2 597
Mexico	151	185	190
United States	2 725	3 128	2 994
Total North America	4 688	5 601	5 781
Argentina	55	96	90
Bolivia	2 963	3 170	3 170
Brazil	1 390e	1 300e	1 300
Peru	528	582	640
Total South America	4 936	5 148	5 200
Burundi	2	..	..
Namibia	8	..	..
Southern Rhodesia	25e	25e	30
Rwanda	450e	375e	370
Uganda	110e	110e	110
Zaire	171	200e	200
Total Africa	766	710	710
Burma	446	450e	450
People's Republic of China	9 000e	10 000e	10 000
Hong Kong	5e	5e	10
India	22	21	20
Japan	776	754	760
Democratic People's Republic of Korea	2 150e	2 150e	2 150
Republic of Korea	2 598	2 589	2 590
Malaysia	99	80e	80
Thailand	2 204	3 186	1 828
Total Asia	17 300	19 235	17 888
Australia	2 358	2 680	3 138
World Total	40 907	44 589	44 097

Sources: UNCTAD Tungsten Statistics, April 1980; Energy, Mines and Resources Canada.

e Estimated; .. Not available; - Nil.

MFN Reductions under GATT (effective January 1 of year given)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
37506-1	5.0	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0

UNITED STATES

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
		per cent, unless otherwise specified								
422.40	Tungsten carbide, on tungsten content	21¢/ lb + 12.5%	16¢/ lb + 12.5%	10¢/ lb + 12.5%	5¢/ lb + 12.5%	12.5%	12.0%	11.5%	11.0%	10.5%
422.42	Other tungsten compounds	11.9	11.7	11.4	11.2	11.0	10.7	10.5	10.2	10.0
601.54	Tungsten ore, per pound, tungsten content	25¢	17¢	17¢	17¢	17¢	17¢	17¢	17¢	17¢
606.48	Ferrotungsten and ferro-silicon tungsten, on tungsten content	21¢/ lb + 6%	21¢/ lb + 6%	21¢/ lb + 6%	8.8	8.2	7.5	6.9	6.2	5.6
629.25	Tungsten metal waste and scrap, not over 50% tungsten	7.6	7.3	6.9	6.6	6.3	5.9	5.6	5.2	4.9
629.26	Tungsten metal waste and scrap, over 50% tungsten	10.5	7.5	4.5	4.2	4.2	4.2	4.2	4.2	4.2
629.28	Tungsten metal, unwrought, other than alloys: lumps, grains and powders, on tungsten content	21¢/ lb + 12.5%	21¢/ lb + 12.5%	21¢/ lb + 12.5%	15¢/ lb + 12.5%	9¢/ lb + 12.5%	3¢/ lb + 12.5%	12.1	11.3	10.5
629.29	Tungsten metal, unwrought, other than alloys: ingots and shot	10.5	10.5	10.5	9.8	9.0	8.3	7.5	6.8	6.0
629.30	Other unwrought tungsten metal	12.5	12.5	12.5	11.5	10.5	9.6	8.6	7.6	6.6
629.32	Unwrought tungsten alloys, not over 50% tungsten	7.2	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
629.33	Unwrought tungsten alloys, over 50% tungsten	12.5	12.5	12.5	11.5	10.5	9.6	8.6	7.6	6.6
629.35	Unwrought tungsten metal	12.5	11.8	11.0	10.3	9.5	8.8	8.0	7.3	6.5

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979, Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

Minor amounts of tungsten are used to make chemicals and compounds for non-metallurgical applications. Some of the end-uses include dyes, toners, phosphors, chemical reagents, corrosion inhibitors and catalysts.

PRICE STABILIZATION

During September, 1979 the second meeting of the United Nations Preparatory Working Group on Tungsten (PWG)[1] was held in Geneva. Discussions were hampered by the on-going impasse that has existed in talks between consumer and producer countries for some time. The week-long meeting ended with no real progress and the three major positions unchanged. The three positions are:

- most major producing countries, excluding Canada, are in favour of establishing an International Commodity Agreement (ICA) with binding economic provisions.

- most major consuming countries support the creation of a producer-consumer consultative forum (PCCF).

- France has proposed, as a compromise solution, a formal mechanism that does not initially have the range of economic provisions normally associated with a commodity agreement, but which has provisions for adding economic measures at a later date. This third position received more producer country support than when it was initially proposed at the first preparatory meeting in 1978.

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[1] The Preparatory Working Group was convened within the Committee on Tungsten to further examine and assess proposals for stabilization of the world tungsten market.

PRICES

Tungsten prices continued their decline from the record levels of 1977. During 1979 the average price during the year, as calculated from the **Metal Bulletin** quotation, was \$138.83 per mtu WO_3, down from \$143.79 in 1978.

The International Tungsten Indicator (ITI), which replaced the Tungsten Users Index in July 1978, averaged \$138.96 per mtu during its first full year of use in 1979. The **Metals Week** price index, which reflects transactions in the United States, averaged \$140.61 per mtu in 1979, compared to \$141.39 in 1978.

OUTLOOK

The outlook for 1980 is a slight strengthening in the tungsten market as more tungsten will be required in applications associated with increased exploration for fuels and minerals.

The supply and demand of tungsten are closely balanced for the present, and prices should remain relatively stable. Historically, the price of tungsten has experienced extreme fluctuations during times of market imbalance.

In the longer term, developments now under way could create a situation for market instability. Large new production capacities are coming on stream in both Canada and the United States. At the same time recycling of tungsten scrap is continuing to grow in importance.

On the other hand, increased attention to market conditions by both consumers and producers in recent years has shown that serious supply and demand disequilibrium can be avoided, and it is expected that the tungsten industry will continue in this way to achieve a stable growth rate in the future.

Tungsten prices according to **Metals Week** for December 1978 and 1979

	1978	1979
	($U.S.)	
Tungsten ore, 65% minimum WO_3		
G.S.A. Domestic, duty excluded, per short ton unit of WO_3	effective December 8, 1978 129.610	effective October 26, 1979 127.438
G.S.A. Export, per short ton, unit of WO_3	effective August 1, 1978 117.350	effective October 26, 1979 127.388
L.M.B. ore quoted by London Metal Bulletin, cif Europe, per metric ton unit of WO_3	effective December 21, 1978 134.50-141.00	effective December 20, 1979 128.00-133.00
Ferrotungsten, per pound W, fob shipping point, low-molybdenum	effective December 1, 1978 11.10	effective June 1, 1979 11.55
Tungsten metal, per pound, fob shipping point		
Hydrogen red, depending on Fisher No. range	effective December 1, 1977 13.90-15.50	effective December 1, 1977 13.90-15.50

cif Cost, insurance and freight; fob free on board.

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, 1980)	free	free	25%	free
37506-1	Ferrotungsten	free	5%	5%	free
37520-1	Tungsten oxide in powder, lumps and briquettes, for 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

Uranium

R.M. WILLIAMS

Although worldwide activity in the uranium industry continued at a high level in 1979, prospects for the short-term future dimmed in the face of a growing imbalance between projected uranium requirements and supply capabilities. Implications of this growing imbalance were that development decisions for some of the recent new discoveries might need to be deferred, that there would probably be a continuing decline in prices, at least in real terms, and that there would likely be some loss in the exploration momentum that had built up during the past five years. Notwithstanding the deteriorating short-term outlook, opportunities for the longer term remained promising, with major additions to production capacity expected to be needed, beginning in the 1990s.

In Canada, exploration and development activity remained high, particularly in Saskatchewan, where another potentially important new discovery was announced, one new production facility was under construction and two additional projects were in the planning stage. Important expansion programs continued in Ontario's Elliot Lake area and new production projects were being considered in British Columbia and Newfoundland. Canada's first "ore-shipping" production operation since the 1950s started early in the year in northern Saskatchewan and a second was being contemplated in the Bancroft area of Ontario. On a less positive note, the unique surface and underground heap-leaching operation at Agnew Lake, Ontario began phasing out, largely due to technical difficulties.

The implications of expanding uranium exploration and development activity in Canada continued to be the subject of public inquiry. Individual projects faced the public hearing process in Saskatchewan, Ontario and Newfoundland. Of particular importance was a commission of inquiry established by the Government of British Columbia, the outcome of which would have a considerable bearing on the future of the industry in that province. On a national scale, the new Progressive Conservative government indicated that it intended to establish a parliamentary inquiry on nuclear energy, the scope of which would cover all aspects of the uranium and nuclear industry in Canada.

Thus, while the industry was expanding in 1979 to meet current domestic and export commitments, and although its potential for still further expansion had increased, the rate and extent of the expansion that could be expected, at least in the short-term, remained uncertain.

PRODUCTION AND DEVELOPMENT

Production of uranium in Canada in 1979 amounted to 6 817 tonnes (t) of uranium (U)[1], compared to 6 803 t U in 1978. Ore production came from the operations of seven

[1] One metric ton of elemental uranium (tonne U) is equivalent to 1.2999 short tons of uranium oxide (U_3O_8).

companies, of which all but one had ore processing plants. Shipments from these plants totalled some 6 530 t U, valued at $616 million; final shipments for 1978 were reported at 8 211 t U, valued at $617,527,537 (Table 1).

Some 61 per cent of Canada's total uranium shipments in 1979 was attributable to four operations in Ontario, the two largest being in the Elliot Lake area. Denison Mines Limited continued with its major Elliot Lake expansion program which will more than double the capacity of its 6 440 tonnes per day (tpd) mill to 13 610 tpd, with completion expected in 1980. During 1979 some 2 213 531 t of ore, with an average grade of 0.861 kg U per t, were milled to produce 1 729 t U. An average of 6 473 t of ore was processed daily, with recovery averaging 93.16 per cent. Underground development work at the Denison mine, which will supply some 80 per cent of the feed to the expanded mill, was expected to be completed in 1982. The remainder of the mill feed will come from the company's adjoining Stanrock/Canmet operation, where rehabilitation work should be completed in 1985.

Rio Algom Limited completed the second phase of its Elliot Lake expansion program, the rehabilitation of its Panel mine and mill, in September 1979; the 2 990 tpd mill was operating at capacity by year-end. Together with the Quirke mill, which operated at full capacity during the year, the company had a total ore processing capacity of 9 340 tpd in the Elliot Lake area. The Quirke mill processed some 2 224 400 t of ore, which included 94 350 t of Panel preproduction ore, at an average rate of 6 354 tpd. Average recovery was 0.975 kg U per t or 93.8 per cent; total output from the Quirke mill was 2 036 t U. The Panel mill, which started commercial operation in November, processed some 129 725 t of ore at an average rate of 2 195 tpd. Average recovery was 0.509 kg U per t or 65.9 per cent; total output from the Panel mill was 152 t U, which included 90 t U from preproduction ore. Some 1 823 t U from both the Quirke and Panel operations were delivered to domestic and export customers. Markets permitting, the company's Milliken, Lacnor and Nordic properties located on the south limb of the Quirke Lake syncline will be rehabilitated at a later date, probably as a single operation.

Also in the Elliot Lake area, Preston Mines Limited, an affiliate of Rio Algom, proceeded with the rehabilitation if its

TABLE 1. URANIUM OUTPUT[1] IN CANADA BY PROVINCE, 1978 AND 1979

	1978		1979	
	(t)	($000)	(t)	($000)
Ontario	4 455	363,845	4 005	375,793
Saskatchewan	3 756	253,683	2 525	240,375
Total	8 211	617,528	6 530	616,168

Source: 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).

Stanleigh mine and mill. The bulk of the 1979 effort was associated with the design of surface facilities, including the tailings area, site work and the construction of housing units. Dewatering of the mine commenced in October and completion of the 4 540 tpd project was scheduled for 1983. Significantly, late in the year the boards of directors of Rio Algom and Preston agreed to the terms of an amalgamation of the two companies which took effect early in 1980, following the approval of shareholders and regulatory authorities.

In the Bancroft area of Ontario output from Madawaska Mines Limited's 1 360 tpd mill improved steadily during 1979. A total of 354 135 t of ore was milled at an average mill-head grade of 0.695 kg U per t to produce 233 t U; overall recovery was about 95 per cent. Ore reserves were well- maintained and prospects for proving up additional reserves improved. Rare Earth Resources Limited and Esso Minerals Canada hoped to exploit three deposits in the Bancroft area beginning as early as 1980. Negotiations were under way at year-end with Madawaska Mines which it was felt could lead to a custom-milling contract for the processing of up to 2 720 t of ore a week.

In Ontario's Agnew Lake area the rate of extraction of uranium from Agnew Lake Mines Limited's underground and surface heap-leaching operation continued to be substantially below design expectations. Despite efforts to resolve the recovery problem, production during the year increased only marginally to 172 t U; the surface leach pile provided approximately 43 per cent of the uranium going into solution, with the balance

TABLE 2. URANIUM PRODUCTION IN CANADA, BY COMPANY, 1978 AND 1979

Company	Location	Production tonnes U 1978	1979
Agnew Lake Mines Limited	Agnew Lake, Ont.	154	172
Cenex Limited	Uranium City, Sask.	-	43
Denison Mines Limited	Elliot Lake, Ont.	1 880	1 729
Eldorado Nuclear Limited	Eldorado, Sask.	494	387
Gulf Minerals Canada Limited[1]	Rabbit Lake, Sask.	2 115	2 065
Madawaska Mines Limited	Bancroft, Ont.	210	233
Rio Algom Limited - Quirke	Elliot Lake, Ont.	1 950[2]	2 036[3]
- Panel		-	152[4]
Total Canada		6 803	6 817

Source: Company annual reports.

[1] Joint operation with Uranerz Canada Limited. [2] Includes some 45 t U from Panel preproduction ore. [3] Includes uranium from some 94 350 t of Panel ore processed during the preproduction period. [4] Includes 90 t U from preproduction ore.
- Nil.

coming from the underground stopes. Consequently, in September the company announced that it would phase out its operation over a six-month period. Thereafter, the operation would be placed on a salvage-leach basis for a period that could last about two years.

In Saskatchewan, which accounted for some 39 per cent of Canada's total 1979 uranium shipments, Eldorado Nuclear Limited continued to experience production difficulties at its Beaverlodge operation near Uranium City, largely due to shortages of skilled underground workers. In addition, plans to bring into production certain satellite orebodies were delayed in the regulatory process. In an effort to cope with production problems the company was increasing the mechanization of certain sections of its mining operation, although it was expected to take some time to realize the full benefits. During 1979, 283 075 t of ore from the Beaverlodge operation, with an average grade of 1.567 kg U per t, were milled to produce 387 t U; average recovery declined to 86.9 per cent from 92 per cent in 1978.

Also in the Uranium City area, Cenex Limited commenced ore production from its small underground operation in January, despite a fire during the month which destroyed the powerhouse; shipments were destined for the Eldorado mill to be processed on a toll basis. Although deliveries began in February at a rate of about 1 800 t per week, shipments lagged behind schedule, resulting in a shortfall of working capital. At year-end, total production had amounted to some 43 t U, the company was in receivership and prospects for future operations were uncertain.

At Rabbit Lake the joint operation of Gulf Minerals Canada Limited and Uranerz Canada Limited continued to produce in excess of its designed capacity. During 1979, 649 944 t of ore, with an average grade of 3.333 kg U per t, were milled to produce 2 065 t U, of which Gulf's share was about 1 053 t U. Annual throughput was increased by 13.4 per cent and recovery improved from 93.01 per cent in 1978 to 94.38 per cent in 1979. The Rabbit Lake open pit was approaching 90 metres in depth by year-end and was expected to reach its ultimate depth of some 140 m by 1985. Thereafter, it was expected that Gulf would utilize the capacity of the 1 500 tpd mill to process ore from its other deposits in the area, commencing with ore from those at Collins Bay, about 11 km north of Rabbit Lake.

Construction of Amok Ltd.'s mill at Cluff Lake, Saskatchewan was well under way at year-end. Completion of Phase 1 of the Cluff Lake project was scheduled for late 1980, when production from the very high-grade "D" orebody would commence at the rate of about 1 500 t U a year. Phase 2 will follow after regulatory approval and involve the exploitation of the lower-grade Claude and "N" deposits. The capital cost of each phase was reported at $80 and $85 million, respectively. In July 1979 it was announced that Amok had agreed in principle to sell a 20 per cent interest in the Cluff Lake project to the Saskatchewan Mining Development Corporation (SMDC).

Early in 1979 a new company, Key Lake Mining Corporation, was formed to develop Saskatchewan's Key Lake deposits, jointly owned by SMDC (one-half), Uranerz Exploration and Mining Limited (one-third), and Eldor Resources Limited (one-sixth), a wholly-owned subsidiary of Eldorado Nuclear Limited. In October 1979 Key Lake released its environmental impact statement for public review. Total reserves in the Gaertner and Deilmann deposits were revised upward by the company to more than 57 700 t U. The joint venture planned to exploit the Gaertner deposit first, and it was hoped that mill construction could begin in 1981, with first production in 1983. It would be an open-pit operation and the mill would process about 456 tpd to produce 3 080 to 4 600 t U a year. The capital cost of the project was reported to be $300 million.

Progress was made during 1979 by Esso Minerals Canada in further evaluation of its Midwest Lake deposit some 24 km west of Rabbit Lake. In August it was announced that, based on the results of 279 drill holes, the deposit contained 2.0 million t of ore assaying 1.06 per cent U, for a total of 21 540 t U. Earlier it had been reported that the deposit contained as much as 37 300 t U. Various environmental baseline studies and the necessary environmental and socio-economic impact statements were in progress at year-end. It was envisaged that open-pit methods would be used to mine the high-grade portions of the deposit and that a mill with a capacity of about 770 tpd would be constructed, which would produce some 1 700 t U a year. Contingent on early regulatory approval and the availability of markets, construction could be under way by mid-1981. Late in the year, Canada Wide Mines Ltd., controlled by Esso Resources Canada Limited, took over management of the project, the total capital cost of which was estimated at $300 million.

In mid-1979 Brinex Limited exercised an option on the 40 per cent interest held in its eastern Labrador (Newfoundland) Kitts/Michelin project by Urangesellschaft Canada Limited. The 40 per cent interest was to be transferred to Edison Development Canada Inc., a wholly-owned subsidiary of Commonwealth Edison Company of Chicago. An agreement in principle was reached whereby Edison Development would arrange financing of the $160 million project and purchase up to a reported 6 920 t U. Both the Kitts and Michelin deposits would initially be mined by open-pit methods, supplying ore to a 1 360 tpd mill with a planned output of about 500 t U a year, beginning in late 1982. The project, which would be serviced by a 135 km

TABLE 3. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1970 AND 1975-79

	United States	Canada	South Africa	Namibia	France	Niger	Gabon	Australia	Other[1]	Total[2]
					(tonnes U)					
1970	9 900	3 520	3 170	-	1 250	-	400	255	110	18 605
1975	8 900	3 560	2 490	-	1 730	1 310	800	-	330	19 120
1976	9 800	4 850	2 760	650	1 870	1 460	..	360	340	22 090
1977	11 500	5 790	3 360	2 340	2 100	1 610	1 410	355	390	28 855
1978	14 200	6 800	3 960	2 700	2 180	2 060	1 020	515	460	33 895
1979	14 400	6 820	4 700	3 830	2 350	3 620	1 100	705	710	38 235

Sources: Data derived principally from "Uranium: Resources, Production and Demand", a biennial report jointly produced by the Nuclear Energy Agency of the Organization for Economic Co-operation and Development, and the International Atomic Energy Agency; also U.S. Department of Energy, Statistical Data of the Uranium Industry; Energy, Mines and Resources Canada; South African Chamber of Mines, Analysis of Working Results; and the 1979 annual reports of Commissariat a l'Energie Atomique and Rio Tinto Zinc Corporation Limited.

[1] Includes Argentina, Brazil (1979), Federal Republic of Germany (from 1975 - not available in 1979), Japan (from 1975 - not available in 1979), Portugal (from 1975), Spain (from 1970), and Sweden (1975). [2] Totals are of listed figures only.
- Nil; .. Not available.

all-weather road from Goose Bay, was expected to have a life of 15 years. At year-end Brinco Limited's plans were being reviewed by a provincial board of inquiry.

In British Columbia, development of the Blizzard project was in abeyance pending the outcome of a provincial government inquiry into uranium exploration and production activity which was established early in the year. The project, 80 km southeast of Kelowna, was operated and managed by Norcen Energy Resources Limited, as part of a joint venture including E & B Explorations Ltd., Campbell Chibougamau Mines Ltd. and Ontario Hydro. The joint venture had a 70 per cent interest in the property which was optioned from Lacana Mining Corporation. It was envisaged that the deposit would be worked by open-pit methods, and that a 600 tpd mill would produce some 385 t U a year over an 11-year period. Contingent on early regulatory approval, the $50 million project could be in production as early as 1983.

Also in British Columbia, Consolidated Rexspar Minerals & Chemicals Limited was awaiting the outcome of the provincial inquiry before proceeding with efforts to develop its Birch Island project 130 km north of Kamloops.

ESI Resources Limited, a wholly-owned subsidiary of Earth Sciences Incorporated of Golden, Colorado, received approval to construct a uranium extraction facility near Calgary, Alberta. Uranium will be recovered as a byproduct from phosphoric acid produced at the adjacent plant of Western Co-operative Fertilizers Limited. The extraction plant, the first such operation in Canada, was nearing completion at year-end, with initial production expected in 1980.

EXPLORATION

Uranium exploration activity remained high in Canada during 1979, particularly in Saskatchewan. It was expected that uranium exploration expenditures would surpass the $90 million level that had been reported for 1978 by Energy, Mines and Resources Canada (EMR) on the basis of its annual uranium exploration survey (Figure 1)[1]. Of the $90 million total reported for 1978 almost 50 per cent was spent in Saskatchewan. The EMR survey, results of which were released in June 1979, also reported that 333 900 m of uranium exploration and surface development drilling was carried out in Canada during 1978, more than 60 per cent of which took place in Saskatchewan.

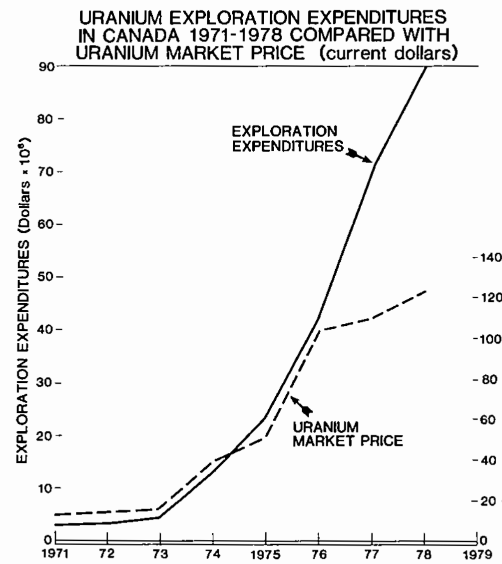


Figure 1

Of 116 companies or joint ventures that responded to the EMR survey, including virtually all the major companies known to be active, 77 incurred uranium exploration expenditures in 1978. Of these, 24 had annual uranium exploration budgets over $1 million. The 10 most active companies, accounting for about 60 per cent of the $90 million total, were: Saskatchewan Mining Development Corporation, Uranerz Exploration and Mining Limited, Gulf Minerals Canada Limited, E & B Explorations Ltd., Esso Minerals Canada, Urangesellschaft Canada Limited, Norcen Energy Resources Limited, Denison Mines Limited, Asamera Oil Corporation Ltd. and BP Minerals Limited.

In May 1979 Canadian Occidental Petroleum Ltd. announced the discovery of the McClean Lake deposit about 11 km northwest of Rabbit Lake, Saskatchewan.

[1] **1978 Assessment of Canada's Uranium Supply and Demand,** Report EP 79-3, Energy, Mines and Resources Canada, June 1979.

The deposit was evaluated jointly by Canadian Occidental and Inco Metals Company, which can earn a 50 per cent interest by bearing stipulated percentages of the expenditures over a 10-year period dating from 1977. By late 1979 results of 92 drill holes had indicated that the deposit was 670 m long with widths of up to 60 m. There were possibilities of greater widths, as well as some discontinuities within this length. Mineralization occurred at depths from 150 to 175 m and grades ranged from 0.21 to 23.6 per cent U over intercepts of 3 to 19 m. It was expected that more than 100 additional drill holes would be required to completely evaluate the deposit.

In the Keefe Lake-Henday Lake area just east of Midwest Lake, Saskatchewan, Asamera Oil Corporation Ltd. continued evaluating two prospects, known as the Dawn Lake and the Hole No. 11 areas, jointly with SMDC, Canadian Kelvin Resources Ltd. and several other private interests (Asamera and SMDC hold 25 and 50 per cent interests, respectively). By year- end, drilling on the Dawn Lake prospect had extended the zone of anomalous radioactivity to approximately 3 km in length. Within this trend was the original mineralized zone of 700 m and, potentially, a second mineralized zone 900 m long, the latter based on the results of only 10 holes. Grades in the original Dawn Lake zone ranged up to 4.3 per cent U and the mineralization varied up to 70 m wide and 22 m thick. Drilling in the Hole No. 11 area also resulted in a second mineralized zone 700 m south of the original Hole No. 11 discovery; the latter covered a strike length of 450 m, with mineralized widths up to 60 m, and grades as high as 14.5 per cent U.

While the focus of activity was clearly in Saskatchewan, programs were also under way in a number of other provinces and in the territories. Little activity was recorded in British Columbia, however, in view of the provincial inquiry that began there early in the year (see Government Affairs). Although exploration in the general Baker Lake area of the Northwest Territories was curtailed by a temporary court injunction restricting activity in certain specified areas, Urangesellschaft continued to evaluate its Lone Gull deposits in the nearby Schultz Lake area. Also of interest was an announcement late in 1979 that the James Bay Development Corporation (JBDC) had discovered a potentially important uranium occurrence at Lake Gayot, north of LaGrande River in the James Bay area of northwestern Quebec, on property owned in equal shares by JBDC and Uranerz Exploration and Mining Limited. Although mineralization grading from 0.09 to 0.38 per cent U was indicated in 60 of 90 holes drilled on the prospect, it was believed that at least another season would be required to confirm the potential.

TABLE 4. 1978 ESTIMATES OF CANADA'S MINEABLE URANIUM RESOURCES

Resource Category	Mineable at prices up to $125/kg U[1]	$175/kg U[2]
	(tonnes U contained in mineable ore)[3]	
(1) Measured	76 000	80 000
(2) Indicated	139 000	155 000
(1) + (2) = Reasonably Assured[4]	215 000	235 000
(3) Inferred	223 000	302 000
(4) Prognosticated	147 000	426 000
(3) + (4) = Estimated Additional[4]	370 000	728 000

Source: **1978 Assessment of Canada's Uranium Supply and Demand;** Report EP79-3, Energy, Mines and Resources Canada, June 1979.

[1] $125/kg U (Canadian dollars) was the estimated uranium market price in September 1978 at the beginning of the assessment. [2] Includes resources mineable at up to $125/kg U. [3] 1 tonne (metric ton) U is equivalent to 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's low and high "price" categories may be considered equivalent to the NEA/IAEA's low and high "cost" categories, respectively.

On March 31, 1979, funding for the Uranium Reconnaissance Program was terminated as part of federal government economy measures. All outstanding data were publicly released by September 30, although the Geological Survey of Canada continued to acquire a limited amount of airborne gamma-ray spectrometric data in support of geological mapping.

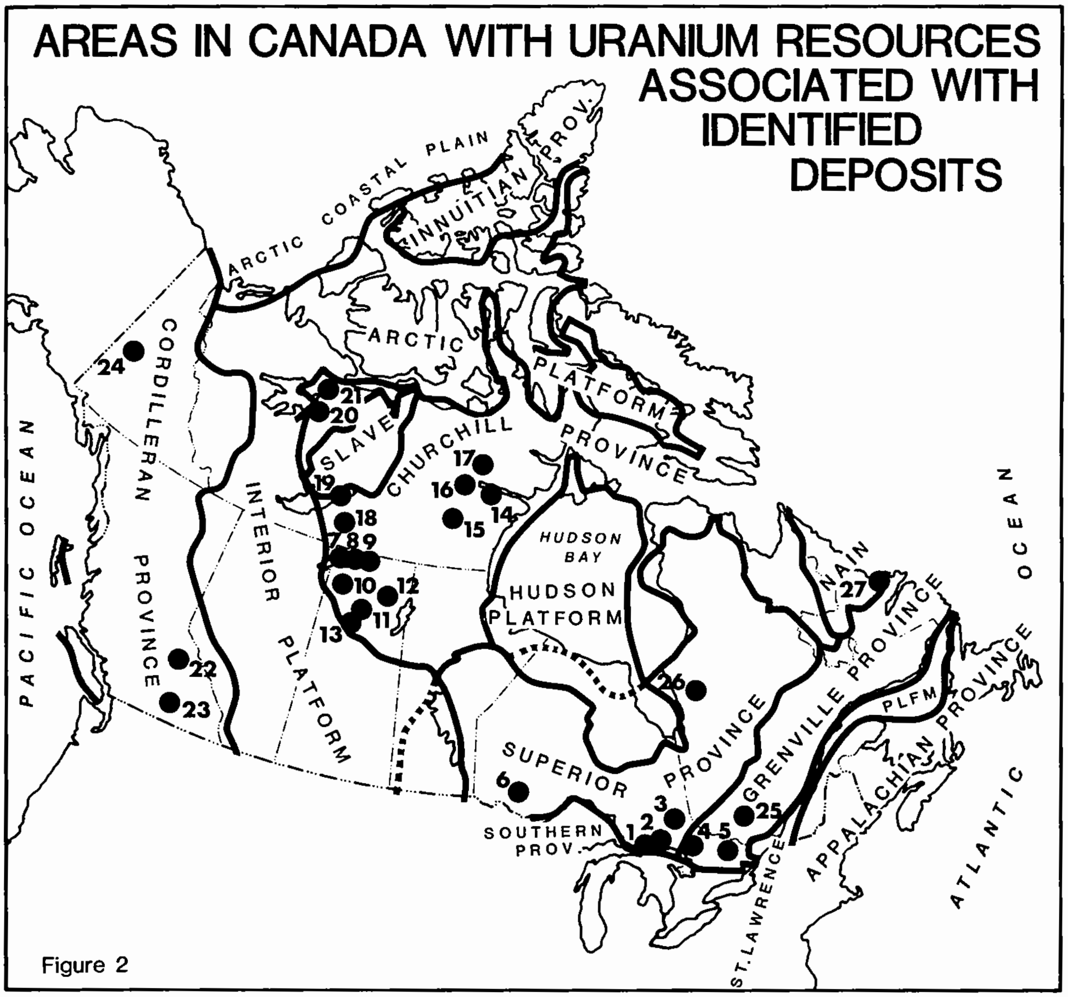


Figure 2

(numbers refer to locations on map above)

1. Elliot Lake
2. Agnew Lake
3. Cobalt Embayment
4. Lake Nipissing
5. Bancroft - Sharbot Lake
6. Kenora
7. Region NW of Lake Athabasca
8. Region of N of Lake Athabasca
9. Region NE of Lake Athabasca
10. Carswell Structure
11. Key Lake area
12. Rabbit Lake area
13. Wollaston Lake Belt
14. Baker Lake
15. Yathkyed - Dubawnt Lake
16. Schultz Lake
17. Amer Lake
18. Nonacho Lake
19. East Arm of Great Slave Lake
20. Western part of Bear Province
21. Dismal Lakes
22. Birch Island
23. Kelowna - Beaverdell
24. Tombstone Mountain
25. Mont Laurier
26. Sakami Lake
27. Makkovik - Seal Lake

URANIUM RESOURCES

The Uranium Resource Appraisal Group (URAG) of EMR completed its fifth annual (1978) assessment in early 1979. 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 1978 assessment the lower price category was bounded by the uranium market price estimated at $125/kg U in September 1978 and the higher price category spanned the $125-$175/kg U range. The results of URAG's 1978 uranium resource assessment were published in June 1979 and are summarized in Table 4. Areas in Canada in which these resources occur are illustrated in Figure 2.

Comparison of the 1978 estimates with those published a year earlier, indicated only a slight decrease in the measured category, despite production of 6 803 t U, a 44.9 per cent increase in the indicated category; and a 5.0 per cent decrease in the inferred category. Overall, allowing for 1978 production and taking into account processing recoveries (93.2 per cent for existing conventional deposits), resources in these three categories combined[1] increased by some 7.4 per cent over those quantities reported in 1978. While the increase in the indicated category was largely a result of continued evaluation of Saskatchewan's Key Lake and Collins Bay "A" deposits, the major contributors to the overall increase in the three resource categories were discoveries in the Rabbit Lake area (Midwest Lake and Collins Bay "B" deposits) of northern Saskatchewan and in the Schulz Lake area, west-northwest of Baker Lake, Northwest Territories.

URAG also reported an increase of 10 per cent in the prognosticated category, reflecting increased potential for additional discoveries in areas with known deposits. Resources in the speculative category (i.e., resources that are thought to exist in virgin uranium areas or in areas where only uranium occurrences are known) were judged to range between 1 and 1.2 million t U. The areas designated by URAG that are favourable for such uranium mineralization are shown in Figure 3.

In order to provide a more meaningful illustration of uranium availability, URAG also prepares a projection of uranium production capability to 1990 based on "known resources" (i.e., Reasonably Assured plus Estimated Additional Resources). Assuming adequate availability of manpower, equipment, capital financing and the existence of base load contracts, it was estimated that the resources summarized in Table 4 could support production levels increasing from 6 900 t U in 1979 to 14 400 and 15 500 t U in 1985 and 1990, respectively. Projected domestic requirements were expected to grow from 980 t U in 1979 to 1 620 and 2 350 t U a year in 1985 and 1990, respectively (Figure 4).

GOVERNMENT AFFAIRS

In October 1978 the Government of British Columbia indicated that a provincial inquiry would be held to recommend standards for uranium mining, following which new guidelines would be established for the approval of uranium development projects. On January 14, 1979 the Lieutenant-Governor of British Columbia appointed Dr. David Bates as chairman of a commission of inquiry which would have a mandate "to examine the adequacy of existing federal and provincial requirements for the protection of the health and safety of workers associated with exploration, mining and milling of uranium in British Columbia, and for the protection of the environment and of the public; to receive public input on these matters; and to make recommendations for setting and maintaining standards for worker and public safety and for the protection of the environment as a result of the exploration for and the mining and milling of uranium ores".

Activities of the three-member "Bates" Commission began in February and public hearings commenced in June. The commission's first interim report, which was released in August 1979, indicated its view "that the present methods of control of exploration for uranium within the Province are not adequate for the proper protection of the public and the environment". The commission recommended that the Province of

[1] Only resources in the measured, indicated and inferred categories are considered for domestic allocation purposes.

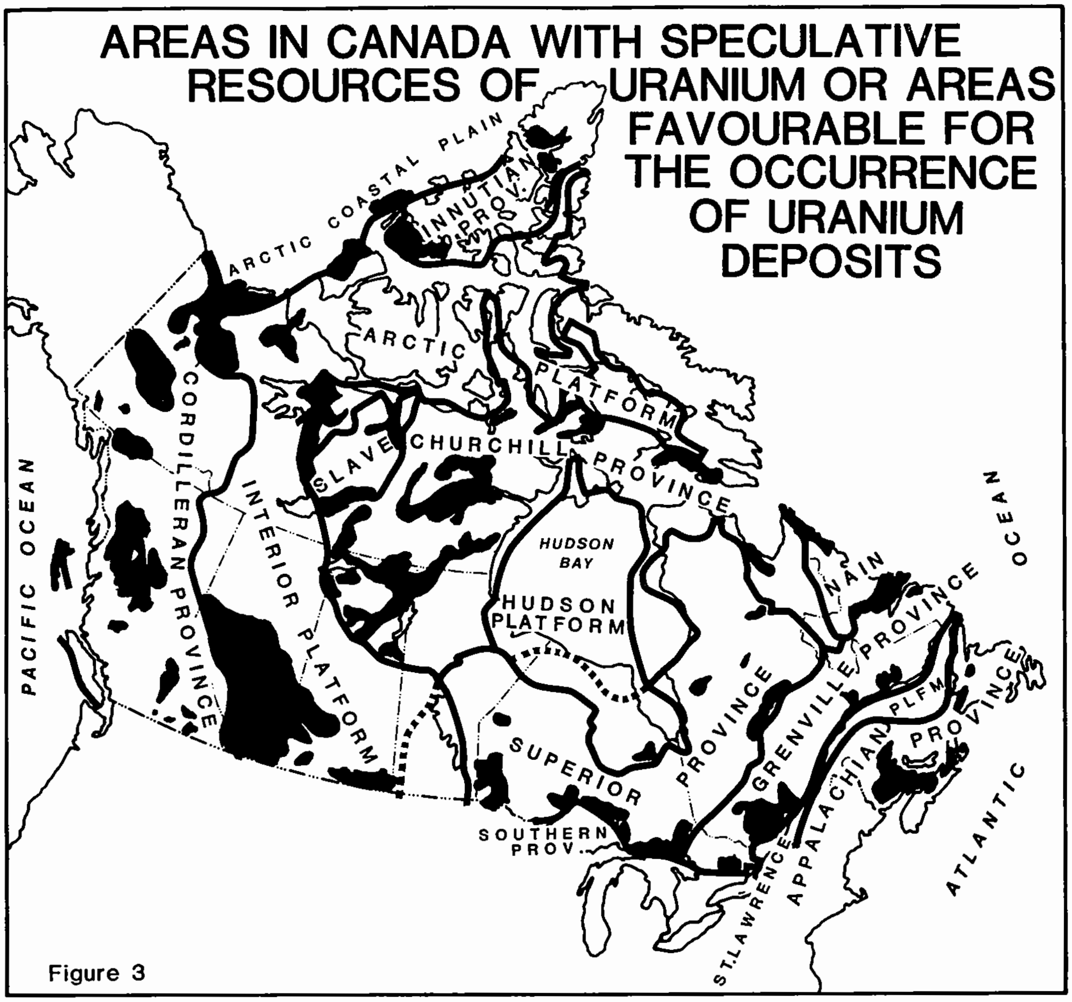


Figure 3

British Columbia should initiate a licensing procedure for uranium exploration, and that strict guidelines and regulations for the control of uranium exploration be introduced as part of the licensing process. On the basis of its deliberations to year-end, the commission did not recommend a moratorium on uranium exploration.

In May 1979 the Ontario Environmental Assessment Board released the report of its review of plans for the expansion of uranium mining activities in the Elliot Lake area. The report concluded that "the technology exists to carry out the expansion in an environmentally acceptable manner in the short term. This applies to all areas including mining, milling, waste management, air and water environments and radioactivity emissions". With respect to the long-term effects of the expansion, however, the board expressed concern because "present-day knowledge is, to a large extent, limited". It was evident, according to the board, "that considerable effort and time is required before solutions to the long-term aspects of waste management can be found".

PROJECTED CANADIAN PRODUCTION CAPABILITY COMPARED WITH ESTIMATED ANNUAL URANIUM REQUIREMENTS

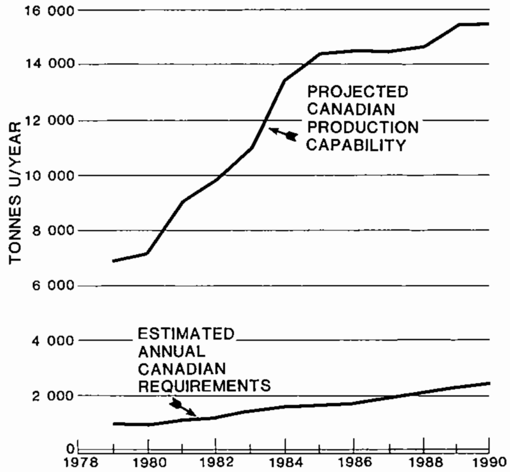


Figure 4

In August 1979 the Atomic Energy Control Board (AECB) discontinued the licensing of surface uranium exploration activities, thereby strictly limiting the application of its exploration permit system to the bounds of the Atomic Energy Control Regulations as revised in 1974. Companies engaged in uranium exploration activity were no longer obliged to obtain an exploration permit from the AECB unless they intended to remove more than 10 kg of uranium from a deposit in one calendar year.

In September 1979 the federal government announced that Eldorado Nuclear Limited was one of several Crown companies that it wished to return to the private sector. An advisory group was set up to make recommendations to the government as to the desirability of making these companies private and the methods for doing so.

On October 22, 1979 a notice of motion was placed before the House of Commons outlining the terms of reference for an intended parliamentary inquiry on nuclear energy. It was to be moved "that a special joint committee of the Senate and the House of Commons be appointed to inquire into the economic, social, environmental, health and international considerations bearing on the role of the Government of Canada in the development, use, regulation and export of nuclear energy". The terms of reference were to be very broad and were not to be limited to those outlined in the intended motion. The motion had not been tabled in the House of Commons before Parliament was dissolved in December.

In November 1979 the Federal Court of Canada ruled that the Inuit have aboriginal title to some 130 000 km^2 in the Baker Lake area of the Northwest Territories which permits them to hunt and fish. However, the court ruled that the Inuit do not possess the surface rights to the land, and consequently, the temporary injunction against exploration in the area was lifted on December 17, 1979.

Internationally, Canada's Denison Mines Limited was one of 14 organizations to submit proposals to the Government of Australia late in the year, to acquire the government's interest in the Ranger uranium project in Australia's Northern Territory. The government's objective was to divest its entire 50 per cent interest to a single assignee, provided that the level of foreign ownership in the total project did not exceed 25 per cent.

The International Nuclear Fuel Cycle Evaluation (INFCE), a major international exercise in which more than 60 countries participated to examine the future role of nuclear power, was completed late in the year. The results of the eight established working groups were expected to be released early in 1980.

MARKETS AND PRICES

The uranium marketplace was somewhat more active during 1979 than in 1978 although few new sales were reported by Canadian producers. Export contracts totalling some 3 600 t U were reviewed in 1979 by the federal government and found to be consistent with Canadian uranium export policy. These contracts, representing additional sales, primarily to Japan but also to Belgium, South Korea, Sweden and the United States, brought the total amount of uranium under export contracts that had been reviewed by the federal government since September 5, 1974 to some 65 000 t U (Table 5). As of December 1979, forward export commitments under contracts that had been reviewed and found to be consistent with Canadian export policy were estimated at some 52 400 t U, while forward domestic commitments were in excess of 80 000 t U, over periods to 1993 and 2020, respectively.

TABLE 5. URANIUM UNDER EXPORT CONTRACTS REVIEWED[1] SINCE SEPTEMBER 5, 1974 (as of December 1979)

Country	short tons[2] U_3O_8	tonnes U
Belgium	1,220	939
Finland	2,300	1 769
France	2,000	1 539
Italy	1,800	1 385
Japan	25,358	19 508
South Korea	400	308
Spain	6,250	4 808
Sweden	1,025	788
Switzerland	1,050	808
United Kingdom	10,000	7 693
United States	24,850	19 117
West Germany	8,260	6 354
Total	84,513	65 016

[1] Reviewed and found to be consistent with Canadian uranium export policy. [2] Most Canadian uranium export contracts are written in terms of Imperial units.

Two potential sales agreements of particular interest were announced in late-1979 calling for the delivery of a reported 2 390 t U from the Blizzard deposit of Norcen et al to the Korea Electric Company (KECO) over an 11-year period, perhaps beginning in 1983. The first agreement was with Norcen and Lacana Mining (1 540 t U), while the second was with E & B Explorations. These agreements had not been reviewed by the federal government at year-end.

The Elliot Lake operations of Rio Algom were potentially affected by efforts of the Tennessee Valley Authority (TVA) in 1979 to cancel its contract with Rio Algom for the purchase of 6 540 t U over the period 1979 to 1990. TVA's actions were part of a continuing and complex legal battle related to the abrogation by Westinghouse Electric Corporation in 1975 of contracts for the supply of uranium to its U.S. and non-U.S. customers, and to subsequent civil anti-trust actions launched in United States courts by Westinghouse and TVA against a number of non-U.S. uranium producers. It was expected that a resolution to these court actions and, more importantly, to the related extraterritorial legal issues, would take some time. In the meantime Rio Algom began sales efforts to replace the TVA contract, which represented a major portion of the capacity of its newly rehabilitated Panel operation.

Early in 1979 Uranium Canada, Limited announced that it had entered into a loan agreement with Ontario Hydro whereby Hydro could borrow up to 800 t U from the federal government's 5 565 t U stockpile during the year. The uranium was to be repaid in kind; up to 300 t U by December 31, 1983 and up to 500 t U by December 31, 1984. Two earlier agreements had also been negotiated, the first with Eldor Resources Limited for 770 t U and the second with Eldorado Nuclear Limited for 115 t U. The latter loan to Eldorado had been repaid by the end of 1979, while the Eldor loan was outstanding. Only 300 t U were actually borrowed by Ontario Hydro under its agreement during 1979, so that the uncommitted portion of the general stockpile stood at 4 495 t U at year-end.

Uranium prices had been relatively unchanged for more than three years, having stabilized about $US 104/kg U ($US 40/lb U_3O_8) in mid-1976. By the end of 1978 market prices had gradually increased to a level of between $US 112 and $US 114/kg U ($US 43 and $US 44/lb U_3O_8) for immediate delivery. Deliveries under older contracts, which did not have provisions for price renegotiation, tended to be priced at lower levels. Illustrative of 1979 price levels was a U.S. Department of Energy (USDOE) survey which reported that the average floor prices of market-price contracts for 1980 deliveries in the U.S. was $US 114.92/kg U ($US 44.20/lb U_3O_8). By year-end, however, there were indications of price softening, as illustrated, for example, by a decline of over $US 5.20/kg U ($US 2.00/lb U_3O_8) in the Nuclear Exchange Corporation's exchange value during the last half of 1979. Indeed, in view of continued increases in costs, prices had declined in real terms since 1976.

REFINING

Output of uranium hexafluoride (UF_6)[1] and uranium dioxide (UO_2) reached record levels

[1] Uranium hexafluoride is the required feed material for the uranium enrichment process.

TABLE 6A. EXPORTS[1] OF RADIOACTIVE ORES AND CONCENTRATES[2] FROM CANADA, 1970, 1975-79

	United States[3]	United Kingdom	Japan	Italy	Total
		($000)			
1970	17,032	8,990	-	-	26,021
1975	28,129	21,987	986	-	51,101
1976	46,850	20,541	-	-	67,392
1977	72,848	2,590	-	-	75,438
1978	163,911	39,106	791	3,348	207,156
1979	347,388	18,851	9	12,613	378,862

[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium in concentrates. [3] For years 1970 to 1976, uranium almost entirely destined for transshipment, primarily to western Europe and Japan, following enrichment; for years 1977 to 1979, figures represent a mixture of sales to U.S. and others, primarily in western Europe and Japan.
- Nil.

TABLE 6B. EXPORTS[1] OF RADIOACTIVE ELEMENTS[2] AND ISOTOPES FROM CANADA, 1970, 1975-79

	U.S.[3]	U.S.S.R.[4]	U.K.	West Germany	Japan	Argentina	France	Pakistan	Other	Total
					($000)					
1970	3,116	-	492	103	266	82	395	2,544	961	7,959
1975	69,596	6,295	1,109	304	787	119	227	1,737	2,200	82,374
1976	151,427	24,471	3,786	288	1,068	84	375	2,571	1,627	185,697
1977	151,869	6,133	356	384	288	287	685	-	1,163	161,165
1978	269,903	101,619	38,602	6,918	1,017	12,177	19,046	-	1,701	450,983
1979	293,577	170,500	5,147	26,159	1,101	94,038	1,762	-	9,793	602,077

[1] Material that cleared Canadian customs with destination as indicated. [2]Includes UF_6 and radioisotopes for medical and industrial purposes. [3] For years 1970 to 1976, UF_6 exports destined for transshipment, primarily to western Europe and Japan, following enrichment; for years 1977 to 1979, UF_6 component of these figures represent a mixture of sales to U.S. and others, primarily in western Europe and Japan. [4] Primarily UF_6, all destined for transshipment to western Europe following enrichment.
- Nil.

at Eldorado Nuclear Limited's Port Hope, Ontario, refinery during 1979. Some 4 486 t U as UF_6 were produced, exceeding the previous record set in 1977 by 16 per cent. However, output remained below projected levels as technical problems associated with the introduction of new equipment and processes persisted. As one of five commercial uranium refiners in the world, Eldorado converts uranium concentrates to natural UF_6 for a variety of customers in Europe, Japan and the United States. Production of natural ceramic-grade uranium dioxide, used for CANDU-type reactors, reached 1 324 t U as UO_2, representing a 37 per cent increase over the 1978 level. The installation of a new UO_2 circuit was completed in December and commissioning was expected in January 1980.

In February, the Minister of the Environment approved Eldorado's proposal for the construction of a new refining facility, to be built near Port Hope, Sudbury or Blind River, Ontario. The approval followed the receipt of recommendations from a federal environmental assessment panel that all three locations would be acceptable provided certain safety conditions were met. In July Eldorado received federal approval to build its new $130 million complex in Hope Township, west of Port Hope. The facility, which would be capable of producing some 9 000 t U as UF_6 yearly, was expected to be in operation in mid-1982 with a workforce of 200. At that time Eldorado would be operating between 20 and 25 per cent of the UF_6 conversion capacity of the western world. By year-end the access road construction and site preparation were completed and plant construction was scheduled to begin in early 1980.

In Saskatchewan, the company submitted an Environmental Impact Statement concerning the social and environmental effects of its proposed UF_6 conversion plant to be built at Warman, some 25 km northwest of Saskatoon. Output from this second conversion facility would also be about 9 000 t U, as UF_6, per year. Environment Canada announced that public hearings would be conducted in the region beginning in January 1980.

NUCLEAR POWER DEVELOPMENTS

At the end of 1979 it was estimated that 238 nuclear reactors were operable throughout the world, with a combined generating capacity of some 123 000 electrical megawatts (MWe). Within Canada, 10 CANDU reactors with an aggregate capacity of 5 270 MWe were operating at year-end and a further 14 reactors with an aggregate capacity of some 9 807 MWe were either under construction or committed (see Table 7).

Ontario Hydro's Pickering "A" Generating Station achieved a net capacity factor[1] of 84.4 per cent in 1979; the four reactors ranked 2nd, 5th, 7th and 12th in the world-wide-reported capacity factors for 104 nuclear units over 500 MWe.

[1] The amount of electricity produced as a percentage of the theoretical maximum.

TABLE 7. NUCLEAR POWER PLANTS IN CANADA, DECEMBER 1979

Reactors	Owner	Net Output (MWe)	In-Service Dates
Operating			
Nuclear Power Demonstration	Atomic Energy of Canada Limited	22	1962
Douglas Point	Atomic Energy of Canada Limited	208	1968
Pickering 1 to 4	Ontario Hydro	2 056	1971-73
Bruce 1 to 4	Ontario Hydro	2 984	1977-79
Sub-total		5 270	
Under Construction or Committed			
Pickering 5 to 8	Ontario Hydro	2 064	1982-84
Gentilly 2	Hydro-Québec	637	1982[1]
Point Lepreau	New Brunswick Electric Power Commission	630	1981[1]
Bruce 5 to 8	Ontario Hydro	3 076+	1983-87
Darlington 1 to 4	Ontario Hydro	3 400+	1987-90
Sub-total		9 807	
Grand Total		15 077	

Source: **1978 Assessment of Canada's Uranium Supply and Demand;** Report EP 79-3, Energy, Mines and Resources Canada, June 1979.

[1] Projected in-service dates were revised again in 1980, to 1983 for Gentilly 2 and 1982 for Point Lepreau. + Net output figures were revised in early-1980 to 3 024 for Bruce B, and 3 524 for Darlington.

Note: AECL's Gentilly 1 reactor of 250 MWe output excluded because owner has allowed operating licence to lapse.

On January 18, 1979, Unit 4 of Ontario Hydro's Bruce "A" Generating Station was declared in-service. All units operated at maximum rated capacity until September, at which time pressure restrictions were effected, resulting in minor electrical output cutbacks. The station nonetheless achieved a net capacity factor of 75 per cent for the year.

During 1979, hydro-electric sources supplied about 38 per cent of Ontario Hydro's electricity, nuclear-electric generators supplied some 32 per cent and oil or coal-fired units 30 per cent.

The in-service dates of the four Pickering "B" units were set back, as shown in Table 7, because of the need to rebuild the steam generators to correct a manufacturing fault. However, the construction program proceeded, with the first of the high-voltage power lines to the station placed into service in March and the last reactor vessel for Unit 8, delivered to the site in June. A number of systems were turned over to the operating staff for commissioning.

Construction work proceeded on schedule at the Bruce "B" Station; the powerhouse was completed and installation of the turbine generator was expected to begin in October 1980. However, to bring capacity into phase with projected electricity demand, Ontario Hydro deferred the in-service dates of Bruce "B" Units 7 and 8 by one year and the in-service dates of Darlington "A" Station by two years.

The Douglas Point CANDU prototype had a record 152 days of continuous operation in 1979 and its 92.2 per cent availability-for-service factor was an all-time high. In addition to generating electricity, the unit continued to supply steam to the Bruce heavy water plant and, like the NPD generating station at Rolphton, Ontario continued to be used for staff training and for the development of new work techniques, equipment and fuel elements.

In Quebec, Atomic Energy of Canada Limited's (AECL) Gentilly 1 Station (a CANDU-Boiling Light Water prototype) remained inoperative throughout 1979, and the owner allowed the operating licence to lapse. At Gentilly 2[1], damage was discovered in the tubes of the steam generators early in the year. It was decided to replace all the tubing and to repair the steam generators on-site. Although by year-end some 96 per cent of the engineering work had been completed and 95 per cent of the permanent equipment had been delivered, commercial operation was not expected until 1982.

[1] A conventional CANDU-Pressurized Heavy Water Reactor.

At the Point Lepreau Nuclear Generating Station in New Brunswick, construction was 80 per cent complete by year-end; each of the station's systems is being precommissioned upon completion. Although faulty tubing was discovered in the steam generators, necessitating the same repairs as for Gentilly 2, it was expected that electrical generation would begin in 1981.

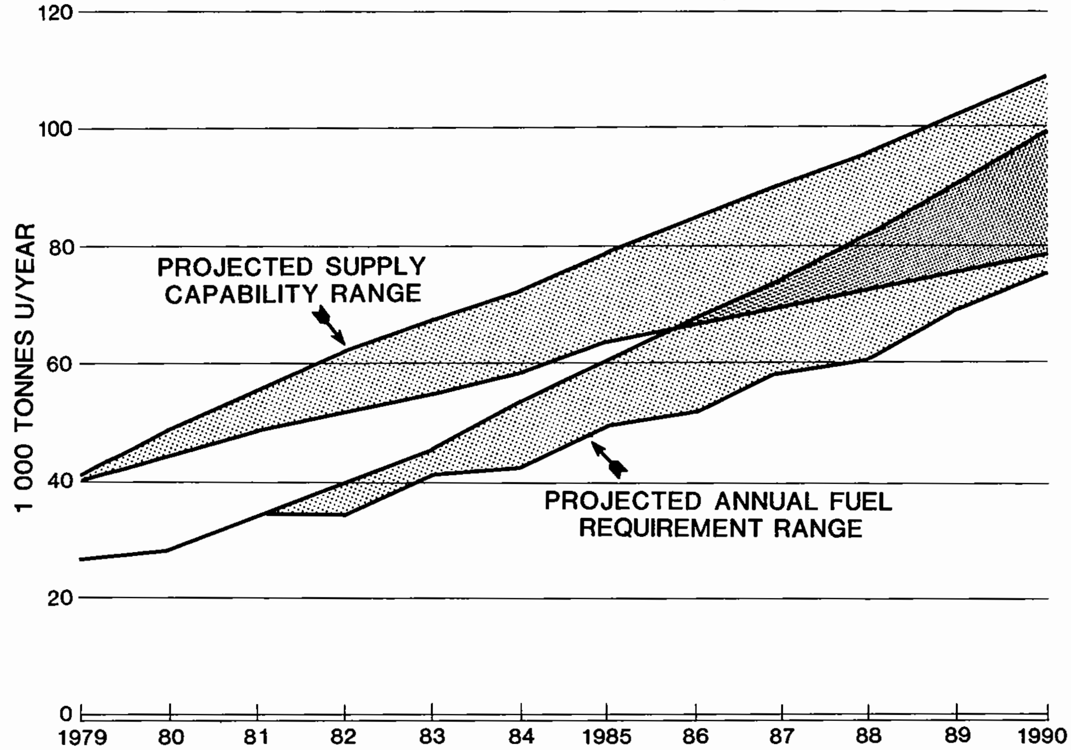
During 1979 the Ontario Legislature's Select Committee on Hydro Affairs conducted an extensive examination into the safety of the CANDU system. After many weeks of testimony and deliberation it concluded that Ontario Hydro's nuclear reactors were "acceptably safe". The investigation was sparked by the Three Mile Island incident in the United States where a serious accident resulted in the contamination and subsequent closure of a nuclear generating facility.

OUTLOOK

In February 1979 the Uranium Institute released a study which examined in some detail the outlook for the uranium industry to 1990[1]. Projections of supply, based on then-current knowledge of uranium resources, were presented as a range; the upper limit representing an estimate of maximum production capability and the lower limit representing a more realistic level of achievable production in view of various constraints on the industry. Projections of annual fuel requirements were also presented as a range, the upper-bound reflecting the Institute's consensus of the build-up of nuclear capacity and the lower-bound being characterized as a more realistic expectation in light of the likely impact on utilities' plans of the various constraints on nuclear development. Comparison of these projections of supply and requirements (Figure 5), showed an apparent surplus of uranium supply capability, particularly until the mid-1980s.

[1] **The Balance of Supply and Demand, 1978 to 1990;** Uranium Institute, London, February 1979.

SHORT TERM OUTLOOK
WORLD URANIUM SUPPLY AND REQUIREMENTS



Source: URANIUM INSTITUTE

Figure 5

By year-end 1979, indications were that the Uranium Institute's view of the short term was optimistic, and that there had been a growing imbalance between projections of supply capability and nuclear fuel requirements since the completion of the Institute's study. Notwithstanding certain possibilities for moderating the imbalance, it was expected that opportunities for expanding uranium markets during the 1980s would be limited. The implications were that some new uranium supply development plans would need to be deferred, that there might be a loss in exploration momentum, and that uranium prices could not be expected to increase markedly. Indeed, it was expected that prices would likely continue to decline in real terms.[1]

Opportunities in the longer term, however, were considerably brighter. It was still expected that nuclear power would contribute a growing fraction of the world's future energy supply, and that requirements

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[1] R.M. Williams, **Market Opportunities for Canadian Uranium,** paper presented to Seminar on Markets for Canadian Uranium, the Canadian Energy Research Institute, Calgary, October 25, 1979.

TABLE 1. CANADA, ZINC PRODUCTION, TRADE AND CONSUMPTION, 1978 AND 1979

	1978		1979p	
	(tonnes)	($)	(tonnes)	($)
Production				
All forms[1]				
Ontario	275 907	211,416,273	276 166	266,289,000
New Brunswick	204 226	156,490,413	264 580	255,117,000
Northwest Territories	187 810	143,911,352	214 667	206,985,000
Yukon	96 673	74,076,827	118 843	114,593,000
British Columbia	96 045	73,595,668	90 990	87,736,000
Quebec	95 517	73,190,838	82 470	79,521,000
Newfoundland	47 715	36,561,788	50 895	49,075,000
Manitoba	57 071	43,731,337	46 258	44,604,000
Saskatchewan	5 938	4,550,386	3 629	3,499,000
Total	1 066 902	817,524,882	1 148 498	1,107,419,000
Mine output[2]	1 245 248		1 204 401	
Refined[3]	495 243		580 449	
Exports				
Zinc blocks, pigs and slabs				
United States	259 396	190,485,000	262 007	220,271,000
United Kingdom	52 955	36,524,000	46 989	38,411,000
Brazil	11 380	8,544,000	20 373	16,660,000
Venezuela	6 617	4,176,000	10 492	8,645,000
Philippines	10 794	7,693,000	10 037	7,916,000
Italy	5 711	4,174,000	7 735	6,250,000
Singapore	6 666	4,151,000	6 956	5,604,000
Belgium and Luxembourg	3 341	2,532,000	7 029	5,493,000
West Germany	5 771	3,701,000	5 624	4,449,000
Thailand	5 253	3,286,000	4 826	3,806,000
Israel	4 289	3,232,000	4 665	3,703,000
Other countries	67 088	42,948,000	42 627	34,313,000
Total	439 261	311,446,000	429 360	355,521,000
Zinc contained in ores and concentrates				
Belgium and Luxembourg	194 636	57,208,000	169 584	76,679,000
Japan	149 423	31,427,000	175 919	64,027,000
United States	133 845	42,831,000	116 339	42,877,000
West Germany	78 426	17,783,000	61 394	20,426,000
Italy	15 645	5,548,000	21 927	9,380,000
United Kingdom	24 388	5,341,000	13 854	5,710,000
U.S.S.R.	10 113	2,411,000	13 061	4,437,000
France	23 842	6,104,000	11 600	3,846,000
Netherlands	29 290	11,984,000	4 124	1,975,000
Algeria	-	-	3 577	1,678,000
Other countries	29 728	3,804,000	7 152	2,758,000
Total	689 336	184,441,000	598 531	233,793,000
Zinc alloy scrap, dross and ash[4]				
United States	13 507	3,698,000	10 296	3,457,000
United Kingdom	2 764	891,000	2 941	989,000
West Germany	564	107,000	1 008	241,000
Spain	295	122,000	125	72,000
Belgium and Luxembourg	801	75,000	321	66,000
Taiwan	304	105,000	111	64,000
Other countries	939	180,000	641	137,000
Total	19 174	5,178,000	15 443	5,026,000

TABLE 1. (cont'd.)

	1978		1979P	
	(tonnes)	($)	(tonnes)	($)
Zinc dust and granules				
United States	3 980	3,843,000	3 478	3,608,000
Venezuela	187	219,000	125	150,000
United Kingdom	35	9,000	34	11,000
Trinidad and Tobago	-	-	3	5,000
Other countries	5	5,000	1	1,000
Total	4 207	4,076,000	3 641	3,775,000
Zinc fabricated material, nes				
United States	1 189	1,778,000	1 474	2,316,000
Singapore	-	-	151	116,000
New Zealand	-	-	124	107,000
United Kingdom	44	44,000	44	88,000
Greece	-	-	49	43,000
Other countries	74	67,000	93	110,000
Total	1 307	1,889,000	1 935	2,780,000
Imports				
In ores, concentrates and scrap	6 145	2,038,000	9 868	5,646,000
Dust and granules	272	327,000	304	401,000
Slabs, blocks, pigs and anodes	2 405	1,840,000	2 572	2,501,000
Bars, rods, plates, strip and sheet	385	567,000	468	843,000
Zinc oxide	2 067	1,647,000	1 751	1,727,000
Zinc sulphate	1 950	755,000	1 934	826,000
Zinc fabricated materials, nes	918	2,145,000	877	2,253,000
Total	14 142	9,319,000	17 774	14,197,000

	1977r			1978r		
	Primary	Secondary	Total	Primary	Secondary	Total
			(tonnes)			
Consumption[5]						
Zinc used for, or in the manufacture of:						
Copper alloys (brass, bronze, etc.)	11 410			13 477		
Galvanizing: electro	1 174	520	74 851	1 295	519	83 884
hot dip	61 747			68 592		
Zinc die-cast alloy	11 686	-	11 686	12 081	x	x
Other products (including rolled and ribbon zinc, zinc oxide)	16 902	1 973	18 875	21 924	x	x
Total	102 919	2 493	105 412	117 369	4 005	121 374
Consumer stocks on hand at end of year	8 512	846	9 358	12 237	1 004	13 241

Sources: Energy, Mines and Resources Canada; 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; r Revised; - Nil; nes Not elsewhere specified; x Confidential.

TABLE 2. CANADA, MINE OUTPUT, ZINC, 1978 AND 1979

	1978	1979
	(tonnes)	
Newfoundland	63 620	54 155
Nova Scotia	-	1 274
New Brunswick	246 764	251 676
Quebec	113 040	93 034
Ontario	276 436	300 631
Manitoba-Saskatchewan	82 500	65 080
British Columbia	93 449	91 261
Yukon Territory	134 038	119 936
Northwest Territories	235 401	227 354
Total	1 245 248	1 204 401

Source: Energy, Mines and Resources Canada.

- Nil.

Hudson Bay's 3 450 tpd Stall Lake mill started up in June at a cost of $33 million and is expected to process 900 000 t of ore annually to produce 145 000 t of zinc and copper concentrates. The new mill will provide substantial transportation cost savings on Snow Lake area ores and backfill tonnages which previously had been shipped to and from the company's mill at Flin Flon. The increased mill capacity will also permit higher mining rates and encourage the development of other deposits in the area.

Zinc-gold-silver mining operations at the Louvem Mining Company Inc.'s Louvicourt and Manitou Divisions ceased in 1978; however, the Louvicourt Division was scheduled to reopen at year-end 1979. At the Manitou Division ore has been exhausted. The company's Val d'Or mill was able to process broken ore until mid-year at which time it undertook temporary custom milling for a neighbouring gold producer.

This temporary loss in production was the only closure in Canada during 1979. ASARCO Incorporated's Buchans mine had been scheduled to close in March 1979 but was granted a reprieve due to increased prices for lead and zinc. This mine may be able to continue operations at reduced rates to year-end 1980.

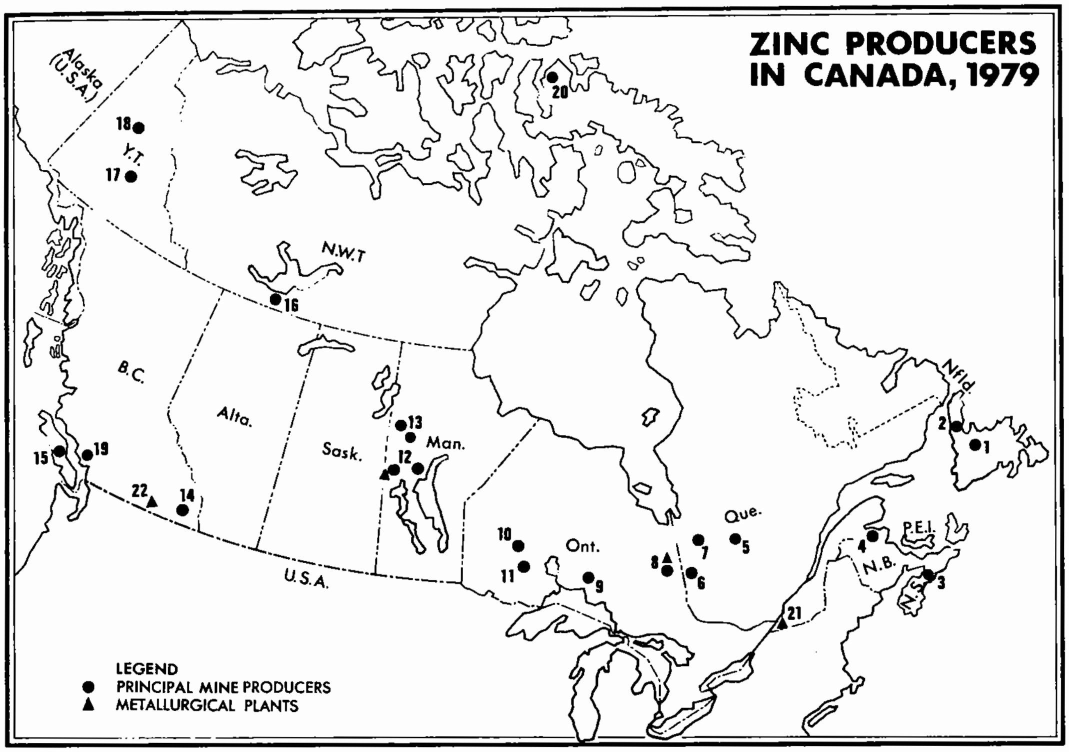
A number of other zinc mine projects continued with their development during the year. The $53 million expansion program at the No. 12 zinc-lead mine of Brunswick Mining and Smelting Corporation Limited in New Brunswick is expected to be completed in late 1980. Ore reserves at the nearby No. 6 mine are limited and should be exhausted in 1981. The expansion will increase Brunswick's capacity to produce zinc- and lead-in-concentrates by 40 000 t and 9 000 t respectively. In Ontario, Mattagami Lake Mines Limited resumed development of its two zinc-lead-copper mines in the Sturgeon Lake area. The Lyon Lake mine is scheduled to startup in 1980, producing 28 000 t of zinc-in-concentrate

TABLE 3. CANADA, ZINC PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975-79

	Production		Exports			Producers'
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Domestic Shipments
			(tonnes)			
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	952 562	149 214
1976	982 057	472 316	653 737^r	352 072^r	1 005 809^r	133 561
1977	1 070 515	494 938^r	598 452^r	295 358	893 810^r	130 641
1978	1 066 902	495 243	689 336	439 261	1 128 597	144 740
1979P	1 148 498	580 449	598 531	429 360	1 027 891	153 744

Source: Energy, Mines and Resources Canada; 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. Esso Resources Canada Limited
   (Gays River)
4. Brunswick Mining and Smelting
   Corporation Limited
   Heath Steele Mines Limited
5. Lemoine Mines Limited
6. Falconbridge Copper Limited,
   Lake Dufault Division
   Louvem Mining Company Inc.
7. Mattagami Lake Mines Limited
   Noranda Mines Limited, (Orchan Mine)
8. Texasgulf Canada Ltd.
9. Noranda Mines Limited (Geco Division)
10. Selco Mining Corporation Limited
11. Mattabi Mines Limited
    Falconbridge Copper Limited
    (Sturgeon Lake Joint Venture)
12. Hudson Bay Mining and Smelting Co.,
    Limited (Chisel Lake, Osborne Lake,
    Stall Lake, Ghost Lake, Anderson
    Lake, Westarm, Flin Flon, White Lake,
    Centennial)
13. Sherritt Gordon Mines Limited
    (Fox Lake mine and Ruttan mine)
14. Cominco Ltd. (Sullivan mine)
    Teck Corporation (Beaverdell mine)
    Silvana Mines Inc. (Silmonac mine)
15. Western Mines Limited
16. Pine Point Mines Limited
17. Cyprus Anvil Mining Corporation
18. United Keno Hill Mines Limited
19. Northair Mines Ltd.
20. Nanisivik Mines Ltd.

Metallurgical Plants

8. Texasgulf Canada Ltd., Hoyle
12. Hudson Bay Mining and Smelting Co.,
    Limited, Flin Flon
21. Canadian Electrolytic Zinc Limited,
    Valleyfield
22. Cominco Ltd., Trail

TABLE 4. PRINCIPAL ZINC MINES IN CANADA, 1979 AND (1978)

Company and Location	Daily Mill Capacity (tonnes ore)	Zinc (%)	Lead (%)	Copper (%)	Silver (grams/tonne)	Ore Produced (tonnes)	Zinc Concentrates Produced (tonnes)	Zinc Concentrates Zinc Grade (%)	Zinc Content of all Concentrates (tonnes)	Destination of Zinc Concentrate
Newfoundland										
ASARCO Incorporated	1 100	11.64	6.51	1.04	109.7	113 398	18 527	56.40	12 413	6
Buchans	(1 100)	(10.78)	(6.07)	(1.04)	(104.9)	(183 251)	(27 663)	(56.23)	(18 452)	(6,11)
Newfoundland Zinc Mines	1 500	8.56	-	-	-	523 598	71 519	61.38	43 898	3,6,12
Limited,	(1 500)	(9.10)	(-)	(-)	(-)	(516 946)	(74 395)	(62.30)	(46 348)	(3,6)
Daniel's Harbour										
Nova Scotia										
Canada Wide Mines Ltd.	1 350	4.50	-	-	-	45 359	3 016	62.00	1 877	-
Gays River	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
New Brunswick										
Brunswick Mining and Smelting Corporation Limited	9 050	8.93	3.61	0.31	95.0	2 971 516	418 968	49.43	222 588	3,7,8,9, 11,12
Bathurst	(9 050)	(8.88)	(3.56)	(0.29)	(93.9)	(3 058 300)	(410 361)	(53.37)	(227 964)	(3,6,7,9, 10,11,12)
Heath Steele Mines Limited	3 200	4.55	1.53	0.91	55.2	1 172 737	84 508	48.72	43 925	6,8,9,12
Newcastle	(3 200)	(4.43)	(1.53)	(1.03)	(77.5)	(1 137 767)	(76 144)	(47.77)	(38 676)	(6,8,9,12)
Quebec										
Falconbridge Copper Limited	1 400	4.90	-	3.60	48.7	419 827	31 822	52.18	19 151	3
Lake Dufault Division	(1 400)	(3.85)	(-)	(3.36)	(43.5)	(372 722)	(22 208)	(51.97)	(13 456)	(3,6,8)
Noranda										
Lemoine Mines Limited	300	11.61	-	5.07	92.9	108 267	18 723	52.30	11 477	12
Lemoine Mine	(300)	(11.18)	(-)	(4.97)	(94.6)	(105 611)	(17 498)	(53.41)	(10 855)	(12)
Chibougamau										
Louvem Mining Company Inc.	900	4.51	0.55	0.04	137.8	72 261	4 793	56.70	2 906	6
Val d'Or	(900)	(5.33)	(0.29)	(0.15)	(87.8)	(248 073)	(20 811)	(55.14)	(11 901)	(2,6)
Mattagami Lake Mines Limited	3 500	5.37	-	0.73	26.9	1 329 428	123 228	52.04	65 128	3,6
Matagami	(3 500)	(7.56)	(-)	(0.52)	(32.6)	(878 484)	(116 102)	(53.03)	(62 175)	(3,6)

TABLE 4. (cont'd.)

Company and Location	Daily Mill Capacity (tonnes ore)	Zinc (%)	Lead (%)	Copper (%)	Silver (grams/ tonne)	Ore Produced (tonnes)	Zinc Concentrates Produced (tonnes)	Zinc Concentrates Zinc Grade (%)	Zinc Content of all Concentrates (tonnes)	Destination of Zinc Concentrate
Ontario										
Falconbridge Copper Limited	1 100	8.70	1.23	2.17	169.7	373 953	43 677	53.12	26 650	3,6
Sturgeon Lake Joint Venture	(1 100)	(9.14)	(1.17)	(2.73)	(171.8)	(370 087)	(54 800)	(53.00)	(32 220)	(3,6)
Sturgeon Lake										
Mattabi Mines Limited	2 700	6.91	0.77	0.55	97.7	945 015	108 617	52.89	59 511	1,2,3,12
Sturgeon Lake	(2 700)	(6.49)	(0.67)	(0.83)	(93.3)	(871 675)	(91 713)	(54.57)	(51 880)	(3,12)
Noranda Mines Limited	4 550	3.24	0.11	1.82	59.0	1 475 841	75 042	50.13	44 023	3
Geco Division	(4 550)	(2.19)	(0.12)	(1.54)	(38.7)	(1 572 458)	(50 565)	(50.78)	(30 802)	(3)
Manitouwadge										
Selco Mining Corporation	450	10.75	-	1.44	63.8	132 923	23 332	52.97	12 595	6
Limited,	(450)	(12.20)	(-)	(1.43)	(75.8)	(121 635)	(24 807)	(53.05)	(13 354)	(6)
South Bay Division										
Uchi Lake										
Texasgulf Canada Ltd.,	9 050	5.47	0.15	1.95	76.0	3 680 858	310 326	53.42	178 515	5,6
Kidd Creek	(9 050)	(6.12)	(0.22)	(1.62)	(78.9)	(3 002 148)	(313 348)	(50.69)	(169 955)	(5,6,12)
Manitoba and Saskatchewan										
Hudson Bay Mining and										
Smelting Co., Limited,										
Flin Flon	7 250	2.73	0.17	2.00	19.0	1 253 875	42 432	48.41	26 394	2
	(7 250)	(3.16)	(0.13)	(2.26)	(20.6)	(1 679 001)	(72 899)	(49.80)	(42 684)	(2)
Stall Lake	3 400	3.55	0.14	2.87	12.3	446 947	20 724	51.91	11 356	2
	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Sherritt Gordon Mines Limited,	2 700	1.82	-	1.19	4.7	772 500	20 583	50.90	12 066	2
Fox mine	(2 700)	(1.73)	(-)	(1.24)	(4.8)	(874 935)	(22 368)	(51.12)	(13 291)	(2)
Lynn Lake										
Ruttan mine	9 050	1.17	-	1.39	5.6	2 094 159	32 905	51.44	18 661	2,6
Ruttan Lake	(9 050)	(1.53)	(-)	(1.15)	(5.7)	(2 307 069)	(53 810)	(51.63)	(29 792)	(2,6)
British Columbia										
Cominco Ltd.	9 050	3.73	5.33	-	63.8	2 047 726	129 443	49.37	70 794	1
Sullivan mine	(9 050)	(3.31)	(4.64)	(-)	(62.1)	(2 107 876)	(119 163)	(49.52)	(64 228)	(1)
Kimberley										

TABLE 4. (cont'd.)

Company and Location	Daily Mill Capacity (tonnes ore)	Zinc (%)	Lead (%)	Copper (%)	Silver (grams/ tonne)	Ore Produced (tonnes)	Zinc Concentrates Produced (tonnes)	Zinc Concentrates Zinc Grade (%)	Zinc Content of all Concentrates (tonnes)	Destination of Zinc Concentrate
British Columbia (continued)										
Silvana Mines Inc., Silmonac mine Sandon	100 (100)	4.51 (4.34)	4.89 (5.81)	- (-)	478.6 (508.8)	19 625 (15 966)	1 323 (970)	(51.05 (51.23)	810 (634)	6 (6)
Northair Mines Ltd., Brandywine area	250 (250)	1.50 (1.96)	0.91 (1.30)	0.50 (0.20)	26.3 (70.6)	91 587 (93 397)	1 643 (2 161)	51.34 (45.96)	1 124 (1 613)	1 (1)
Teck Corporation Beaverdell mine Beaverdell	100 (100)	0.63 (0.60)	0.28 (0.35)	- (-)	320.2 (323.7)	33 662 (35 280)	343 (403)	29.40 (26.10)	133 (148)	1 (1)
Western Mines Limited, Lynx and Myra Falls	900 (900)	8.45 (8.24)	1.37 (1.33)	1.32 (1.25)	131.3 (139.9)	266 877 (269 035)	35 834 (35 581)	51.96 (51.47)	20 975 (20 667)	6,12 (1,12)
Yukon Territory										
Cyprus Anvil Mining Corporation Faro	9 050 (9 050)	5.28 (5.14)	3.26 (3.17)	- (0.20)	25.0 (19.9)	2 823 031 (3 280 660)	250 701 (246 376)	47.85 (50.41)	126 901 (143 940)	7,8,12 (6,7,8)
United Keno Hill Mines Limited Elsa	450 (450)	- (0.79)	3.00 (5.50)	- (-)	818.4 (1 224.7)	112 783 (81 721)	- (30)	- (38.32)	- (487)	- (12)
Northwest Territories										
Pine Point Mines Limited Pine Point	10 000 (10 000)	5.48 (5.91)	1.91 (2.62)	- (-)	- (-)	2 985 536 (2 985 072)	261 161 (273 705)	57.25 (58.52)	151 029 (161 948)	1,2,6,8,12 (1,2,7,8, 12)
Nanisivik Mines Ltd. Baffin Island	2 200 (2 200)	12.92 (13.24)	1.39 (1.44)	- (-)	66.2 (61.7)	615 459 (574 314)	133 353 (128 472)	57.22 (56.82)	76 498 (73 192)	6,8,9 (8,12)

Sources: Company reports in response to survey by Energy, Mines and Resources Canada.
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.

and 1 000 t of lead-in-concentrate a year. The F Zone mine is expected to startup in 1981, producing 12 000 t of zinc-in-concentrate and 1 000 t of lead-in-concentrate a year. The ore from both mines will be processed by Mattabi Mines Limited as replacement tonnages to offset its declining reserves.

In 1979 the Foreign Investment Review Agency (FIRA) approved the November 1978 purchase by Cyprus Anvil Mining Corporation of the Grum, Swim Lake and Vangorda properties in the Yukon Territory from Kerr Addison Mines Limited and Canadian Natural Resources Limited at a cost of $20.8 million. About $0.9 million was further expended to buy out the minority Vangorda shareholders. Cyprus plans to use the acquired reserves to blend with Faro ore and extend the Faro mine's operating life. The prior owners had considered constructing a separate mine-mill complex to process these ores but decided the cost of a mill would make the project uneconomic.

Also in 1979 Noranda Mines Limited merged with Mattagami Lake Mines Limited and acquired the mining properties of Orchan Mines Limited. Apart from the merged mining interests, Noranda now also directly controls 90.2 per cent of Canadian Electrolytic Zinc Limited, the other owner being an associate company, Kerr Addison Mines Limited. Subsequently, Noranda also acquired AMAX Inc.'s 75 per cent interest in Heath Steele Mines Limited, which operates a zinc-lead-copper mine in New Brunswick.

Three mines that had been under consideration for several years received favourable decisions and were committed to proceed with construction during 1979. Cominco Ltd., the operator for Arvik Mines Ltd., decided to proceed with development of the Polaris zinc-lead deposit on Little Cornwallis Island in the Canadian high Arctic. The mine is expected to cost about $150 million and its 2 000 tpd mill is expected to produce 100 000 t of zinc-in-concentrate and 30 000 t of lead-in-concentrate annually, when the operation starts up in 1982. To date, ore reserves are estimated at 23 million t, grading 14.1 per cent zinc and 4.3 per cent lead. Another major project decision was the $80 million Detour copper-zinc deposit in northwestern Quebec, which is owned by Selco Mining Corporation Limited and Hudson's Bay Oil and Gas Company Limited (HBDG). Initially in 1981, the 750 tpd mill will process only copper ore from the B Zone; however, should the partners decide to supplement this ore with zinc-copper ore from the A2 Zone an estimated 6 000 t of zinc-in-concentrate a year would become available towards the mid-1980s.

On a smaller scale, Noranda Mines Limited and MacDonald Mines, Ltd. announced their joint venture company, Les Mines Gallen Limitée, would spend $5.5 million to reopen the former West MacDonald mine in mid-1981. The open-pit zinc mine will produce 1 000 to 1 500 tpd of ore for treatment at Noranda's Horne Division concentrator. Zinc output is expected to be about 19 000 tpy and ore reserves are estimated to be 1.6 million t, grading 5.4 per cent zinc. A low grade, copper-precious metals concentrate will also be produced.

Other serious zinc projects that are still under active consideration are:

- the Howard's Pass zinc-lead deposit in the Yukon Territory, held by Placer Development Limited and United States Steel Corporation, with potential output of 200 000 tpy zinc in the mid-to-late 1980s.
- the Great Slave Reef zinc-lead deposit near Pine Point in the Northwest Territories, held by Western Mines Limited, Philipp Brothers (Canada) Ltd. and Du Pont Canada Inc. with potential output of 45 000 tpy zinc in 1983-86.
- the Kutcho Creek copper-zinc deposit near Dease Lake, British Columbia, held by Esso Minerals Canada and Sumac Mines Ltd., with potential output of 40 000 tpy zinc in the mid-1980s.
- the Vendome zinc deposit in Quebec, held by Noranda Mines Limited, with potential output of 22 000 tpy zinc in the mid-1980s.
- the Trout Lake copper-zinc deposit near Flin Flon in Manitoba, held by Gränges Exploration AB and Manitoba Mineral Resources Ltd., with potential output of 15 000 tpy zinc.
- the P.D. copper-zinc deposit in Quebec, held by Noranda Mines Limited, with potential output of 11 000 tpy zinc in the early 1980s.

TABLE 5. CANADA'S PRODUCERS' ZINC ORE RESERVES AT JANUARY 1, 1979

Company and Province	Zinc-Bearing Ore Reserves (000 tonnes)	Per Cent Zinc (%)	Zinc in Ore (000 tonnes)
Newfoundland			
ASARCO Incorporated (Buchans)	279.4	11.25	31.4
Newfoundland Zinc Mines Limited	2 215.9	10.07	223.1
	2 495.3	10.20	254.5
Nova Scotia			
Esso Minerals Canada (Gays River)[1]	10 886.3	4.50	489.9
New Brunswick			
Brunswick Mining and Smelting Corporation Limited	111 817.1	8.28	9 257.4
Heath Steele Mines Limited	21 150.3	4.87	1 029.2
	132 967.4	7.74	10 286.6
Quebec			
Falconbridge Copper Limited (Corbet)	2 657.2	1.98	52.6
Falconbridge Copper Limited (Millenbach)	704.9	4.95	34.9
Lemoine Mines Limited	316.9	10.27	32.5
Les Mines Gallen Limitée (West MacDonald)[1]	2 502.0	4.50	112.6
Louvem Mining Company Inc.	76.4	4.80	3.7
Noranda Mines Limited (Orchan)	297.6	6.10	18.2
Noranda Mines Limited (Norita)	3 039.1	4.51	136.9
Noranda Mines Limited (Radiore No. 2)	138.8	1.00	1.4
Noranda Mines Limited (Mattagami)	6 917.8	7.30	505.0
	16 650.7	5.39	897.8
Ontario			
Falconbridge Copper Limited (Sturgeon)	570.0	7.90	45.0
Mattabi Mines Limited	2 993.0	7.87	235.5
Noranda Mines Limited (Geco)	21 667.0	3.78	819.0
Noranda Mines Limited (Lyon Lake)[1]	2 488.1	6.89	171.4
Noranda Mines Limited (F Group)[1]	571.5	8.10	46.3
Selco Mining Corporation Limited (South Bay)	296.5	11.01	32.6
Texasgulf Canada Ltd. (No. 1)	68 191.0	6.27	4 275.5
Texasgulf Canada Ltd. (No. 2)	26 435.0	2.10	555.1
	123 212.1	5.00	6 180.4
Manitoba			
Hudson Bay Mining and Smelting Co., Limited	12 629.1	3.02	381.2
Sherritt Gordon Mines Limited (Ruttan)	26 100.9	1.20	313.2
Sherritt Gordon Mines Limited (Fox)	5 745.3	2.22	127.5
	44 475.3	1.85	821.9
Saskatchewan			
Hudson Bay Mining and Smelting Co., Limited	1 836.5	2.1	38.6
British Columbia			
Cominco Ltd. (Sullivan)	50 802.9	5.80	2 946.5
Silvana Mines Inc.	9.1	4.50	0.4
Northair Mines Ltd.	178.1	3.69	6.6
Teck Corporation (Beaverdell)	31.8	1.00	0.3
Western Mines Limited (Buttle Lake)	1 154.8	8.00	92.4
	52 176.7	5.83	3 046.2

TABLE 5. (cont'd.)

Company and Province	Zinc-Bearing Ore Reserves	Per Cent Zinc	Zinc in Ore
	(000 tonnes)	(%)	(000 tonnes)
Yukon Territory			
Cyprus Anvil Mining Corporation (Faro)	36 260.8	5.65	2 048.7
United Keno Hill Mines Limited	223.1	0.78	1.7
	36 483.9	5.62	2 050.4
Northwest Territories			
Arvik Mines Ltd. (Polaris and Eclipse)[1]	23 587.0	14.0	3 310.6
Nanisivik Mines Ltd.	4 765.1	11.56	550.8
Pine Point Mines Limited	33 819.1	5.1	1 724.8
	62 171.2	8.99	5 586.2
National Total	483 355.4	6.13	29 652.5

Source: MR 186 Canadian Reserves of Copper, Nickel, Lead, Zinc, Molybdenum, Silver and Gold as of January 1, 1979; Energy, Mines and Resources Canada, 1979.

[1] Committed but not in production at January 1, 1979.

- the Magusi copper-zinc deposit in Quebec, held by Noranda Mines Limited, with potential output of 11 000 tpy zinc in the mid-1980s.
- the Goldstream copper-zinc deposit in British Columbia, held by Noranda Mines Limited, with potential output of 6 000 tpy zinc in 1982-83.

Canada has seldom had so many new zinc mine projects that are either under construction or under serious consideration. At present, the total potential output represented by these projects is approximately 543 000 tpy zinc. This exceeds prior totals in the 1970s by about 25 per cent, and indicates the much improved outlook in Canada accorded to base metals by the mining industry.

METAL OUTPUT AND DEVELOPMENTS IN CANADA

Refined zinc metal production in 1979 was 580 449 t compared with 495 420 t the previous year. With this increase in output, Canada surpassed the United States and is now the second largest zinc metal producer in the western world following Japan. Canadian zinc output had earlier been planned at higher levels but reduced export consumer demand in the fall necessitated some cutbacks in production.

There were no physical changes to refinery capacity during the year, although actual operating experience at the Canadian Electrolytic Zinc Limited's expanded zinc plant in Valleyfield, Quebec prompted a revision in that plant's capacity to 218 000 t from 205 000 tpy of zinc.

As a result of this revision, Canada's zinc metal capacity stands at 644 000 tpy which is sufficient to process 50 per cent of domestic mine production to metal.

During the year, Cominco Ltd. announced that its zinc plant capacity at Trail, British Columbia would be expanded by 25 000 tpy of zinc commencing in 1982. As part of this expansion, the company announced the start of construction for the world's first commercial scale zinc pressure-leaching plant. The $23 million plant, using a process developed jointly with Sherritt Gordon Mines Limited, will comprise two units, the first to be built in 1981 and the second to be built in 1983, and together will ultimately treat 25 per cent of the zinc concentrates processed to metal at Trail. This new system reportedly will greatly improve industrial hygiene, productivity and environmental control and will allow the company to produce elemental sulphur instead of sulphur dioxide gas.

TABLE 6. CANADA'S ZINC-BEARING DEPOSITS CONSIDERED MOST PROMISING FOR FUTURE PRODUCTION

Company and Province	Deposit Name	Indicated Tonnage	Per Cent Zinc	Zinc Content
New Brunswick				
Placer Development Limited and	Restigouche	2 721.6	6.00	163.3
Gowganda Silver Mines Limited	Murray Brook	21 479.8	1.95	418.9
Caribou-Chaleur Bay Mines Ltd.	Caribou	44 815.4	4.48	2 007.7
Cominco Ltd.	Stratmat 61	2 041.2	6.29	128.4
Key Anacon Mines Limited	Key Anacon	851.9	5.98	50.9
	Key Anacon	917.2	5.78	53.0
Texasgulf Inc. and Bay Copper Mines Limited	Halfmile Lake	6 168.9	6.80	419.5
		78 996.0	4.10	3 241.7
Quebec				
Louvem Mining Company Inc.	Louvicourt	726.6	6.38	46.4
Noranda Mines Limited	Magusi	1 378.9	4.80	66.2
	P.D. Division	1 401.6	4.50	63.1
Selco Mining Corporation	Detour A1	32 114.7	2.30	738.6
Limited	Detour B	3 447.3	0.50	17.2
Muscocho Explorations Limited	Montauban	691.2	3.46	23.9
Conwest Exploration Company Limited	(Base Metal Zone)			
Quebec Mining Exploration Company				
Ontario				
Giant Yellowknife Mines Limited	Low Pyrite	4 008.4	3.97	159.1
Emington and Vermillion Mines	High Pyrite	8 199.5	3.82	313.2
		39 760.3	2.40	955.4
Manitoba				
Dickstone Copper Mines Limited		304.4	4.50	13.7
Falconbridge Nickel Mines Limited				
Stall Lake Mines Limited	Stall Lake	610.2	2.28	13.9
Hudson Bay Mining and Smelting Co., Limited	Rail Lake	294.8	0.70	2.1
Gränges Exploration AB	Trout Lake	3 175.2	4.30	136.5
Manitoba Mineral Resources Ltd.				
		4 384.6	3.79	166.2
British Columbia				
Imperial Oil Limited				
Sumitomo Metal Mining Co. Ltd.	Kutcho Creek	n.a.	3.0	n.a.
Noranda Mines Limited	Goldstream	3 628.8	2.60	94.3
Yukon Territory				
Hudson Bay Mining and Smelting Co., Limited	Tom	7 842.7	8.40	658.8
Cyprus Anvil Mining Corporation	Grum	26 081.8	6.40	1 669.2
	Swim Lake	4 536.0	5.50	249.5
	Vangorda	8 527.6	4.96	423.0
Placer Development Limited and United States Steel Corporation	Howard's Pass[1]	272 158.2	6.40	17 418.1
Sovereign Metals Corporation	Mel Property	3 628.8	5.20	188.7
		322 775.1	8.15	20 607.3

TABLE 6. (cont'd.)

Company and Province	Deposit Name	Indicated Tonnage	Per Cent Zinc	Zinc Content
Northwest Territories				
Bathurst Norsemines Ltd.	Cleaver Lake	3 628.8	7.07	256.6
and Cominco Ltd.	Boot Lake	4 536.0	4.97	225.4
	Main A Group	3 628.8	8.50	308.4
Cadillac Explorations Limited	Prairie Creek	1 814.4	15.50	281.2
Texasgulf Canada Ltd.	Isok Lake	11 022.4	13.77	1 517.8
	Hood River 10	453.6	3.50	15.9
	Hood River 41	290.3	3.20	9.3
Western Mines Limited	R-19°	1 270.1	n.a.	n.a.
Du Pont Canada Inc. and	V-46	544.3	n.a.	n.a.
Philipp Brothers (Canada) Ltd.	X-25	3 447.3	9.10	313.7
		30 636.0	10.16	2 928.3
Canada		492 388.7	5.80	28 465.5

Source: MR 186 Canadian Reserves of Copper, Nickel, Lead, Zinc, Molybdenum, Silver and Gold, as of January 1, 1979; Energy, Mines and Resources Canada, 1979.

[1] MR 186 indicates ore reserves at Howard's Pass exceed 272.2 million tonnes with an average grade of 6-12% combined lead-zinc. Data in above table compiled using a lead to zinc ratio of about 1.0/2.5 applied to an average grade of 9% combined lead and zinc based upon minimum ore reserves.

In February 1979, Brunswick Mining and Smelting Corporation Limited began detailed work on process selection and engineering for a 100 000 tpy electrolytic zinc refinery at Belledune, New Brunswick. The program is scheduled for completion no later than January 31, 1981. Upon completion of this work, which has been jointly sponsored by the federal government and the province, the company will have a specified period of time to evaluate and reach a decision on whether to proceed with zinc plant construction. An earlier feasibility evaluation undertaken in 1976-77 was set aside when world conditions for zinc began to deteriorate. Despite this, company officials have pointed out that the Brunswick orebody is one of the great zinc orebodies in the world and that it would merit a zinc plant when economic market conditions improved.

TABLE 7. CANADA, PRODUCERS' DOMESTIC SHIPMENTS OF REFINED ZINC, 1977-79

	1977	1978	1979P
		(tonnes)	
1st Quarter	33 607	42 492	42 951
2nd Quarter	35 844	33 439	40 015
3rd Quarter	28 640	30 806	30 528
4th Quarter	32 550	38 003	40 250
Total	130 641	144 740	153 744

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary.

The availability in Canada of zinc in scrap metal has traditionally been modest at about 5 000 tpy and was 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 tpy of zinc diecast alloy, mainly from shredded automobiles. The plant's capacity to process the non-ferrous portion of scrapped automobiles currently exceeds the automotive scrapping rate in Canada. 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 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.

METAL CONSUMPTION AND END-USAGE IN CANADA

Domestic zinc consumption, as measured by producers' domestic shipments, increased once again in 1979 to about 154 000 t from 145 000 t in 1978, equivalent to about 25 per cent of zinc metal output. This growth continued to be broadly based and at least in part, a reflection on the fact that the devalued Canadian dollar enabled manufacturers of zinc products to be more competitive in foreign markets. The steel sector is Canada's largest consumer of zinc, accounting for almost 50 per cent of domestic usage; galvanized sheet and strip steel is the principle outlet. The Steel Company of Canada, Limited and Dominion Foundries and Steel, Limited have installed capacity to produce about 910 000 tpy of galvanized sheet steel; however, in 1981 this will increase by about 420 000 tpy due to the addition of two new lines. At capacity, they should increase domestic consumption by about 15 per cent.

Consumer surveys by Statistics Canada cover about 75 per cent of zinc consumption in Canada. The most recent survey of zinc consumption for 1978 indicated that the manufacture of copper alloys consumed 13 500 t, galvanized steel consumed 69 900 t, zinc diecast alloys consumed 12 100 t, and zinc oxides, rolled zinc, etc. consumed 21 900 t, a total of 117 400 t of zinc. All sectors of zinc consumption in Canada are also export dependent for a significant proportion of production.

WESTERN WORLD OUTPUT AND DEVELOPMENTS FOR ZINC

Whereas 1978 witnessed a dramatic decline in world stocks of zinc metal, 1979 witnessed a massive reduction of world stocks of zinc-in-concentrate. Together these changes eliminated the glut of surplus zinc production generated during 1975-77.

Under these conditions, the producer basis quotations for zinc outside North America increased from 1978 lows of U.S. 29 cents and U.S. 37.5 cents a pound, while in Canada, the domestic price approximated the currency-equivalent of the U.S. zinc price, equal to a low of 31 cents a pound in 1978 and 43 cents a pound at year-end 1979.

Just as increased metal prices for zinc emerged from an improved supply-demand balance for zinc metal, declining smelter charges for the processing of concentrates to zinc metal resulted from increased demand for mine output of zinc. Traditionally, under balanced market conditions, the cost to mines and smelters in the production of zinc had resulted in a near-sharing of the zinc price of roughly 55 per cent for zinc mines and 45 per cent for zinc smelters. For zinc smelters, this 45 per cent comprised a treatment charge paid by the mine, plus some 8 to 10 per cent zinc-in-concentrate that the smelter did not pay for. At the height of the zinc concentrate surplus, which coincided with low metal prices, treatment charges increased and the smelter's share of revenues increased to record levels, exceeding 55 per cent of the zinc price. A new high in zinc mine closures was reached in 1977-78 as the result of these factors, and this undoubtedly reflected upon the difficulty of zinc mines in meeting demand in 1979. The shortfall in mine output in 1979 reversed the prior situation and treatment charges were reported to have declined such that the smelter's share of revenues were reduced to about the 35 per cent level during the year. This decline in smelter revenues has been offset to some degree by the increasing price for zinc metal in 1979; however, the net result appears inadequate to ensure the economic viability of custom smelters in some countries. Unlike the mining industry, there has not been a rash of zinc smelter closures even though surplus capacity has persisted worldwide throughout 1975-79. The only exception is the St. Joe Zinc Company in the U.S., which closed its 172 000 tpy zinc smelter at year-end 1979. The company currently has a study under way to rebuild a more economic replacement plant. This complete lack of smelter closures amongst the highest cost zinc plants in existence today must to some degree reflect their ownership by both financially secure parent corporations and sovereign governments who are willing and able to subsidize unprofitable operations in the hope of an improved future.

The realignment of currencies that took place earlier in this decade continued to be a factor of instability for zinc in 1979, and for some producers its impact continued to detract from the concept of an international price for zinc quoted in U.S. currency. In

TABLE 8. INTERNATIONAL ZINC METAL PRICES, 1979

Month	Canada	U.S.A.	Producers Outside North America	London Metal Exchange Prompt
	(¢/lb)	(¢/lb)	($US/tonne)	(/tonne)
January	39.5	34.6	734.5	359.2
February	42.2	35.6	782.0	395.5
March	44.1	37.2	800.0	390.0
April	45.0	39.0	800.0	380.5
May	45.0	39.4	808.6	378.1
June	45.0	39.4	845.0	356.8
July	45.0	39.4	845.0	319.4
August	42.5	36.9	780.0	297.5
September	41.9	35.8	780.0	329.7
October	43.0	36.2	780.0	329.7
November	43.0	36.8	780.0	328.0
December	43.0	37.2	780.0	340.9
1979 Average	43.3	37.3	792.9	350.4
1978 Average	34.0	34.7	607.2	309.1

Source: International Lead and Zinc Study Group Bulletin, **Northern Miner** quotes as compiled by Energy, Mines and Resources Canada.

the strong currency areas these shifts depressed prices realized by the mines and reduced operating margins for custom smelters. Alternatively, custom smelters operating in weak currency countries gained a competitive advantage, experiencing relatively higher margins. Since December 1975 when the international producer price for zinc was first quoted in U.S. currency, Japan and many countries throughout Europe have witnessed a reduction to domestic zinc prices on a currency equivalent basis in the order of 10 to 35 per cent, due to the revaluation of their currencies vis-a-vis the U.S. dollar. In many ore exporting countries, devalued currencies in the range of 10 to 500 per cent have not only increased domestic prices, but in some cases have pushed prices to record highs. This is the case in Australia, Canada, Peru, Mexico and Spain; however, in some countries rampant inflation and currency devaluation have consumed any apparent currency gains. The economic incentive to new zinc investments in the two camps simply on the basis of currency criteria becomes obvious. 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 in 1978 and domestic zinc prices were, of necessity, increased to 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 product that defies significant differentiation and as such there is little basis for price discrimination between countries. Furthermore, consumer demand for zinc is relatively insensitive to price changes and thus despite the fact that zinc remains a bargain in many strong currency countries there is little hope for rapid self-correction on this basis. These general concerns may well translate into upward price pressures if the supply-demand balance for zinc continues to improve in 1980-81, while currency disparities remain unchanged or deteriorate further.

ZINC PRICES-MONTHLY AVERAGE

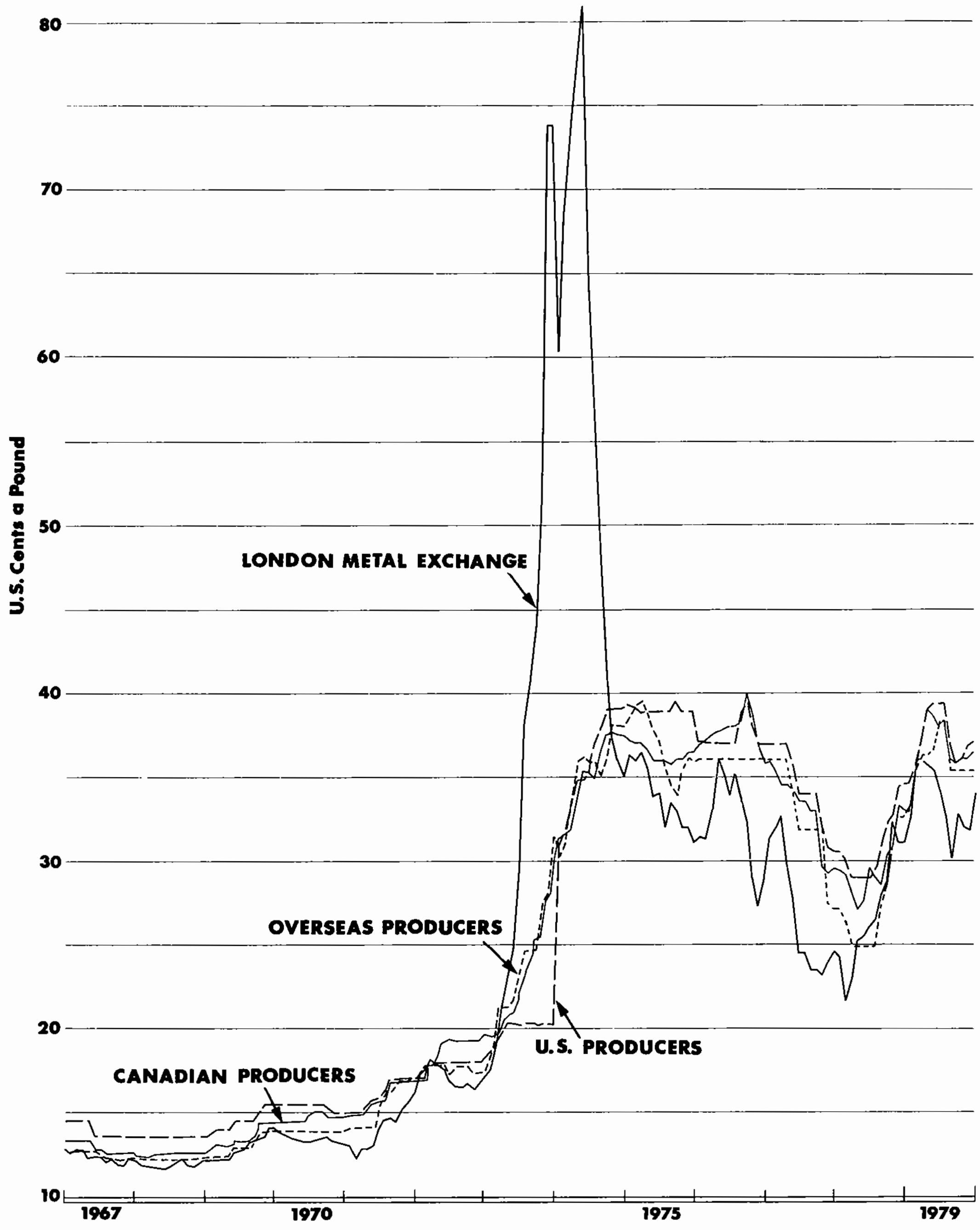


TABLE 9. WESTERN WORLD PRIMARY ZINC STATISTICS, 1977-80

	1977	1978	1979p	1980e
	(000 tonnes)			
Mine production (Zn content)	4 839r	4 676r	4 620	4 611
Metal production	4 277r	4 293r	4 720	4 473
Metal consumption	4 256r	4 601r	4 697	4 522

Source: International Lead and Zinc Study Group.

e Estimated by Energy, Mines and Resources Canada; p Preliminary; r Revised.

World mine production of zinc in 1979 is expected to be about 4 600 000 t. During the year, some 102 000 t of new zinc mine capacity came into production, the most significant being the 57 000 tpy Aznal-collar project in Spain. Zinc metal output was about 4 680 000 t, approximately 82 per cent of nameplate capacity. Two electrolytic zinc plants began production in 1979; namely, the 82 000 tpy Clarksville plant in the U.S. and the 30 000 tpy Visag plant in India. Estimated world zinc metal capacity at year-end 1979 was approximately 5 700 000 tpy of zinc. By comparison, world consumption of zinc in 1979 is expected to be about 4 540 000 t. According to the International Lead and Zinc Study Group, there were new zinc mine projects outside of Canada totalling 383 000 t of annual zinc capacity firmly committed as of late 1979. Firmly committed zinc smelter projects totalled 308 000 t of annual output.

TABLE 10. CANADA, PRIMARY ZINC METAL CAPACITY, 1979

Company and Location	Annual Rated Capacity
	(t of slab zinc)
Canadian Electrolytic Zinc Limited Valleyfield, Quebec	218 000
Texasgulf Canada Ltd. Hoyle, Ontario	108 000
Hudson Bay Mining and Smelting Co., Ltd. Flin Flon, Manitoba	73 000
Cominco Ltd. Trail, British Columbia	245 000
Canada total	644 000

Source: Energy, Mines and Resources Canada.

TARIFFS

The Tokyo Round of Multilateral Trade Negotiations under the General Agreement on Tariffs and Trade (GATT) that was convened in 1973, was brought to a successful conclusion in 1979. The negotiations resulted in the signing of a number of so-called non-tariff Agreements that are intended to liberalize world trade, and a reduction in Most Favoured Nation (MFN) tariffs on most industrial products. For most items, the tariff reductions will be phased in over the 8-year period January 1, 1980 to January 1, 1987. From a Canadian perspective, the results for zinc were not gratifying as our main trading partners strove to maintain protected markets.

Selected tariff items from Canada's four-column customs tariff schedule and some MFN reductions by the U.S.A. are presented below showing the tariffs for 1979 and the full phase-in period. For the European Economic Community and Japan, only the tariff applicable for 1979, the base rate for the tariff reductions (i.e., the previously bound MFN tariff), and the concession rate are presented (i.e., for most items January 1, 1987). In the case of Japan, one would not expect the tariffs actually applied during any part of the phase-in period to exceed those in effect for 1979.

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
32900-1	Zinc in ores and concentrates	free	free	free	free
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	free	free	free	10%
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
35800-1	Zinc anodes	free	free	free	10%

UNITED STATES (MFN)

Item No.		1979	1980	1981	1982	1983	1984	1985	1986	1987
602.20	Zinc in ores and concentrates	.67¢/lb	.62¢/lb	.58¢/lb	.53¢/lb	.48¢/lb	.44¢/lb	.39¢/lb	.35¢/lb	.3¢/lb
626.02	Zinc, unwrought, unalloyed	.7¢/lb	1.9%	1.9%	1.8%	1.8%	1.7%	1.6%	1.6%	1.5%
.04	Zinc, unwrought, alloyed	19% no change								
.10	Zinc, waste and scrap	.75¢/lb	4.8%	4.4%	4.0%	3.7%	3.3%	2.9%	2.5%	2.1%

EUROPEAN ECONOMIC COMMUNITY (MFN)

		1979	Base Rate	Concession Rate
26.01	Zinc, ores and concentrates	free	free	free
79.01	Zinc, unwrought	3.5%	3.5%	3.5%
	Zinc, waste and scrap	free	free	free

JAPAN (MFN)

26.01	Zinc, ores and concentrates	free	free	free
70.01	Zinc, unwrought, unalloyed	2%	2.5%	2.1%
	Zinc, unwrought, alloyed	8 yen/kg	10 yen/kg	7 yen/kg
	Zinc, waste and scrap	2%	2.5%	1.9%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 20, No. L289, 1977; Customs Tariff Schedules of Japan, 1977; GATT Documents, 1979.

Statistical Summary of the Mineral Industry in Canada

In January 1979, the responsibility for Canadian mineral statistics was transferred from Statistics Canada to the Department of Energy, Mines and Resources. The first annual statistical report of this nature on the Canadian mineral industry was published by the Geological and Natural History Survey of Canada in 1886 and later by the Mines Branch of the Department of Mines until 1920. In 1921, the Dominion Bureau of Statistics, later Statistics Canada, assumed the responsibility and continued to publish the reports until 1978.

The statistical material contained in this summary was principally derived from surveys conducted by the Information Systems Division of the Mineral Policy Sector of Energy, Mines and Resources Canada.

The statistical survey program of Energy, Mines and Resources Canada is conducted jointly with the provincial government and Statistics Canada. This joint program is intended to minimize the reporting burden on the mineral companies. The cooperation of the companies that provide information is greatly appreciated. Without this cooperation, a statistical report of this nature would not be possible. International mineral statistics contained in this summary are derived from the U.S. Bureau of Mines, The American Bureau of Metal Statistics, The World Bureau of Metal Statistics, **Metals Week, Engineering and Mining Journal,** The United Nations and the Organization for Economic Co-operation and Development (OECD).

This statistical summary of the mineral industry in Canada for the year 1979 was prepared by J.T. Brennan and staff, Statistics Section, Mineral Policy Sector, Energy, Mines and Resources Canada, Ottawa. Telephone (613) 995-9466.

STATISTICAL TABLES

SECTION 2: TRADE

SECTION 3: CONSUMPTION

SECTION 4: PRICES

SECTION 5: PRINCIPAL STATISTICS

SECTION 6: EMPLOYMENT, SALARIES AND WAGES

SECTION 7: MINING, EXPLORATION AND DRILLING

SECTION 8: TRANSPORTATION

SECTION 9: INVESTMENT AND FINANCE

		1965	1966	1967	1968	1969
Gross national product, current dollars	($ million)	55,364	61,828	66,409	72,586	79,815
Gross national product, constant dollars (1971 = 100)	"	69,981	74,844	77,344	81,864	86,225
Value of manufacturing industry shipments	"	33,889	37,303	38,955	42,062	45,930
Value of mineral production	"	3,715	3,981	4,381	4,722	4,734
Merchandise exports	"	8,525	10,071	11,112	13,270	14,498
Merchandise imports	"	8,633	10,072	10,873	12,358	14,130
Balance of payments, current account	"	-1,130	-1,162	-499	-97	-917
Corporation profits before taxes	"	6,318	6,714	6,823	7,742	8,294
Capital investment current dollars	"	12,935	15,088	15,348	15,455	16,927
Capital investment, constant dollars (1971 = 100)	"	15,944	17,645	17,571	17,628	18,498
Population	000's	19,644	20,015	20,378	20,701	21,001
Labour force	"	7,141	7,420	7,694	7,919	8,162
Employed	"	6,862	7,152	7,379	7,537	7,780
Unemployed	"	280	267	315	382	382
Unemployment rate	%	3.9	3.6	4.1	4.8	4.7
Employment index	1961=100	114.3	120.7	122.6	122.7	127.0
Labour income	($ million)	28,201	31,878	35,303	38,444	43,065
Index industrial production	1971=100	73.8	79.2	82.3	87.6	93.6
Index manufacturing production	"	75.8	81.5	83.9	89.1	95.8
Index mining production	"	70.5	74.1	79.9	86.2	86.9
Index real domestic product	"	74.5	79.5	82.3	86.9	92.2
Consumer price index	1971=100	80.5	83.5	86.5	90.0	94.1

p Preliminary; r Revised.

INDICATORS, 1965–79

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979[p]
85,685	94,450	105,234	123,560	147,528	165,343	191,031[r]	208,806[r]	229,698	260,305
88,390	94,450	100,248	107,812	111,678	113,005	119,249[r]	121,823[r]	125,995	129,439
46,381	50,276	56,191	66,674	82,455	88,427	98,076	109,747	128,925	150,292
5,722	5,963	6,408	8,370	11,754	13,347	15,693	18,473	20,261	26,098
16,401	17,397	19,671	24,838	31,739	32,587	37,651	43,685	52,259	64,190
13,952	15,617	18,669	23,325	31,880	34,830	37,494	42,363[r]	50,102	62,724
+1,106	+431	-386	+108	-1,460	+4,757	-3,842	-4,301	-5,046	-5,098
7,699	8,681	10,799	15,417	20,062	19,663[r]	19,985	21,090	25,360	34,338
17,798	20,184	22,218	26,618	32,882	38,216	43,636	46,597	50,360	57,441
18,635	20,184	21,242	23,551	24,927	25,694	26,727	26,527	26,546	27,999
21,297	21,568	21,802	22,043	22,364	22,697	22,993	23,258	23,476	23,671
8,395	8,639	8,897	9,276	9,639	9,974	10,206	10,498	10,882	11,207
7,919	8,104	8,344	8,761	9,125	9,284	9,479	9,648	9,972	10,369
476	535	553	515	514	690	727	850	911	838
5.7	6.2	6.2	5.5	5.3	6.9	7.1	8.1	8.4	7.5
127.1	127.8	129.9	135.9	142.8	141.1	144.1	144.3	146.5	150.7
46,706	51,528	57,570	66,501	79,844	93,289	107,914	119,003	129,885	144,082
94.9	100.0	107.5	118.1	122.2	114.9	121.3	125.2	132.4	137.7
94.5	100.0	107.1	117.6	122.0	114.3	120.8	124.1	133.8	138.0
98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3	113.4
94.4	100.0	105.5	113.6	119.0	119.8	126.1	130.1	135.3	139.5
97.2	100.0	104.8	112.7	125.0	138.5	148.9	160.8	175.2	191.2

TABLE 1. MINERAL PRODUCTION OF CANADA, 1978 AND 1979, AND AVERAGE 1975-79

	Unit of Measure	1978		1979P		Average 1975-79	
		(Quantity)	($ 000)	(Quantity)	($ 000)	(Quantity)	($ 000)
Metals							
Antimony	t	..	8,151	..	8,275	..	8,274
Bismuth	t	145	1,160	112	875	142	1,788
Cadmium	t	1 151	7,094	1 256	9,000	1 220	8,179
Calcium	t	575	2,689	477	2,335	497	1,861
Cobalt	t	1 234	32,750	1 381	82,134	1 362	31,888
Columbium (Cb_2O_5)	t	2 473	14,220	2 406	15 492	2 110	11,241
Copper	000 t	659	1,084,245	644	1,515,443	705	1,178,799
Gold	kg	53 967	382,423	49 175	543,068	52 223	335,385
Indium	kg	3 857	..	..	..	..	..
Iron ore	000 t	42 931	1,221,599	60 185	1,888,815	51 409	1,325,410
Iron remelt	000 t	..	85,968	..	46,438	..	71,683
Lead	000 t	320	259,624	316	414,416	304	230,605
Magnesium	t	8 309	19,825	9 172	25,073	7 006	16,856
Mercury	t	-	-	-	-	83	..
Molybdenum	t	13 943	179,069	11 187	330,114	13 928	166,232
Nickel	000 t	128	635,451	132	826,423	195	984,289
Platinum group	kg	10 768	65,293	5 754	56,193	11 276	58,022
Selenium	t	122	4,917	107	3,462	136	5,299
Silver	kg	1 266 927	251,361	1 184 000	451,913	1 256 138	253,403
Tantalum (Ta_2O_5)	t	..	..	..	..	..	..
Tellurium	t	31	1,580	33	1,669	34	1,234
Thorium	t	-	-	-	-	-	-
Tin	t	360	5,099	362	7,022	329	3,983
Tungsten (WO_3)	t	2 886	..	..	..	..	..
Uranium (U)	t	8 211	617,528	6 956	663,939	6 214	..
Zinc	000 t	1 067	817,525	1 148	1,107,419	1 065	890,083
Total metals			5,697,571		7,999,518		5,584,514
Nonmetals							
Arsenious oxide	t	..	..	-	-	..	..
Asbestos	000 t	1 422	532,403	1 501	641,221	1 406	491,322
Barite	000 t	99	2,657	67	1,984	93	2,327
Feldspar	000 t	-	-	-	-	-	-
Fluorspar	000 t	-	-	-	-	..	2,324
Gemstones	t	..	1,505	..	1,535	..	1,202
Gypsum	000 t	8 074	38,624	8 105	42,808	7 027	31,176
Magnesitic dolomite and brucite	000 t	..	5,990	..	8,990	..	6,127
Mica	kg	..	..	..	..	..	..
Nepheline syenite	000 t	599	14,182	617	15,180	560	12,156

Peat	000 t	435	35,162	409	33,828	397	28,999
Potash (K_2O)	000 t	6 344	504,535	7 046	695,305	5 808	463,124
Pyrite, pyrrhotite	000 t	9	72	31	275	23	182
Quartz	000 t	2 165	21,747	2 246	24,333	2 323	18,902
Salt	000 t	6 452	98,326	6 672	113,855	6 056	89,210
Soapstone, talc & pyrophyllite	000 t	62	2,177	88	2,972	71	2,156
Sodium sulphate	000 t	377	19,300	452	26,156	431	22,253
Sulphur in smelter gas	000 t	676	11,649	605	12,675	683	13,342
Sulphur, elemental	000 t	5 752	101,392	6 718	145,072	5 157	97,818
Titanium dioxide	000 t	..	88,156	..	66,595	..	72,301
Total nonmetals			1,477,877		1,832,784		1,354,921
Fuels							
Coal	000 t	30 478	779,426	33 120	858,000	28 571	688,093
Natural gas	000 m^3	88 610 000	3,923,465	94 116 000	4,708,800	89 875 903	3,244,843
Natural gas by-products	000 m^3	16 313	1,063,670	19 290	1,351,091	17 351	993,146
Oil, crude	000 m^3	76 348	5,810,996	89 320	7,610,953	80 337	5,222,254
Total fuels			11,577,557		14,528,844		10,148,336
Structural materials							
Clay products	000 $	..	109,635	..	125,357	..	103,047
Cement	000 t	10 558	572,591	11 835	736,862	10 348	488,535
Lime	000 t	2 034	76,218	2 092	79,151	1 883	64,527
Sand and gravel	000 t	272 092	416,860	275 127	449,030	261 288	374,073
Stone	000 t	122 144	332,744	114 989	346,721	106 917	281,879
Total structural materials			1,508,048		1,737,121		1,312,061
Total, all minerals			20,261,053		26,098,267		18,399,832

Notes: [1] Production statistics for the following are not available for publication: diatomite, helium, nitrogen and yttrium. [2] Nil production for the following between 1975 and 1979: feldspar, grindstone, iron oxide, lithia and thorium. [3] Dollar values only available for publication for the following: antimony, iron remelt, gemstones, 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, 1938-79

	Metallics	Industrial Minerals	Fuels	Total	Per Capita Value of Mineral Production	Population of Canada
		($ million)			($)	(000)
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	22,043
1974	4,821	1,731	5,202	11,754	525.55	22,364
1975	4,796	1,898	6,653	13,347	588.05	22,697
1976	5,315	2,269	8,109	15,693	682.51	22,993
1977	5,988	2,612	9,873	18,473	794.26	23,258
1978	5,698	2,986	11,577	20,261	863.05	23,476
1979p	7,999	3,570	14,529	26,098	1,102.53	23,671

p Preliminary.

TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1979P

	Metals		Industrial Minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	-	-	387,841	10.86	12,496,899	86.01	12,884,740	49.37
Ontario	2,532,814	31.66	709,912	19.89	28,643	0.20	3,271,369	12.54
British Columbia	1,397,264	17.47	273,498	7.66	1,070,705	7.37	2,741,467	10.50
Quebec	1,157,969	14.48	1,089,881	30.53	-	-	2,247,850	8.61
Saskatchewan	297,034	3.71	786,789	22.04	730,920	5.03	1,814,743	6.95
Newfoundland	1,033,565	12.92	66,587	1.87	-	-	1,100,152	4.22
Manitoba	446,840	5.59	90,593	2.54	48,005	0.33	585,438	2.24
New Brunswick	465,351	5.82	54,386	1.52	10,189	0.07	529,926	2.03
Northwest Territories	369,117	4.61	-	-	42,983	0.30	412,100	1.58
Yukon	299,564	3.74	-	-	-	-	299,564	1.15
Nova Scotia	-	-	108,218	3.03	100,500	0.69	208,718	0.80
Price Edward Island	-	-	2,200	0.06	-	-	2,200	0.01
Total, Canada	7,999,518	100.00	3,569,905	100.00	14,528,844	100.00	26,098,267	100.00

P Preliminary; - Nil.

TABLE 4. CANADA, PRODUCTION OF LEADING MINERALS

	Unit of measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario
Oil, crude	000 m^3	-	-	-	1	-	78
	$000	-	-	-	40	-	6,977
Natural gas	000 m^3	-	-	-	3 000	-	297 000
	$000	-	-	-	49	-	21,666
Iron ore	000 t	29 968	-	-	-	21 377	8 164
	$000	949,449	-	-	-	639,881	286,012
Copper	000 t	8	-	-	11	80	185
	$000	18,415	-	-	25,691	189,887	435,240
Natural gas byproducts	000 m^3	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Zinc	000 t	51	-	-	264	82	276
	$000	49,075	-	-	255,117	79,521	266,289
Coal	000 t	-	-	2 160	305	-	-
	$000	-	-	100,500	10,100	-	-
Nickel	000 t	-	-	-	-	-	95
	$000	-	-	-	-	-	604,505
Cement	000 t	..	-	..	..	3 012	4 257
	$000	8,180	-	22,854	15,794	153,488	216,971
Potash (K_2O)	000 t	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Uranium (U)	t	-	-	-	-	-	4 419
	$000	-	-	-	-	-	390,870
Asbestos	000 t	78	-	-	-	1 329	-
	$000	41,019	-	-	-	532,932	-
Gold	kg	373	-	-	187	13 654	19 253
	$000	4,137	-	-	2,061	150,788	212,505
Silver	kg	11 000	-	-	196 000	60 000	438 000
	$000	4,318	-	-	74,906	23,077	166,985
Sand and gravel	000 t	4 808	998	9 072	7 257	71 101	95 254
	$000	7,950	2,200	20,500	11,600	70,880	162,750
Lead	t	5 860	-	-	75 673	216	8 619
	$000	7,692	-	-	99,319	283	11,312
Stone	000 t	680	-	2 087	3 175	66 137	35 834
	$000	2,362	-	6,900	10,850	193,144	108,625
Molybdenum	t	-	-	-	-	409	-
	$000	-	-	-	-	7,965	-
Sulphur, elemental	000 t	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Clay products	$000	450	-	5,000	2,500	22,747	68,260
Salt	000 t	-	-	1 050	-	-	4 962
	$000	-	-	24,327	-	-	70,235
Cobalt	t	-	-	-	-	-	1 112
	$000	-	-	-	-	-	67,320
Lime	000 t	-	-	-	..	363	1 406
	$000	-	-	-	1,905	16,037	49,782
Titanium dioxide	000 t	-	-	-	-	..	-
	$000	-	-	-	-	66,595	-
Platinum group	kg	-	-	-	-	-	5 754
	$000	-	-	-	-	-	56,193
Total leading minerals	$000	1,093,047	2,200	180,081	509,932	2,147,225	3,202,497
Total all minerals	$000	1,100,152	2,200	208,718	529,926	2,247,850	3,271,369
Leading minerals as % of all minerals		99.4	100.0	86.3	96.2	95.5	97.9

P Preliminary; - Nil; .. Not available.

BY PROVINCES AND TERRITORIES, 1979P

	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
	580	9 171	77 079	2 272	-	139	89 320
	48,005	684,508	6,686,481	179,260	-	5,682	7,610,953
	-	1 398 000	81 383 000	10 426 000	-	609 000	94 116 000
	-	15,495	4,265,148	369,141	-	37,301	4,708,800
	-	-	-	676	-	-	60 185
	-	-	-	13,473	-	-	1,888,815
	59	6	-	286	8	1	644
	139,288	13,774	-	674,462	18,053	633	1,515,443
	-	146	18 755	389	-	-	19 290
	-	9,267	1,313,770	28,054	-	-	1,351,091
	46	4	-	91	119	215	1 148
	44,604	3,499	-	87,736	114,593	206,985	1,107,419
	-	4 990	14 950	10 715	-	-	33 120
	-	21,650	231,500	494,250	-	-	858,000
	37	-	-	-	-	-	132
	221,918	-	-	-	-	-	826,423
	694	410	1 324	1 357	-	-	11 835
	38,712	34,715	155,783	90,365	-	-	736,862
	-	7 046	-	-	-	-	7 046
	-	695,305	-	-	-	-	695,305
	-	2 537	-	-	-	-	6 956
	-	273,069	-	-	-	-	663,939
	-	-	-	94	-	-	1 501
	-	-	-	67,270	-	-	641,221
	1 306	342	-	7 994	778	5 288	49 175
	14,357	3,864	-	88,210	8,675	58,471	543,068
	27 000	7 000	-	233 000	132 000	80 000	1 184 000
	10,221	2,618	-	88,882	50,315	30,591	451,913
	13 608	12 247	23 587	37 195	-	-	275 127
	30,000	17,550	55,900	69,700	-	-	449,030
	307	-	-	87 653	82 232	55 191	315 751
	403	-	-	115,042	107,928	72,437	414,416
	2 903	-	272	3 901	-	-	114 989
	9,920	-	945	13,975	-	-	346,721
	-	-	-	10 778	-	-	11 187
	-	-	-	322,149	-	-	330,114
	-	2	6 573	143	-	-	6 718
	-	38	141,942	3,092	-	-	145,072
	2,800	3,100	11,500	9,000	-	-	125,357
	10	274	376	-	-	-	6 672
	66	11,288	7,939	-	-	-	113,855
	269	-	-	-	-	-	1,381
	14,814	-	-	-	-	-	82,134
	..	-	154	73	-	-	2 306
	1,905	-	6,475	3,047	-	-	79,151
	-	-	-	-	-	-	..
	-	-	-	-	-	-	66,595
	-	-	-	-	-	-	5 754
	-	-	-	-	-	-	56,193
	577,013	1,789,740	12,877,383	2,717,108	299,564	412,100	25,807,890
	585,438	1,814,743	12,884,740	2,741,467	299,564	412,100	26,098,267
	98.6	98.6	99.9	99.1	100.0	100.0	98.9

TABLE 5. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1970-79

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979P
Oil, crude	20.2	22.8	24.5	26.8	30.0	28.2	25.8	26.4	28.7	29.2
Natural gas	5.5	5.7	6.2	5.4	6.2	11.4	16.9	18.5	19.4	18.0
Iron ore	10.3	9.3	7.6	7.2	6.2	6.9	7.8	7.5	6.0	7.2
Copper	13.6	12.7	12.6	13.8	11.9	7.7	7.0	6.3	5.4	5.8
Natural gas byproducts	2.8	3.2	3.9	4.2	5.6	5.9	5.1	5.3	5.3	5.2
Zinc	7.0	7.0	7.5	7.8	7.4	6.5	5.2	4.5	4.0	4.2
Coal	1.5	2.0	2.4	2.1	2.6	4.4	3.9	3.3	3.8	3.3
Nickel	14.5	13.4	11.2	9.7	8.3	8.3	7.3	6.6	3.1	3.2
Cement	2.7	3.1	3.3	2.9	2.4	2.5	2.4	2.3	2.8	2.8
Potash (K_2O)	1.9	2.3	2.1	2.1	2.6	2.7	2.3	2.2	2.5	2.7
Uranium (U)	...	...	...	0.1	...	...	1.5	1.9	3.1	2.5
Asbestos	3.6	3.4	3.2	2.8	2.6	2.0	2.9	3.1	2.6	2.5
Gold	1.5	1.3	1.9	2.3	2.2	2.0	1.3	1.5	1.9	2.1
Silver	1.4	1.2	1.2	1.4	1.7	1.3	1.1	1.1	1.2	1.7
Sand and gravel	2.3	2.6	2.8	2.6	2.3	2.3	2.1	2.0	2.1	1.7
Lead	2.2	1.8	1.8	1.5	1.1	1.2	0.8	1.1	1.3	1.6
Stone	1.5	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6	1.3
Molybdenum	1.0	0.6	0.7	0.6	0.5	0.5	0.6	0.8	0.9	1.3
Sulphur, elemental	0.5	0.4	0.3	0.3	0.6	0.7	0.5	0.4	0.5	0.6
Clay products	0.9	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.5	0.5
Salt	0.6	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4
Cobalt	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3
Lime	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3
Titanium dioxide	0.6	0.7	0.6	0.6	0.4	0.4	0.5	0.4	0.4	0.3
Platinum group	0.8	0.7	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.2
Other minerals	2.5	2.1	2.2	2.0	1.8	1.7	1.6	1.3	1.5	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; ... Too small to be expressed.

TABLE 6. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES AND TERRITORIES, 1970-79

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979P
	($ million)									
Alberta	1,396	1,641	1,979	2,760	4,517	5,750	6,934	8,576	10,087	12,885
Ontario	1,593	1,555	1,536	1,855	2,435	2,354	2,712	2,980	2,698	3,271
British Columbia	490	541	678	978	1,156	1,296	1,606	1,687	1,883	2,741
Quebec	803	766	786	936	1,222	1,232	1,493	1,675	1,796	2,248
Saskatchewan	379	410	410	510	791	862	974	1,208	1,582	1,815
Newfoundland	353	343	291	374	448	551	745	867	675	1,100
Manitoba	332	330	323	414	489	530	511	564	459	585
New Brunswick	105	107	120	164	217	232	239	289	339	530
Northwest Territories	134	116	120	165	223	206	225	256	310	412
Yukon	78	93	107	151	171	230	125	210	219	300
Nova Scotia	58	60	57	61	83	102	127	159	211	209
Prince Edward Island	1	1	1	2	1	2	2	2	2	2
Total	5,722	5,963	6,408	8,370	11,753	13,347	15,693	18,473	20,261	26,098

P Preliminary.

TABLE 7. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1970-79

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979P
Alberta	24.4	27.5	30.9	33.0	38.4	43.1	44.2	46.4	49.8	49.4
Ontario	27.8	26.0	23.9	22.2	20.7	17.6	17.3	16.1	13.3	12.5
British Columbia	8.6	9.1	10.6	11.7	9.8	9.7	10.2	9.1	9.3	10.5
Quebec	14.0	12.9	12.3	11.2	10.4	9.2	9.5	9.1	8.9	8.6
Saskatchewan	6.6	6.9	6.4	6.1	6.7	6.5	6.2	6.5	7.8	7.0
Newfoundland	6.2	5.8	4.5	4.5	3.8	4.1	4.7	4.7	3.3	4.2
Manitoba	5.8	5.5	5.0	4.9	4.2	4.0	3.3	3.1	2.3	2.2
New Brunswick	1.8	1.8	1.9	1.9	1.9	1.7	1.5	1.6	1.7	2.0
Northwest Territories	2.4	1.9	1.9	2.0	1.9	1.6	1.5	1.4	1.5	1.6
Yukon	1.4	1.6	1.7	1.8	1.5	1.7	0.8	1.1	1.1	1.2
Nova Scotia	1.0	1.0	0.9	0.7	0.7	0.8	0.8	0.9	1.0	0.8
Prince Edward Island	0.02	0.02	0.02	0.02	0.01	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.

TABLE 8. CANADA'S WORLD ROLE AS A PRODUCER OF

		World production
Zinc (mine production)	t	6 427 700
	% of world total	
Asbestos	t	5 169 200
	% of world total	
Potash (K_2O equivalent)	000 t	26 944
	% of world total	
Uranium (U concentrates)	t	36 068
	% of world total	
Nickel (mine production)	t	621 200
	% of world total	
Sulphur, elemental	000 t	34 232
	% of world total	
Molybdenum	t	99 747
	% of world total	
Gypsum	000 t	70 322
	% of world total	
Titanium concentrates (Ilmenite)	t	4 116 000
	% of world total	
Silver	kg	10 594 200
	% of world total	
Platinum group metals (mine production)	kg	199 631
	% of world total	
Gold (mine production)	kg	1 213 332
	% of world total	
Lead (mine production)	t	3 618 600
	% of world total	
Copper (mine production)	t	7 873 300
	% of world total	
Aluminum (primary metal)	t	14 643 300
	% of world total	
Cadmium (smelter production)	t	17 134
	% of world total	
Iron ore	000 t	847 772
	% of world total	

[p] Preliminary; [e] Estimated.

Rank of Six Leading Countries					
1	2	3	4	5	6
Canada	U.S.S.R.	Australia	Peru	U.S.	Japan
1 245 200	1 040 000^e	473 300	457 500	337 000	275 100
19.4	16.2	7.4	7.1	5.2	4.3
U.S.S.R.	**Canada**	Republic of South Africa	Southern Rhodesia	People's Republic of China	Italy
2 500 000^e	1 421 808	257 325	225 000^e	220 000^e	135 402
48.4	27.5	5.0	4.4	4.3	2.6
U.S.S.R.	**Canada**	East Germany	West Germany	U.S.	France
8 900^e	6 344	3 270^e	2 470	2 253	1 795
33.0	23.6	12.1	9.2	8.4	6.7
U.S.	**Canada**	Republic of South Africa	Territory of South-West Africa	France	Niger
14 224	8 211	3 842	3 460	2 183	2 062
39.4	22.8	10.7	9.6	6.1	5.7
U.S.S.R.	**Canada**	Australia	New Caledonia	Cuba	Philippine Republic
140 000^e	128 310	80 900	66 100	37 000	29 500
22.5	20.7	13.0	10.6	6.0	4.8
U.S.	**Canada**	Poland	U.S.S.R.	France	Mexico
9 703	5 752	5 325	3 800	2 060	1 818
28.3	16.8	15.6	11.1	6.0	5.3
U.S.	**Canada**	Chile	U.S.S.R.	People's Republic of China	Peru
59 802	13 943	13 196	9 900^e	1 500^e	729
60.0	14.0	13.2	9.9	1.5	0.7
U.S.	**Canada**	Iran	France	U.S.S.R.	Spain
13 509	8 074	7 000	5 800	5 300^e	4 500
19.2	11.5	10.0	8.3	7.5	6.4
Australia	Norway	**Canada**	U.S.	U.S.S.R.	Malaysia
1 259 666	767 033	545 210	535 013	410 000^e	186 816
30.6	18.6	13.3	13.0	10.0	4.5
Mexico	U.S.S.R.	**Canada**	U.S.	Peru	Australia
1 579 403	1 430 800^e	1 266 927	1 199 692	1 152 228	773 170
14.9	13.5	12.0	11.3	10.9	7.3
U.S.S.R.	Republic of South Africa	**Canada**	Colombia	Australia	U.S.
94 865^e	91 755^e	10 768	434	286^e	256
47.5	46.0	5.4	0.2	0.1	0.1
Republic of South Africa	U.S.S.R.	**Canada**	U.S.	Papua-New Guinea	Australia
704 448	248 828^e	53 967	31 067	23 367	20 200
58.1	20.5	4.5	2.6	1.9	1.7
U.S.S.R.	U.S.	Australia	**Canada**	Peru	Mexico
600 000^e	541 000	400 300	365 800	182 700	170 500
16.6	15.0	11.1	10.1	5.1	4.7
U.S.	U.S.S.R.	Chile	**Canada**	Zambia	Zaire
1 357 600	1 140 000	1 035 500	659 380	643 000	423 800
17.2	14.5	13.2	8.4	8.2	5.4
U.S.	U.S.S.R.	Japan	**Canada**	West Germany	Norway
4 358 100	2 300 000^e	1 057 700	1 048 500	739 600	656 900
29.8	15.7	7.2	7.2	5.1	4.5
U.S.S.R.	Japan	U.S.	West Germany	**Canada**	Belgium
3 000^e	2 531	1 708	1 181	1 151	1 139
17.5	14.8	10.0	6.9	6.7	6.7
U.S.S.R.	Brazil	Australia	U.S.	People's Republic of China	**Canada**
240 800	85 000	83 189	82 784	70 000^e	42 931
28.4	10.0	9.8	9.8	8.3	5.1

TABLE 9. CANADA, CENSUS VALUE ADDED, COMMODITY-PRODUCING INDUSTRIES, 1971-77

	1971	1972	1973	1974	1975	1976	1977P
				($ million)			
Primary industries							
Agriculture	2,686	2,802r	4,593r	5,754r	6,130r	5,943	5,699
Forestry	698	829	1,109	1,244r	1,126r	1,348	1,440
Fishing	205	237	321r	293	293r	393	488
Hunting and trapping	11	17	28	31	21	31	44
Mining[1]	3,826	4,292	6,289	8,930	9,750	11,361	13,247
Electrical power	1,685	1,841	2,137	2,468	2,706	3,331	4,377
Total	9,111	10,018r	14,477r	18,720r	20,026r	22,407	25,295
Secondary industries							
Manufacturing	23,188	25,982	30,767	37,655	38,683r	42,553	46,776
Construction	7,581	8,244	9,695	11,850	13,718	17,271	18,275
Total	30,769	34,226	40,462	49,505	52,401r	59,824	65,051
Grand total	39,880	44,244r	54,939r	68,225r	72,427r	82,231	90,346

[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, 1973-77

	1973	1974	1975	1976	1977P
			($000)		
Mining					
Metallic minerals					
Gold-quartz	119,192	163,590	149,869	113,749	151,974
Copper-gold-silver	1,026,497	1,028,643	595,410	600,677	571,296
Silver-lead-zinc	292,731	382,281	320,776	233,678	279,831
Nickel-copper	820,344	1,049,650	729,656	888,080	672,980
Iron	345,830	403,910	556,710	732,118	807,267
Miscellaneous metal mines	106,713	143,301	211,517	270,105	418,093
Total	2,711,307	3,171,375	2,563,938	2,838,407	2,901,441
Industrial minerals					
Asbestos	176,368	239,816	230,612	373,206	474,812
Feldspar, quartz and nepheline syenite	13,933	15,339	14,707	18,454	22,468
Gypsum	16,748	16,542	14,861	15,753	21,023
Peat	14,216	19,772	20,556	23,726	27,364
Potash	128,957	232,652	298,471	262,052	301,367
Salt	36,731	49,751	45,888	70,671	70,902
Sand and gravel	59,841	83,522	102,305	99,014	91,251
Stone	66,999	92,852	111,031	110,988	106,075
Talc and soapstone	1,456	1,412	(1)	(1)	(1)
Miscellaneous nonmetals	12,400	20,711	25,711	23,899	23,116
Total	527,649	772,369	864,142	997,763	1,138,378
Fuels					
Coal	166,705	261,246	483,493	474,338	508,542
Petroleum and natural gas	2,883,273	4,724,990	5,838,459	7,050,003	8,698,328
Total	3,049,978	4,986,236	6,321,952	7,524,341	9,206,870
Total mining industry	6,288,934	8,929,980	9,750,032	11,360,511	13,246,689
Mineral manufacturing					
Primary metal industries					
Iron and steel mills	1,169,567	1,398,735	1,364,022	1,498,808	1,677,648
Steel pipe & tube mills	115,589	152,339	170,265	148,786	160,267
Iron foundries	163,711	222,415	238,117	241,893	257,682
Smelting and refining	590,724	794,193	886,405	812,654	1,176,050
Aluminum rolling, casting and extruding	94,600	146,721	132,636	149,366	193,671
Copper and alloy rolling, casting and extruding	91,040	91,301	68,282	71,429	78,467
Metal rolling, casting and extruding, nes	83,647	106,108	88,446	113,332	110,212
Total	2,308,878	2,911,812	2,948,173	3,036,268	3,653,997

(continued on following page)

TABLE 10. (cont'd)

	1973	1974	1975	1976	1977P
			($000)		
Mineral manufacturing (cont'd)					
Nonmetallic mineral products industries					
Cement manufacturers	172,236	190,396	210,342	249,142	274,976
Lime manufacturers	17,871	25,033	24,913	30,041	36,562
Concrete products manufacturers	197,733	248,548	282,131	282,089	273,484
Ready-mix concrete manufacturers	202,110	236,308	282,597	282,614	292,796
Clay products (domestic clay)	41,595	51,531	59,732	65,881	69,573
Clay products (imported clay)	33,802	41,661	41,698	39,078	39,798
Refractories manufacturers	28,075	37,163	45,823	44,393	32,544
Stone products manufacturers	11,002	12,327	13,975	16,282	19,568
Glass manufacturers	162,436	190,028	185,639	205,068	199,243
Glass products manufacturers	73,340	72,378	74,327	87,403	96,615
Abrasive manufacturers	38,038	45,962	43,863	55,076	64,111
Other nonmetallic mineral products industries	171,604	195,228	237,369	270,215	253,582
Total	1,149,842	1,346,563	1,502,409	1,627,282	1,652,852
Petroleum and coal products industries					
Petroleum refining	539,560	925,246	789,680	945,816	1,206,718
Manufacturers of lubricating oil and greases	22,410	26,289	32,633	32,635	36,837
Other petroleum and coal products industries	18,725	26,717	43,639	45,749	44,390
Total	580,695	978,252	865,952	1,024,200	1,287,945
Total mineral manufacturing	4,039,415	5,236,627	5,316,534	5,687,750	6,594,794
Total mining and mineral manufacturing	10,328,349	14,166,607	15,066,566	17,048,261	19,841,483

(1) Included with "Miscellaneous nonmetals".
P Preliminary; nes Not elsewhere specified.

TABLE 11. CANADA, INDEXES OF PHYSICAL VOLUME OF TOTAL INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING, 1966-79 (1971=100)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979p
Total industrial production	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	137.7
Total mining	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	113.4
Metals														
All metals	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	90.3
Placer gold and gold quartz mines	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	58.1
Iron mines	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	122.3
Other metal mines	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	83.9
Fuels														
All fuels	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	125.4
Coal	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	240.9
Crude oil and natural gas	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	116.0
Nonmetals														
All nonmetals	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	131.3
Asbestos	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	93.4
Mineral manufacturing														
Primary metals	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	124.5
Nonmetallic mineral products	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	135.1
Petroleum and coal products	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	145.6

p Preliminary.

TABLE 12. CANADA, INDEXES OF REAL DOMESTIC PRODUCT BY INDUSTRIES, 1970-79 (1971=100)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979P
Real domestic product, all industries	94.4	100.0	105.5	113.6	119.0	119.8	126.1	130.1	135.3	139.5
Agriculture	89.0	100.0	88.5	93.7	89.8	98.0	104.2	108.8	117.8	116.5
Forestry	103.3	100.0	102.4	123.9	117.8	97.6	112.3	116.4	123.8	127.3
Fishing and trapping	105.4	100.0	95.5	100.4	89.3	88.3	102.1	106.9	126.5	130.0
Mining (incl. milling), quarries and oil wells	98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3	113.4
Electric power, gas and water utilities	93.3	100.0	111.4	120.7	130.2	130.7	142.9	151.0	159.7	169.6
Manufacturing	94.5	100.0	107.1	117.6	122.0	114.3	120.8	124.1	133.8	138.0
Construction	90.9	100.0	102.4	107.5	112.6	116.7	122.8	121.8	120.7	123.1
Transportation, storage and communications	94.2	100.0	107.0	116.3	124.0	126.9	133.7	139.5	145.2	154.7
Trade	93.2	100.0	109.2	118.9	128.0	128.8	135.1	136.5	140.9	143.5
Community, business and personal service	95.5	100.0	104.2	108.8	115.0	119.9	125.7	129.9	134.0	138.2
Finance, insurance and real estate	94.6	100.0	106.0	114.7	120.6	127.8	135.6	143.7	150.5	155.7
Public administration and defence	95.2	100.0	104.3	109.8	114.0	119.6	123.0	126.1	128.8	127.1

P Preliminary.

TABLE 13. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS, 1975-79

	1975	1976	1977	1978	1979P
			($ million)		
Ferrous					
Crude material	721.5	984.4	1,115.0	853.6	1,469.5
Fabricated material	913.1	1,007.4	1,242.9	1,695.7	1,948.1
Total	1,634.6	1,991.8	2,357.9	2,549.3	3,417.6
Nonferrous					
Crude material	1,519.6	1,528.0	1,614.8	1,549.2	2,419.5
Fabricated material	1,843.5	2,231.4	2,578.5	3,359.7	3,802.7
Total	3,363.1	3,759.4	4,193.3	4,908.9	6,222.2
Nonmetals					
Crude material	794.9	1,103.4	1,276.0	1,375.8	1,715.3
Fabricated material	162.7	194.7	253.6	377.2	455.5
Total	957.6	1,298.1	1,529.6	1,753.0	2,170.8
Mineral fuels					
Crude material	4,637.3	4,464.0	4,428.9	4,514.8	6,128.9
Fabricated material	638.5	562.0	649.1	776.6	1,879.1
Total	5,275.8	5,026.0	5,078.0	5,291.4	8,008.0
Total minerals and products					
Crude material	7,673.3	8,079.8	8,434.7	8,293.4	11,733.2
Fabricated material	3,557.8	3,995.5	4,724.1	6,209.2	8,085.4
Total	11,231.1	12,075.3	13,158.8	14,502.6	19,818.6

P Preliminary.

TABLE 14. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS, 1975-79

	1975	1976	1977	1978	1979P
			($ million)		
Ferrous					
Crude material	179.5	129.8	106.0	223.8	322.1
Fabricated material	1,494.7	1,274.0	1,501.0	1,838.9	2,529.9
Total	1,674.2	1,403.8	1,607.0	2,062.7	2,852.0
Nonferrous					
Crude material	288.9	294.6	409.0	476.0	765.8
Fabricated material	621.8	600.4	662.1	949.7	2,162.7
Total	910.7	895.0	1,071.1	1,425.7	2,928.5
Nonmetals					
Crude material	183.0	157.9	170.6	222.9	277.5
Fabricated material	358.7	413.5	472.0	537.1	653.5
Total	541.7	571.4	642.6	760.0	931.0
Mineral fuels					
Crude material	3,886.8	3,834.1	3,876.4	4,106.8	5,345.4
Fabricated material	275.8	219.7	299.7	378.3	389.6
Total	4,162.6	4,053.8	4,176.1	4,485.1	5,735.0
Total minerals and products					
Crude material	4,538.2	4,416.4	4,562.0	5,029.5	6,710.8
Fabricated material	2,751.0	2,507.6	2,934.8	3,704.0	5,735.7
Total	7,289.2	6,924.0	7,496.8	8,733.5	12,446.5

P Preliminary.

TABLE 15. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL EXPORT TRADE, 1975-79

	1975		1976		1977		1978		1979P	
	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total
Crude material	7,673.3	23.6	8,079.8	21.5	8,434.7	19.3	8,293.4	16.0	11,733.2	18.3
Fabricated material	3,557.8	10.9	3,995.5	10.6	4,724.1	10.8	6,209.2	12.0	8,085.4	12.6
Total	11,231.1	34.5	12,075.3	32.1	13,158.8	30.1	14,502.6	28.0	19,818.6	30.9
Total exports, all products	32,586.9	100.0	37,650.7	100.0	43,683.9	100.0	51,918.9	100.0	64,193.6	100.0

P Preliminary.

TABLE 16. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL IMPORT TRADE, 1975-79

	1975		1976		1977		1978		1979P	
	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total
Crude material	4,538.2	13.0	4,416.4	12.0	4,562.0	10.8	5,029.5	10.1	6,710.8	10.7
Fabricated material	2,751.0	7.9	2,507.6	6.7	2,934.8	6.9	3,704.0	7.4	5,735.7	9.2
Total	7,289.2	20.9	6,924.0	18.7	7,496.8	17.7	8,733.5	17.5	12,446.5	19.9
Total imports, all products	34,829.7	100.0	37,494.0	100.0	42,332.3	100.0	49,937.7	100.0	62,677.7	100.0

P Preliminary.

TABLE 17. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS AND DESTINATION, 1979P

	United Kingdom	United States	Other Countries	Total
		($ million)		
Ferrous materials and products	182.4	2,512.9	722.3	3,417.6
Nonferrous materials and products	612.8	3,268.7	2,340.7	6,222.2
Nonmetallic mineral materials and products	63.0	1,160.7	947.1	2,170.8
Mineral fuels, materials and products	9.2	6,683.5	1,315.3	8,008.0
Total	867.4	13,625.8	5,325.4	19,818.6
Percentage of total mineral exports	4.4	68.7	26.9	100.0

P Preliminary.

TABLE 18. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS AND DESTINATION, 1979P

	United Kingdom	United States	Other Countries	Total
		($ million)		
Ferrous materials and products	219.7	1,795.5	836.8	2,852.0
Nonferrous materials and products	69.7	2,254.2	604.6	2,928.5
Nonmetallic mineral materials and products	26.7	671.3	233.0	931.0
Mineral fuels, materials and products	29.4	2,217.6	3,488.0	5,735.0
Total	345.5	6,938.6	5,162.4	12,446.5
Percentage of total mineral exports	2.8	55.7	41.5	100.0

P Preliminary.

TABLE 19. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY COMMODITY AND DESTINATION, 1979p

	United States	United Kingdom	E.F.T.A.[1]	E.E.C.[2]	Japan	Other Countries	Total
				($ 000)			
Aluminum	609,239	7,176	19,054	28,723	129,004	203,467	996,663
Asbestos	180,122	47,039	19,648	159,486	48,464	234,513	689,272
Copper	323,550	146,157	43,555	140,383	374,632	131,667	1,159,944
Fuels	6,683,457	9,210	62,499	270,432	615,775	366,589	8,007,962
Iron ore	782,037	163,205	2,979	292,372	72,682	40,810	1,354,085
Lead	98,544	51,418	3,951	35,575	71,528	16,943	277,959
Molybdenum	30,956	30,501	6,289	99,582	76,128	7,461	250,917
Nickel	454,212	139,030	117,886	126,339	30,926	42,873	911,266
Primary ferrous metals	159,426	4,643	198	44,186	9,583	41,742	259,778
Uranium	347,388	18,851	-	12,613	9	1	378,862
Zinc	272,529	45,209	4,078	130,880	64,029	84,172	600,897
All other minerals	3,684,237	205,045	51,175	162,942	173,151	654,483	4,931,033
Total	13,625,697	867,484	331,312	1,503,513	1,665,911	1,824,721	19,818,638

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-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], 1976-79p

	Unit of Measure	1976 Apparent Consumption	1976 Production	1976 Consumption as % of production	1977 Apparent Consumption	1977 Production	1977 Consumption as % of production
Asbestos	t	39 659r	1 536 091	2.6	105 990r	1 517 360	7.0
Cement	t	8 923 466r	9 515 452	93.8	8 622 839	9 639 679	89.5
Gypsum	t	2 258 680r	6 002 154	37.6	2 263 650	7 233 931	31.3
Iron ore	t	13 751 609	55 416 346	24.8	11 065 909	53 621 097	20.6
Lime	t	1 657 920r	1 930 393r	85.9	1 664 984r	2 000 044r	83.2
Quartz (silica)	t	3 686 005r	2 395 948r	153.8	3 362 788	2 316 680	145.2
Salt	t	6 093 579r	5 994 019r	101.7	6 002 545	6 039 483	99.4

	Unit of Measure	1978 Apparent Consumption	1978 Production	1978 Consumption as % of production	1979p Apparent Consumption	1979p Production	1979p Consumption as % of production
Asbestos	t	24 491	1 421 808	1.7	41 917	1 501 000	2.8
Cement	t	9 141 619	10 558 279	86.6	9 740 571	11 835 000	82.3
Gypsum	t	2 966 805	8 074 441	36.7	2 782 697	8 105 000	34.3
Iron ore	t	15 687 577	42 930 803	36.5	17 248 535	60 185 000	28.7
Lime	t	1 586 789	2 034 211	78.0	1 642 608	2 092 000	78.5
Quartz (silica)	t	3 341 674	2 165 050	154.3	3 838 326	2 246 000	170.9
Salt	t	6 173 785	6 451 894	95.7	6 336 701	6 882 640	92.1

[1] Apparent consumption is production, plus imports, less exports. [2] Production refers to producers' shipments.
p Preliminary; r Revised.

TABLE 21. CANADA, REPORTED CONSUMPTION OF MINERALS

	Unit of Measure	1976 Consumption	1976 Production	1976 Consumption as % of production	1977 Consumption	1977 Production	1977 Consumption as % of production
Metals							
Aluminum	t	322 206	628 137	51.3	332 393	973 106	34.2
Antimony	kg	437 998	..	..	370 867	..	..
Bismuth	kg	21 105	129 578	16.3	25 016	164 685	15.2
Cadmium	kg	53 815	1 313 723	4.1	50 369	1 185 446	4.3
Chromium (chromite)	t	30 783	-	..	30 299	-	..
Cobalt	kg	160 492	1 356 337	11.8	146 763	1 484 669	9.9
Copper	t	206 205[1]	730 930	28.2	200 372[1]	759 423	26.4
Lead	t	107 654[2]	256 323	42.0	106 962[2]	280 955	38.1
Magnesium	t	4 230	6 092	69.4	6 222	7 633	81.5
Manganese ore	t	238 629	-	..	182 157	-	..
Mercury	kg	26 039	-	..	30 447	-	..
Molybdenum (Mo content)	kg	1 260 329	14 618 607	8.6	1 149 736[r]	16 567 555	6.9
Nickel	t	9 972	240 825	4.1	9 033	232 512	3.9
Selenium	kg	11 212	109 649	10.2	12 476	161 308	7.7
Silver	kg	551 212	1 281 437	43.0	298 724	1 313 685	22.7
Tellurium	kg	589	48 698	1.2	291	35 116	0.8
Tin	t	4 849	274	1 769.7	5 286	328	1 611.6
Tungsten (W content)	kg	337 345	2 168 153	15.6	449 365	2 284 409	19.7
Zinc	t	98 897[2]	982 057	10.1	105 412[2]	1 070 515	9.9
Nonmetals							
Barite	t	58 066	100 266	57.9	53 508	116 950	45.8
Feldspar	t	4 053	-	..	4 271	-	..
Fluorspar	t	128 352	113 061	113.5	119 991	95 354	125.8
Mica	kg	5 023 989	..	..	4 221 132	..	..
Nepheline syenite	t	103 241	540 121	19.1	86 014	574 558	15.0
Phosphate rock	t	1 582 861	-	..	1 671 399	-	..
Potash (K_2O)	t	242 077[3]	5 215 435	4.6	234 232[3]	5 764 181	4.1
Sodium sulphate	t	265 608	460 193	57.7	254 872	394 795	64.6
Sulphur	t	651 032	4 029 427	16.2	687 381	5 207 028	13.2
Talc, etc.	t	43 595	68 834	63.3	41 884	72 400	57.9
Fuels							
Coal	t	28 219 804	25 476 044	110.8	30 895 999	28 681 759	107.7
Natural gas	$000m^3$	38 834 918[4]	87 683 816	44.3	40 547 055[4]	91 147 120	44.5
Crude oil	m^3	98 326 624[5]	76 075 000	129.2	104 238 897[5]	76 447 000	136.4

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 or not applicable; [e] Estimated; [r] Revised.

AND RELATION TO PRODUCTION, 1976-79

1978			1979[p]		
Consumption	Production	Consumption as % of production	Consumption	Production	Consumption as % of production
380 290	1 048 469	36.3	399 049	860 287	46.4
347 906	..	..	351 627	..	..
25 664	145 104	17.7	25 177	136 733	18.4
47 523	1 151 298	4.1	48 746	1 209 459	4.0
27 472	-	..	27 205	-	..
144 610	1 233 777	11.7	114 606	1 639 624	7.0
228 694[1]	659 380	34.7	210 689[1]	636 383	33.1
100 762[2]	319 809	31.5	126 464[2]	310 745	40.7
3 953	8 309	47.6	4 450	9 015	49.4
201 320	-	..	61 643	-	..
29 904	-	..	26 249	-	..
1 268 640	13 943 405	9.1	1 249 944	11 174 586	11.2
11 790	128 310	9.2	8 336	126 482	6.6
14 364	122 405	11.7	15 773	217 759	7.2
329 320	1 266 927	2.6	251 985	1 146 908	22.0
..	31 421	0.9	..	42 433	..
4 922	360	1 367.2	4 675	338	1 383.1
388 146	2 885 619	13.5	380 229	3 254 067	11.7
121 375[2]	1 066 902	11.4	131 317[2]	1 099 926	11.9
60 785	99 339	61.2	79 863	73 512	108.6
4 586	-	..	4 406	-	..
128 280[r]	-	..	107 004	-	..
4 222 000	..	..	4 498 000	..	..
88 806	599 121	14.8	..	605 699	..
1 833 796	-	..	2 139 420	-	..
..	6 344 010	..	..	7 074 388	..
227 766	376 563	60.5	255 050	443 279	57.5
799 709	5 752 208	13.9	791 482	6 314 144	12.5
43 119	61 661	69.9	46 940	90 330	52.0
31 738 310	30 478 000	104.1	34 764 012	33 200 000	104.7
41 745 254[4]	80 609 000	51.8	43 495 087[4]	94 426 000	46.1
103 746 001[5]	76 348 000	135.9	112 659 758[5]	86 910 000	129.6

TABLE 22. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION[1], 1970-79

	Unit of Measure	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979p
Copper											
Domestic consumption[2]	t	215 834	200 536	207 661	230 982	247 985	185 194	206 205	200 372	228 694	210 689
Production	t	493 261	477 545	495 944	497 581	559 125	529 199	510 469	508 767	446 278	397 263
Consumption of production	%	43.8	42.0	41.9	46.4	44.4	35.0	40.4	39.4	51.2	53.0
Zinc											
Domestic consumption[3]	t	98 306	109 380	125 019	116 386	117 619	98 280	98 897	105 412	121 375	131 317
Production	t	413 196	372 529	476 423	532 556	437 725	426 902	472 316	494 938	495 420	580 449
Consumption of production	%	23.8	29.4	26.2	21.9	26.9	23.0	20.9	21.3	24.5	22.6
Lead											
Domestic consumption[3]	t	84 765	85 835	78 559	108 349	99 734	89 192	107 654	110 763	100 761	126 464
Production	t	185 637	168 332	186 860	186 891	126 460	171 517	175 720	187 457	194 054	183 769
Consumption of production	%	45.7	51.0	42.0	58.0	78.9	52.0	61.3	59.1	51.9	68.8
Aluminum											
Domestic consumption[4]	t	250 150	292 188	302 591	331 782	359 790	293 280	332 206	322 393	380 291	399 049
Production	t	962 541	1 002 116	907 130	930 210	1 006 632	878 056	628 049	973 524	1 048 469	860 287
Consumption of production	%	26.0	29.2	33.4	35.7	35.7	33.4	51.3	34.1	36.3	46.4

[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.

TABLE 23. AVERAGE ANNUAL PRICES[1] OF MAIN METALS, 1975-79

	Unit of Measure	1975	1976	1977	1978	1979
Aluminum, major U.S. producer	cents/lb	39.786	44.341	51.339	53.075	59.395
Antimony, New York dealer	cents/lb	149.425	156.105	123.716	114.461	140.695
Bismuth, U.S. producer	$/lb	7.715	7.500	6.010	3.378	3.011
Cadmium, U.S. producer	cents/lb	335.500	266.200	296.200	245.000	276.000
Calcium, metal crowns	$/lb	1.315	1.335	1.482	1.680	1.868
Chrome, U.S. metal, 9% carbon	$/lb	2.57	2.64	2.90	3.08	3.375
Cobalt metal, shot/cathode/250 kg	$/lb	3.979	4.508	5.633	12.246	24.583
Columbite, spot ore	$/lb	1.800-1.900	2.500-2.800	2.637-3.500	2.883-3.521	4.792-5.542
Copper, U.S. producer refinery	cents/lb	63.535	68.824	65.808	65.510	92.334
Gold, London free market[2]	$Cdn/troy oz	163.781	123.107	157.089	220.407	359.289
Iridium, major producer	$/troy oz	475.00-485.00	316.666-326.666	300.00-310.00	300.00-310.00	258.333-313.333
Iron ore						
Non-Bessemer						
Mesabi	$/lt	17.890	18.500-19.670	21.103-21.180	21.647	22.300
Lead, U.S. producer	cents/lb	21.529	23.102	30.703	33.653	52.642
Manganese, U.S. metal, regular	cents/lb	54.000	55.333-57.000	58.000	58.000	58.333-59.000
Magnesium, U.S. primary ingot	cents/lb	82.000	89.537	97.487	100.500	105.758
Mercury, New York	$/flask (76 lb)	158.115	121.302	135.710	153.322	281.096
Molybdenum, climax concentrate	$/lb	2.493	2.999	3.730	4.644	7.762
Nickel, major producer cathode	cents/lb	207.300	225.600	236.000	209.100	270.700
Osmium, major producer	$/troy oz	200.00-225.00	200.00-225.00	170.00-184.00	150.00-155.00	150.00-155.00
Palladium, major producer	$/troy oz	92.702	50.928	59.702	70.873	113.143
Platinum, major producer	$/troy oz	164.005	161.729	162.544	237.250	351.649
Rhodium, major producer	$/troy oz	337.50-347.50	350.00-364.166	441.666-453.750	516.667-525.00	737.50-745.833
Ruthenium, major producer	$/troy oz	60.00-65.00	60.00-65.00	60.00-65.00	60.00-65.00	45.00
Selenium, major producer commercial	$/lb	18.00	18.00	17.00	15.00	12.250
Silver, Handy & Harman, N.Y.	cents/troy oz	441.852	435.346	462.302	540.089	1,109.418
Tellurium, major producer, slab	$/lb	9.333	10.500-11.083	17.416-17.666	20.000-22.500	20.000-23.000
Tin, New York dealer	cents/lb	320.345	349.241	499.381	587.032	711.446
Titanium, U.S. sponge	$/lb	2.554	2.700	2.671-2.784	3.105	3.860
Titanium, rutile ore	$/st	710.000	526.666	485.000	317.500	368.750
Tungsten, U.S. hydrogen red metal	$/lb	10.210-12.010	10.087-12.337	14.065-15.050	13.900-15.500	13.900-15.500
Vanadium, pentoxide metal	$/lb	2.980-3.060	2.600-3.229	2.750-3.350	2.950-3.810	3.050-3.730
Zinc, U.S. prime western	cents/lb	38.959	37.010	34.392	30.971	37.296

[1] These prices except for gold, are in United States currency and are quoted from "Metals Week". [2] Average of p.m. fixings of the London Gold Market, converted to Canadian dollars.

TABLE 24. CANADA, MINERAL PRODUCTS INDUSTRIES, SELLING PRICE INDEXES, 1976-79 (1971 = 100)

	1976	1977	1978	1979P
Iron and steel products industries				
Agricultural implements industry	165.7	177.6	188.7	206.0
Hardware, tool and cutlery manufacturers	147.3	162.6	179.1	207.3
Heating equipment manufacturers	146.9	156.5	169.8	188.1
Primary metal industries	169.9	190.5	207.7	258.8
Iron and steel mills	177.2	187.9	203.9	233.7
Steel pipe and tube mills	179.1	197.8	218.0	248.1
Iron foundries	181.0	189.6	200.1	223.3
Wire and wire products manufacturers	171.0	175.4	185.8	206.4
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	155.8	173.6	191.5	234.0
Copper and alloy, rolling, casting and extruding	138.4	144.5	153.0	201.8
Jewellery and silverware manufacturers	235.2	277.8	337.6	507.3
Metal rolling, casting and extruding, nes	181.0	216.3	239.8	310.4
Nonmetallic mineral products industries				
Abrasives manufacturers	167.5	194.7	223.6	255.3
Cement manufacturers	171.1	186.7	207.5	233.3
Clay products and manufacturers from imported clay	161.7	164.7	173.7	190.1
Glass and glass products manufacturers	138.6	150.4	162.1	173.4
Lime manufacturers	204.3	228.7	252.9	292.8
Concrete products manufacturers	161.5	173.7	187.7	200.1
Clay products from domestic clay	169.6	182.8	196.4	214.3
Petroleum and coal products industries	210.2	244.5	275.4	321.3
Petroleum refineries	211.5	246.7	278.7	325.8
Mixed fertilizers	176.9	180.2	191.0	229.0

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.

TABLE 25. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1977

	Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establish-ments	Employees	Man-hours paid	Wages	Fuel and Electri-city	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	18	3,839	8,142	58,542	9,075	45,663	206,303	151,564	4,645	72,753	151,974
Copper-gold-silver	33	11,362	24,077	203,753	63,963	628,593	1,257,872	565,316	15,590	284,969	571,296
Silver-lead-zinc	24	5,500	11,434	97,192	29,526	377,508	700,420	293,386	7,512	139,251	279,831
Nickel-copper	5	14,295	27,774	214,763	32,571	528,252	1,221,313	660,490	18,113	298,336	672,980
Iron	19	10,070	21,201	202,926	130,061	428,801	1,383,634	824,772	15,550	332,069	807,267
Misc. metal mines	13	4,348	8,621	72,169	18,395	106,422	537,131	412,314	5,835	99,681	418,093
Total	112	49,414	101,249	849,345	283,591	2,115,240	5,306,673	2,907,842	67,245	1,227,059	2,901,441
Nonmetals											
Asbestos	10	6,375	15,369	115,121	35,045	92,015	601,731	474,671	8,302	150,304	474,812
Feldspar, quartz and nepheline syenite	15	414	929	6,724	2,309	6,507	31,317	22,501	526	8,433	22,468
Gypsum	9	554	1,224	6,847	1,949	7,881	30,953	21,123	652	8,266	21,023
Peat	52	1,042	2,048	9,434	1,264	7,413	34,239	25,561	1,244	12,145	27,364
Potash	9	2,737	5,596	44,958	29,826	49,520	379,694	300,348	3,628	62,419	301,367
Salt	9	930	1,932	13,538	6,227	13,839	91,657	71,591	1,364	21,087	70,902
Sand and gravel	131	1,639	3,717	23,734	8,239	25,182	122,530	89,110	2,186	34,774	91,251
Stone	124	2,387	5,513	35,752	11,012	48,694	166,507	106,801	3,004	45,571	106,075
Misc. nonmetals	19	734	1,515	10,186	6,588	7,811	37,516	23,117	892	13,053	23,116
Totals	378	16,812	37,843	266,294	102,459	258,863	1,496,144	1,134,823	21,798	356,051	1,138,378
Fuels											
Coal	23	8,488	17,710	134,276	25,303	165,497	699,502	508,703	9,781	167,190	508,542
Oil, crude and natural gas	719	5,191	11,082	92,593	61,849	175,868	8,898,141	8,660,424	20,240	387,223	8,698,328
Total	742	13,679	28,792	226,869	87,152	341,365	9,597,643	9,169,127	30,021	554,413	9,206,870
Total mining industry	1,232	79,905	167,884	1,342,508	473,202	2,715,468	16,400,460	13,211,792	119,064	2,137,523	13,246,689

[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, 29 and 31. [2] Total activity includes sales and head offices.

TABLE 26. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1977

	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)
Primary metal industries											
Iron and steel mills	48	41,295	84,747	677,595	229,487	1,992,722	3,843,555	1,683,276	52,709	917,892	1,677,648
Steel pipe and tube mills	27	4,704	10,460	73,120	11,070	339,709	503,758	157,781	5,634	90,397	160,267
Iron foundries	106	8,739	17,863	118,382	16,984	196,556	465,239	250,701	10,459	148,144	257,682
Smelting and refining	30	25,217	51,271	375,106	179,016	735,810	2,053,063	1,138,237	35,647	580,691	1,176,050
Aluminum rolling, casting and extruding	59	5,313	11,045	73,939	12,582	467,866	648,007	193,434	6,884	101,884	193,671
Copper and alloy rolling, casting and extruding	38	2,691	5,619	38,394	6,268	289,179	378,341	80,754	3,183	47,166	78,467
Metal rolling, casting and extruding, nes	74	3,724	7,716	42,854	7,339	198,942	309,510	106,723	4,703	59,173	110,212
Total	382	91,683	188,721	1,399,390	462,746	4,220,784	8,201,473	3,610,906	119,219	1,945,347	3,653,997
Nonmetallic mineral products industries											
Cement manufacturers	25	2,795	5,841	51,483	95,044	74,690	436,009	271,878	4,265	84,498	274,976
Lime manufacturers	16	645	1,360	9,249	18,348	7,872	62,532	36,396	828	12,359	36,562
Concrete products manufacturers	387	7,754	16,742	107,006	14,544	182,451	460,947	267,712	10,001	146,216	273,484
Ready-mix concrete manufacturers	335	6,732	14,468	108,838	19,414	372,898	672,024	281,667	8,521	137,646	292,796
Clay products manufacturers (domestic)	57	2,302	4,852	28,351	14,446	20,958	100,376	68,873	2,820	38,234	69,573
Clay products (manufacturers (imported)	34	1,395	2,913	15,963	2,662	20,684	62,317	39,576	1,733	20,889	39,798
Refractories manufacturers	13	585	1,247	8,121	4,853	37,651	71,537	27,080	1,134	16,177	32,544
Stone products manufacturers	85	755	1,587	8,071	759	11,132	30,888	19,831	934	10,803	19,568
Glass and glass products manufacturers	77	9,104	19,153	126,037	34,638	176,075	496,473	290,584	11,204	164,682	295,858
Abrasive manufacturers	20	1,966	4,131	25,895	16,993	69,301	149,989	64,415	2,557	35,230	64,111
Other nonmetallic mineral products industries	82	5,288	11,141	75,430	25,806	184,718	447,851	237,515	8,511	127,565	253,582
Total	1,131	39,321	83,435	564,444	247,507	1,158,430	2,990,943	1,605,527	52,508	794,299	1,652,852

Petroleum and coal products industries											
Petroleum refining industry	39	6,813	14,344	134,899	84,145	7,234,934	8,327,309	1,195,925	16,464	353,981	1,206,718
Manufacture of lubricating oils & greases	18	383	807	4,894	1,219	82,125	115,928	34,995	669	10,297	36,837
Other petroleum & coal products industries	46	500	1,102	6,773	2,869	46,944	89,429	41,758	716	10,820	44,390
Total	103	7,696	16,253	146,566	88,233	7,364,003	8,532,666	1,272,678	17,849	375,098	1,287,945
Total, mineral manufacturing industries	1,616	138,700	288,409	2,110,400	798,486	12,743,217	19,725,082	6,489,111	189,576	3,114,744	6,594,794

1 Industry coverage is the same as in Tables 28, 30 and 32. 2 Includes sales and head offices.
nes - Not elsewhere specified.

TABLE 27. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1972-77

		Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs							
	Establish-ments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electri-city ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)		Employees (number)	Salaries and Wages ($000)	Value Added ($000)
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	25,767	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
1977	1,232	79,905	167,884	1,342,508	473,202	2,715,468	16,400,460	13,211,792		119,064	2,137,523	13,246,689

[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 25, 29 and 31. [2] Includes sales and head offices.

TABLE 28. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1972-77

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
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
1977	1,616	138,700	288,409	2,110,400	798,486	12,743,217	19,725,082	6,489,111	189,576	3,114,744	6,594,794

[1] Industry coverage is the same as in Tables 26, 30 and 32. [2] Includes sales and head offices.

TABLE 29. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINING INDUSTRY[1], 1977

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 t	126	12	-	138
	$000	2,831	159	-	2,990
Gasoline	000 litres	27 486	30 582	6 633	64 701
	$000	4,819	5,249	955	11,023
Fuel oil, kerosene, diesel oil	000 litres	1 353 525	373 565	83 738	1 810 826
	$000	115,024	41,044	9,621	165,691
Liquefied petroleum gas	000 litres	91 713	4 746	1 777	98 236
	$000	8,406	655	153	9,214
Natural gas	000 m^3	321 538	724 147	98 005	1 143 690
	$000	17,431	25,839	4,388	47,657
Other fuels[2]	$000	67	-	-	67
Total value of fuels	$000	148,578	72,946	15,117	236,642
Electricity purchased	million kwh	11 713	2 457	2 791	16 961
	$000	135,014	29,510	72,035	236,559
Total value of fuels and electricity purchased, all reporting companies	$000	283,591	102,459	87,152	473,202

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing, Tables 30 and 32. Industry coverage is the same as in Tables 25, 27, and 31. [2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
- Nil.
Note: Totals may not add due to rounding.

TABLE 30. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1977

	Unit	Primary Metal Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 t	325	485	-	810
	$000	26,640	16,423	-	43,063
Gasoline	000 litres	16 989	54 639	3 446	75 074
	$000	2,710	8,985	584	12,279
Fuel oil, kerosene, diesel oil	000 litres	1 460 554	837 685	30 022	2 328 261
	$000	103,023	66,038	2,621	171,682
Liquefied petroleum gas	000 litres	35 123	21 244	141	56 508
	$000	3,530	2,291	15	5,836
Natural gas	000 m^3	2 296 581	1 631 843	809 720	4 738 144
	$000	135,021	86,630	36,016	257,667
Other fuels	$000	8,248	1,585	2,948	12,781
Total value of fuels	$000	279,172	181,952	42,184	503,308
Electricity purchased	million kWh	15 352	4 190	3 205	22 747
	$000	183,574	65,553	46,050	295,177
Total value of fuels and electricity purchased, all reporting companies	$000	462,746	247,507	88,233	798,486

[1] Industry coverage is the same as in Tables 26, 28 and 32.
- Nil.

TABLE 31. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINING INDUSTRY[1], 1970-77

	Unit	1970	1971	1972	1973	1974	1975	1976	1977
Metals									
Fuel	$000	33,370	39,887	40,505	54,430	90,596	107,808	128,637	148,578
Electricity purchased	million kWh	7 995	8 692	8 807	10 032	10 282	10 259	11 326	11 713
	$000	52,257	56,847	58,103	68,089	77,669	85,063	107,318	135,014
Total cost of fuel and electricity	$000	85,627	96,734	98,608	122,519	168,265	192,871	235,955	283,592
Electricity generated for own use and for sale	million kWh	459	359	446	..	..	..	..	..
Nonmetals[2]									
Fuel	$000	20,029	22,951	25,277	29,101	42,209	46,561	62,453	72,946
Electricity purchased	million kWh	1 468	1 584	1 642	1 782	2 015	1 763	1 959	2 457
	$000	13,980	14,474	15,080	16,593	20,065	20,049	23,401	29,510
Total cost of fuel and electricity	$000	34,009	37,425	40,357	45,694	62,274	66,610	85,854	102,458
Electricity generated for own use and for sale	million kWh	161	178	194	..	..	..	..	..
Fuels									
Fuels	$000	2,072	2,635	4,103	4,600	5,755	11,352	12,015	15,117
Electricity purchased	million kWh	1 540	1 763	2 154	2 792	2 972	2 539	2 770	2 791
	$000	24,320	27,528	32,494	42,283	49,473	48,663	68,075	72,035
Total cost of fuel and electricity	$000	26,392	30,163	36,597	46,883	55,228	60,015	80,090	87,152
Electricity generated for own use and for sale	million kWh	-	-	-	-	-	-	-	-
Total mining industry									
Fuel	$000	55,470	65,473	69,885	88,131	138,560	165,721	203,105	236,642
Electricity purchased	million kWh	11 003	12 039	12 603	14 606	15 267	14 560	16 055	16 961
	$000	90,558	98,849	105,677	126,965	147,207	153,775	198,794	236,559
Total cost of fuel and electricity	$000	146,028	164,322	175,562	215,096	285,767	319,496	401,899	473,202
Electricity generated for own use and for sale	million kWh	620	537	640	..	..	..	..	..

[1] Cement and lime manufacturing and manufacture of clay products (domestic clays) are included in mineral manufacturing, Tables 30 and 32. Industry coverage is the same as in Tables 25, 27 and 29. [2] Includes structural materials.

vailable; - Nil.

TABLE 32. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1970-77

	Unit	1970	1971	1972	1973	1974	1975	1976	1977
Primary metals									
Fuel	$ 000	83,034	92,903	90,850	103,321	153,468	187,846	224,928	279,172
Electricity purchased	million kWh	14 539	15 028	15 678	16 584	17 727	16 544	16 497	15 352
	$ 000	87,656	90,512	95,447	108,575	122,567	129,750	151,011	183,574
Total cost of fuel and electricity	$ 000	170,690	183,415	186,297	211,896	276,035	317,596	375,939	462,746
Nonmetallic mineral products									
Fuel	$ 000	49,451	57,249	65,166	75,144	112,531	133,016	162,312	181,952
Electricity purchased	million kWh	3 270	3 279	2 280	4 080	4 106	3 723	4 137	4 190
	$ 000	24,507	25,932	29,367	34,624	38,671	41,258	52,113	65,553
Total cost of fuel and electricity	$ 000	73,958	83,181	94,533	109,768	151,202	174,274	214,425	247,507
Petroleum and coal products									
Fuel	$ 000	4,749	5,346	6,431	7,796	13,275	21,758	30,474	42,184
Electricity purchased	million kWh	2 171	2 326	2 475	2 683	2 715	2 904	3 010	3 205
	$ 000	14,430	16,074	17,444	20,061	22,885	28,028	34,988	46,050
Total cost of fuel and electricity	$ 000	19,179	21,420	23,875	27,857	36,160	49,786	65,462	88,233
Total mineral manufacturing industries									
Fuel	$ 000	137,234	155,498	162,447	186,261	279,274	342,620	417,714	503,308
Electricity purchased	million kWh	19 980	20 633	20 433	23 347	24 548	23 171	23 644	22 747
	$ 000	126,593	132,518	142,258	163,260	184,123	199,036	238,112	295,177
Total cost of fuel and electricity	$ 000	263,827	288,016	304,705	349,521	463,397	541,656	655,826	798,486

[1] Industry coverage is the same as in Tables 26, 28 and 30.

TABLE 33. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINING INDUSTRY[1], 1970-77

	Unit	1970	1971	1972	1973	1974	1975	1976	1977
Metals									
Production and related workers	Number	51,102	50,121	46,257	47,984	50,886	50,319	49,834	49,414
Salaries and wages	$000	421,893	434,222	430,919	494,631	580,185	685,562	759,499	849,345
Annual average salary and wage	$	8,256	8,664	9,316	10,308	11,402	13,624	15,241	17,188
Administrative and office workers	Number	15,488	15,891	15,737	18,150	19,152	18,842	18,435	17,831
Salaries and wages	$000	158,653	178,640	189,669	238,454	282,348	320,873	352,847	377,714
Annual average salary and wage	$	10,244	11,242	12,052	13,138	14,732	17,030	19,140	21,183
Total metals									
Employees	Number	66,590	66,012	61,994	66,134	70,038	69,161	68,269	67,245
Salaries and wages	$000	580,546	612,862	620,588	733,085	862,533	1,006,435	1,112,346	1,227,059
Annual average salary and wage	$	8,718	9,284	10,011	11,085	12,315	14,552	16,294	18,248
Nonmetals									
Production and related workers	Number	16,245	16,155	15,911	16,332	17,767	15,397	16,447	16,812
Salaries and wages	$000	114,345	122,355	131,371	147,027	180,962	188,956	237,982	266,294
Annual average salary and wage	$	7,039	7,574	8,257	9,002	10,185	12,272	14,470	15,840
Administrative and office workers	Number	4,415	4,278	4,109	4,335	4,628	4,688	4,887	4,986
Salaries and wages	$000	39,533	40,222	43,030	47,092	57,243	69,208	82,861	89,757
Annual average salary and wage	$	8,954	9,402	10,472	10,863	12,369	14,763	16,955	18,002
Total nonmetals									
Employees	Number	20,660	20,433	20,020	20,667	22,395	20,085	21,334	21,798
Salaries and wages	$000	153,878	162,577	174,401	194,119	238,205	258,164	320,843	356,051
Annual average salary and wage	$	7,448	7,957	8,711	9,393	10,637	12,854	15,039	16,334
Fuels									
Production and related workers	Number	9,861	10,425	10,876	10,849	11,275	11,375	12,708	13,679
Salaries and wages	$000	77,846	90,324	104,215	110,220	133,392	155,491	187,704	226,869
Annual average salary and wage	$	7,894	8,664	9,582	10,160	11,831	13,670	14,771	16,585
Administrative and office workers	Number	12,983	13,540	14,432	13,793	15,022	15,094	15,383	16,342
Salaries and wages	$000	131,744	149,898	169,579	177,447	216,200	235,188	281,789	327,544
Annual average salary and wage	$	10,147	11,071	11,750	12,865	14,392	15,582	18,318	20,043
Total fuels									
Employees	Number	22,844	23,965	25,308	24,642	26,297	26,469	28,091	30,021
Salaries and wages	$000	209,590	240,222	273,794	287,667	349,592	390,679	469,493	554,413
Average annual salary and wage	$	9,175	10,024	10,818	11,674	13,294	14,760	16,713	18,468

Total mining									
Production and related workers	Number	77,208	76,701	73,044	75,165	79,928	77,091	78,989	79,905
Salaries and wages	$000	614,084	646,901	666,505	751,878	894,538	1,030,009	1,185,184	1,342,508
Average annual salary and wage	$	7,954	8,434	9,125	10,003	11,192	13,361	15,004	16,801
Administrative and office workers	Number	32,886	33,709	34,278	36,278	38,802	38,624	38,705	39,159
Salaries and wages	$000	329,930	368,760	402,278	462,993	555,792	625,269	717,498	795,015
Annual average salary and wage	$	10,033	10,940	11,736	12,762	14,324	16,189	18,538	20,302
Total mining									
Employees	Number	110,094	110,410	107,322	111,443	118,730	115,715	117,694	119,064
Salaries and wages	$000	944,014	1,015,661	1,068,783	1,214,871	1,450,330	1,655,278	1,902,682	2,137,523
Annual average salary and wage	$	8,575	9,199	9,959	10,901	12,215	14,305	16,166	17,954

[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 34 under "Nonmetallic mineral products industries". See Table 25 for detail of industries.

TABLE 34. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1970-77

	Unit	1970	1971	1972	1973	1974	1975	1976	1977
Primary metal industries									
Production and related workers	Number	88,839	86,452	86,335	89,853	94,538	90,169	88,939	91,683
Salaries and wages	$000	680,779	714,600	781,209	897,353	1,052,519	1,119,159	1,241,893	1,399,390
Annual average salary and wage	$	7,663	8,266	9,049	9,987	11,133	12,412	13,963	15,263
Administrative and office workers	Number	27,706	27,862	27,623	26,609	27,681	30,161	28,102	27,536
Salaries and wages	$000	277,728	303,113	327,598	340,547	403,151	493,764	511,236	545,957
Annual average salary and wage	$	10,024	10,879	11,860	12,798	14,564	16,371	18,192	19,827
Total primary metal industries									
Employees	Number	116,545	114,314	113,958	116,462	122,219	120,330	117,041	119,219
Salaries and wages	$000	958,507	1,017,713	1,108,807	1,237,900	1,455,671	1,612,923	1,753,128	1,945,347
Annual average salary and wage	$	8,224	8,903	9,730	10,629	11,910	13,404	14,979	16,317
Nonmetallic mineral products industries									
Production and related workers	Number	36,045	38,035	39,159	41,502	42,884	42,149	41,272	39,321
Salaries and wages	$000	244,201	281,046	316,033	366,028	424,096	471,466	529,264	564,444
Annual average salary and wage	$	6,775	7,389	8,071	8,820	9,889	11,186	12,824	14,355
Administrative and office workers	Number	13,383	13,256	13,928	14,447	14,682	13,783	13,749	13,187
Salaries and wages	$000	117,163	124,085	142,193	156,085	180,802	197,884	218,164	229,855
Annual average salary and wage	$	8,755	9,361	10,209	10,804	12,314	14,357	15,868	17,430
Total nonmetallic mineral products									
Employees	Number	49,428	51,291	53,087	55,949	57,566	55,932	55,021	52,508
Salaries and wages	$000	361,364	405,131	458,226	522,113	604,898	669,350	747,428	794,299
Annual average salary and wage	$	7,311	7,899	8,632	9,332	10,507	11,967	13,584	15,127
Petroleum and coal products industries									
Production and related workers	Number	6,686	6,557	6,583	6,822	7,787	7,877	7,099	7,696
Salaries and wages	$000	64,745	68,215	75,735	84,537	105,398	122,268	127,594	146,566
Annual average salary and wage	$	9,684	10,403	11,505	12,392	13,535	15,522	17,974	19,044
Administrative and office workers	Number	8,961	8,960	8,826	9,265	9,648	9,387	9,590	10,153
Salaries and wages	$000	95,908	104,378	110,301	125,906	149,140	175,772	192,722	228,532
Annual average salary and wage	$	10,703	11,649	12,497	13,589	15,458	18,725	20,096	22,509
Total petroleum and coal products									
Employees	Number	15,647	15,517	15,409	16,087	17,435	17,264	16,689	17,849
Salaries and wages	$000	160,653	172,593	186,036	210,443	254,539	298,040	320,316	375,098
[illegible]verage salary and wage	$	10,267	11,123	12,073	13,082	14,599	17,264	19,193	21,015

... mineral manufacturing									
Production and related workers	Number	131,570	131,044	132,077	138,177	145,209	140,195	137,310	138,700
Salaries and wages	$000	989,725	1,063,861	1,172,977	1,347,918	1,582,014	1,712,892	1,898,751	2,110,400
Annual average salary and wage	$	7,522	8,118	8,881	9,755	10,895	12,218	13,828	15,216
Administrative and office workers	Number	50,050	50,078	50,377	50,321	52,011	53,331	51,441	50,876
Salaries and wages	$000	490,799	531,576	580,092	622,538	733,093	867,421	922,122	1,004,344
Annual average salary and wage	$	9,806	10,615	11,515	12,371	14,095	16,269	17,926	19,741
Total mineral manufacturing industries									
Employees	Number	181,620	181,122	182,454	188,498	197,220	193,526	188,751	189,576
Salaries and wages	$000	1,480,524	1,595,437	1,753,069	1,970,456	2,315,107	2,580,313	2,820,872	3,114,744
Annual average salary and wage	$	8,151	8,809	9,608	10,454	11,739	13,333	14,945	16,430

Note: See footnote, Table 33. See Table 26 for detail of industries covered.

TABLE 35. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE MINING INDUSTRY[1], (SURFACE, UNDERGROUND AND MILL), 1974-77

	1974	1975	1976	1977
Metals				
Surface	16,229	16,230	16,143	16,115
Underground	21,045	20,555	20,043	19,482
Mill	13,612	13,534	13,648	13,817
Total	50,886	50,319	49,834	49,414
Nonmetals				
Surface	7,743	7,180	7,264	7,166
Underground	2,210	1,870	2,180	2,245
Mill	7,814	6,347	7,003	7,401
Total	17,767	15,397	16,447	16,812
Fuels				
Surface	8,443	8,789	9,705	10,510
Underground	2,832	2,586	3,003	3,169
Total	11,275	11,375	12,708	13,679
Total mining industry				
Surface	32,415	32,200	33,112	33,791
Underground	26,087	25,010	25,226	24,896
Mill	21,426	19,881	20,651	21,218
Total	79,928	77,091	78,989	79,905

[1] See Table 25 for detail of industry coverage.

LE 36. CANADA, LABOUR COSTS IN RELATION TO TONNES MINED, METAL MINES, 1975-77

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)	($)
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
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	5 950	2.56
1977						
Auriferous quartz	3,839	58,542	15,249	5 768	1 502	10.15
Copper-gold-silver	11,362	203,753	17,933	108 966	9 590	1.87
Nickel-copper	14,295	214,763	15,024	20 395	1 427	10.53
Silver-lead-zinc	5,500	97,192	17,671	16 606	3 019	5.85
Iron ore	10,070	202,926	20,152	127 057	12 617	1.60
Miscellaneous metals	4,348	72,169	16,598	20 737	4 769	3.48
Total	49,414	849,345	17,188	299 529	6 062	2.84

TABLE 37. CANADA, MAN-HOURS PAID, PRODUCTION AND RELATED WORKERS, TONNES OF ORE MINED AND ROCK QUARRIED, METAL MINES AND NONMETALLIC MINERAL OPERATIONS, 1971-77

	Unit	1971	1972	1973	1974	1975	1976	1977
Metal mines[1]								
Ore mined	million tonnes	211.4	205.9	274.7	278.7	264.2	296.5	299.5
Man-hours paid[2]	million	102.1	93.8	98.4	104.0	102.4	100.6	101.2
Man-hours paid per tonne mined	number	0.48	0.46	0.36	0.37	0.39	0.34	0.34
Tonnes mined per man-hour paid	tonnes	2.07	2.20	2.79	2.68	2.58	2.95	2.96
Nonmetallic mineral operations[3]								
Ore mined and rock quarried	million tonnes	165.9	169.3	190.5	209.7	180.2	200.4	243.8
Man-hours paid[2]	million	27.5	27.4	28.6	30.5	25.5	29.0	30.1
Man-hours paid per tonne mined	number	0.17	0.16	0.15	0.15	0.14	0.14	0.12
Tonnes mined per man-hour paid	tonnes	6.03	6.18	6.66	6.88	7.07	6.91	8.10

[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 38. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED, HOURLY-RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1972-79

	1972	1973	1974	1975	1976	1977	1978	1979P
Mining								
Average hours per week	40.3	40.9	40.4	40.0	40.3	40.6	40.5	41.1
Average weekly wage ($)	174.94	196.89	225.25	260.74	298.44	329.45	354.51	396.62
Metals								
Average hours per week	39.0	39.6	39.4	39.4	39.6	39.8	39.4	40.4
Average weekly wage ($)	174.69	195.89	222.80	260.33	296.21	325.75	344.94	387.58
Mineral fuels								
Average hours per week	41.0	41.0	40.6	39.7	40.6	41.3	41.0	40.8
Average weekly wage ($)	176.36	198.08	231.51	264.98	309.24	333.51	367.34	410.36
Nonmetals								
Average hours per week	41.3	41.3	41.1	40.1	40.5	40.3	40.5	40.3
Average weekly wage ($)	158.30	173.10	191.51	230.84	273.56	301.92	326.23	366.74
Manufacturing								
Average hours per week	40.4	39.6	38.9	38.6	38.7	38.7	38.8	38.8
Average weekly wage ($)	141.53	152.77	170.03	195.12	222.79	246.63	265.06	288.44
Construction								
Average hours per week	40.1	39.5	39.1	39.0	38.9	38.7	39.0	39.4
Average weekly wage ($)	206.43	223.86	251.08	293.96	330.95	378.50	400.58	435.69

P Preliminary.

TABLE 39. CANADA, AVERAGE WEEKLY WAGES OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1971 DOLLARS, 1972-79

	1972	1973	1974	1975	1976	1977	1978	1979P
Current dollars								
All mining	174.94	196.89	222.25	260.74	298.44	329.45	354.51	396.62
Metals	174.69	195.89	222.80	260.33	296.21	325.75	344.94	387.58
Gold	131.92	151.73	192.78	219.97	251.23	280.34	300.26	337.34
Mineral fuels	176.36	198.08	231.51	264.98	309.24	333.51	367.34	410.36
Coal	158.18	181.29	212.56	243.01	274.00	303.53	323.49	364.21
Nonmetals except fuel	158.30	173.10	191.51	230.84	273.56	301.92	326.23	366.74
1971 dollars								
All mining	166.93	174.70	177.80	188.26	200.43	204.88	202.35	207.44
Metals	166.69	173.82	178.24	187.96	198.93	202.58	196.88	202.71
Gold	125.88	134.63	154.22	158.82	168.72	174.34	171.38	176.43
Mineral fuels	168.27	175.76	185.21	191.32	207.68	207.41	209.67	214.62
Coal	150.94	160.86	170.05	175.46	184.02	188.76	184.64	190.49
Industrial minerals	151.05	153.59	153.21	166.67	183.72	187.76	186.20	191.81

P Preliminary.

TABLE 40. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS, BY INDUSTRY GROUPS, 1977-79[1]

	Fatalities (number)			Number of Workers (000)			Rate per 1,000 Workers[2]		
	1977r	1978	1979p	1977	1978	1979p	1977r	1978	1979p
Agriculture	16	7	13	143.0	132.0	161.0	0.11	0.05	0.08
Forestry	59	85	100	64.4	66.6	70.2	0.92	1.28	1.42
Fishing	18	15	12	7.6	10.4	15.0	2.37	1.44	0.80
Mining[1]	131	114	125	141.7	139.7	151.0	0.92	0.82	0.83
Manufacturing	183	182	146	1,775.4	1,803.6	1,873.9	0.10	0.10	0.08
Construction	173	165	165	466.6	436.3	465.0	0.37	0.38	0.35
Transportation	178	204	192	794.7	802.9	819.6	0.22	0.25	0.23
Trade	74	64	62	1,413.5	1,467.3	1,515.8	0.05	0.04	0.04
Finance	9	6	4	472.1	488.2	502.4	0.02	0.01	0.01
Service	64	55	66	2,470.0	2,544.5	2,656.4	0.03	0.02	0.02
Public administration	50	77	59	620.7	633.0	625.0	0.08	0.12	0.09
Unknown	-	17	19	-	..	..	-	..	..
Total	955	991	963	8,369.7	8,524.5	8,855.3	0.11	0.12	0.11

Note: See footnotes, Table 41.

[1] Includes fatalities resulting from occupational chest diseases such as silicosis, lung cancer, etc. In 1979, 49 (1978, 58) 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; .. Not available; - Nil.

TABLE 41. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS, BY INDUSTRY GROUPS, 1970-79P

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979P
Agriculture	0.12	0.16	0.24	0.25	0.27	0.10	0.13	0.11	0.05	0.08
Forestry	1.48	1.56	1.36	1.58	1.31	1.25	1.14	0.92	1.28	1.42
Fishing[1]	3.57	1.38	0.99	1.65	1.38	3.25	3.60	2.37	1.44	0.80
Mining[2]	1.22	1.34	1.41	1.43	1.52	1.20	1.18	0.92r	0.82	0.83
Manufacturing	0.11	0.12	0.16	0.15	0.17	0.13	0.11	0.10	0.10	0.08
Construction	0.54	0.58	0.52	0.53	0.52	0.48	0.42	0.37	0.38	0.35
Transportation[3]	0.28	0.30	0.33	0.37	0.33	0.28	0.28	0.22	0.25	0.23
Trade	0.06	0.07	0.06	0.07	0.09	0.05	0.04	0.05	0.04	0.04
Finance[4]	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01
Service[5]	0.03	0.04	0.06	0.05	0.05	0.04	0.03	0.03	0.02	0.02
Public administration	0.18	0.14	0.13	0.19	0.11	0.14	0.09	0.08	0.12	0.09
Total	0.16	0.17	0.17	0.18	0.18	0.15	0.13	0.11	0.12	0.11

[1] Includes trapping, 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; r Revised.

TABLE 42. CANADA, INDUSTRIAL FATALITIES BY OCCUPATIONAL INJURIES AND ILLNESSES, 1977-79P

	Occupational Injuries			Occupational Illnesses			Total		
	1977r	1978	1979P	1977r	1978	1979P	1977r	1978	1979P
Agriculture	16	7	13	0	0	0	16	7	13
Forestry	59	85	100	0	0	0	59	85	100
Fishing	18	15	12	0	0	0	18	15	12
Mining	77	56	76	54	58	49	131	114	125
Manufacturing	138	146	116	45	36	30	183	182	146
Construction	165	160	157	8	5	8	173	165	165
Transportation	176	202	191	2	2	1	178	204	192
Trade	74	63	60	0	1	2	74	64	62
Finance	9	6	4	0	0	0	9	6	4
Service	64	53	63	0	2	3	64	55	66
Public administration	50	74	55	0	3	4	50	77	59
Unknown	0	17	19	-	-	-	-	17	19
Total	846	884	866	109	107	97	955	991	963

P Preliminary; r Revised; - Nil.

TABLE 43. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRIES, 1978 AND 1979

	1978			1979P		
	Strikes and lockouts	Workers involved	Duration in person-days	Strikes and lockouts	Workers involved	Duration in person-days
Agriculture	1	4	20	1	12	10
Forestry	19	5,446	67,810	11	2,632	110,940
Fishing and trapping	1	600	1,200	-	-	-
Mines	39	31,147	1,699,460	40	28,396	1 586,360
Manufacturing	459	117,548	2,527,980	511	149,656	3 129,460
Construction	108	63,105	1,232,610	48	10,839	88,290
Transportation and utilities	126	74,332	945,480	129	79,933	1 181,580
Trade	91	10,618	245,950	78	16,442	247,410
Finance, insurance and real estate	16	924	7,520	18	2,164	38,110
Service	143	33,824	407,650	139	64,855	760,600
Public administration	55	64,140	257,140	74	58,845	642,740
Various industries	-	-	-	1	48,730	48,730
All industries	1,058	401,688	7,392,820	1,050	462,504	7,834,230

P Preliminary; - Nil.

TABLE 44. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING, 1978 AND 1979

	1978			1979P		
	Strikes and lockouts	Workers involved	Duration in person-days	Strikes and lockouts	Workers involved	Duration in person-days
Mines	39	31,147	1,699,460	40	28,396	1,586,360
Metal	16	23,711	1,521,540	17	18,861	1,506,980
Mineral fuels	10	3,983	39,640	8	7,717	55,010
Nonmetals	12	3,443	137,550	10	1,645	22,980
Quarries	1	10	730	5	173	1,390
Mineral manufacturing	59	21,108	310,130	73	25,080	1,126,900
Primary metals	24	17,838	215,400	30	17,929	924,150
Nonmetallic mineral products	31	2,480	92,020	41	5,875	185,870
Petroleum and coal products	4	790	2,710	2	1,276	16,880

P Preliminary.

TABLE 45. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1975-77

	1975	1976	1977
		(tonnes)	
Metals			
Gold-quartz	5 900 860	5 920 845	5 767 646
Copper-gold-silver	97 656 374	103 599 508	108 965 503
Silver-cobalt	75 020	112 426	123 953
Silver-lead-zinc	16 094 171	14 197 435	16 606 403
Nickel-copper	23 264 576	21 462 226	20 394 650
Iron	101 482 119	133 072 912	127 056 875
Miscellaneous metals[1]	19 744 630	18 161 907	20 613 005
Total	264 217 750	296 527 259	299 528 035
Nonmetals			
Asbestos	61 709 522	84 233 640	89 896 038
Feldspar, nepheline syenite	596 787	550 217	275 650
Quartz (excluding sand)	1 268 565	1 144 657	1 141 359
Gypsum	5 578 241	5 977 803	7 216 157
Talc, soapstone	75 051	77 369	73 288
Rock salt	3 626 984	5 080 030	4 974 195
Other nonmetallics	22 030 535	20 559 514	25 035 287
Total	94 885 685	117 623 230	128 611 974
Structural materials			
Stone, all kinds quarried[2]	88 920 782	87 875 936	120 162 599
Stone used to make cement	13 653 506	13 350 220	12 613 674
Stone used to make lime	2 979 661	3 441 932	3 533 915
Total	105 553 949	104 668 088	136 310 188
Total ore mined and rock quarried	464 657 384	518 818 577	564 450 197

[1] Includes uranium ore. [2] Excludes stone used to manufacture cement and lime.

TABLE 46. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1942-77

	Metals	Nonmetal[1]	Total
		(million tonnes)	
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
1977	299.5	264.9	564.4

[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 45.

TABLE 47. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1], BY PROVINCES AND TERRITORIES, 1977-79

		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	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
	1978	1.2	20.0	12.6	33.8	59.5	93.3	8.5	110.5	119.0	212.3	17.6	1.0	230.9
	1979P	2.0	47.2	27.5	76.7	51.4	128.1	10.3	173.2	183.5	311.6	21.2	(2)	(2)
Quebec	1977	(2)	(2)	(2)	318.3	211.9	530.2	15.8	184.5	200.3	730.5	29.3	10.5	770.3
	1978	16.1	73.9	36.5	126.5	48.2	174.7	17.3	179.4	196.7	371.4	39.9	2.5	413.8
	1979P	7.5	109.6	40.2	157.3	72.3	229.6	25.1	199.8	224.9	454.5	39.6	0.8	494.9
Ontario	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
	1978	7.8	121.0	47.5	176.3	85.9	262.2	18.6	169.2	187.8	450.0	21.0	(2)	(2)
	1979P	6.6	150.1	67.7	224.4	127.1	351.5	23.3	220.0	243.3	594.8	18.7	(2)	(2)
Manitoba	1977	(2)	(2)	(2)	23.6	11.5	35.1	3.4	29.1	32.5	67.6	8.2	0.1	75.9
	1978	(2)	(2)	(2)	45.9	28.1	74.0	2.0	25.9	27.9	101.9	11.8	(2)	(2)
	1979P	(3)	32.7	14.2	46.9	15.3	62.2	(4)	34.2	34.2	96.4	11.8	-	108.2
Saskatchewan	1977	(2)	(2)	(2)	37.3	74.0	111.3	3.8	53.2	57.0	168.3	15.1	0.3	183.7
	1978	(2)	(2)	(2)	58.6	78.5	137.1	5.7	58.6	64.3	201.4	27.9	1.7	231.0
	1979P	4.9	29.2	40.0	74.1	66.9	141.0	5.6	76.8	82.4	223.4	52.6	8.1	284.1
Alberta	1977	(2)	(2)	(2)	53.1	47.9	101.0	5.5	38.9	44.4	145.4	3.0	2.6	151.0
	1978	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
	1979P	(3)	5.2	14.1	19.3	39.6	58.9	(4)	38.1	38.1	97.0	9.9	1.2	108.1
British Columbia	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
	1978	16.2	55.7	33.2	105.1	43.9	149.0	10.8	167.2	178.0	327.0	32.5	1.0	360.5
	1979P	18.0	94.8	115.7	228.5	85.6	314.1	10.7	177.5	188.2	502.3	48.1	1.3	551.7
Yukon and Northwest Territories	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
	1978	5.3	13.6	6.3	25.2	16.8	42.0	6.6	29.8	36.4	78.4	37.2	0.3	115.9
	1979P	5.6	11.3	10.1	27.0	23.4	50.4	5.7	46.0	51.7	102.1	48.8	18.6	169.5
Canada	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	54.1	345.1	195.6	594.8	405.7	1,000.5	71.9	776.7	848.6	1,849.1	194.9	13.3	2,057.3
	1979P	49.4	475.3	329.5	854.2	481.6	1,335.8	84.7	961.6	1,046.3	2,382.1	250.7	31.1	2,663.9

[1] Excludes the crude oil and natural gas industries and the smelting and refining industries. (2) Confidential, figures are included in "Canada". (3) Confidential, figures are included in "On-property Development. (4) Confidential, figures are included in "Machinery and Equipment".
P Preliminary; - Nil.

TABLE 48. CANADA, EXPLORATION AND CAPITAL EXPENDITURES[1] IN THE MINING INDUSTRY, BY TYPE OF MINING, 1977-79

		Capital: Construction: On-property Exploration	Capital: Construction: On-property Development	Capital: Construction: Structures	Capital: Construction: Total	Capital: Machinery and Equipment	Total Capital	Repair: Construction	Repair: Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total, all Expenditures
							($ million)							
Metal Mining														
Gold	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)
	1978	4.2	24.1	3.6	31.9	4.8	36.7	2.0	15.8	17.8	54.5	1.1	-	55.6
	1979p	4.1	29.5	6.8	40.4	16.8	57.2	3.2	23.4	26.6	83.8	5.5	-	89.3
Copper-gold-silver	1977	10.2	53.0	44.5	107.7	74.2	181.9	14.1	136.5	150.6	332.5	5.2	(3)	(4)
	1978	8.7	42.9	27.6	79.2	52.0	131.2	11.7	144.4	156.1	287.3	5.0	(3)	(4)
	1979p	10.3	78.2	76.5	165.0	84.5	249.5	17.1	165.0	182.1	431.6	8.5	(3)	(4)
Silver-lead-zinc	1977	6.6	29.0	18.3	53.9	23.1	77.0	5.8	32.3	38.1	115.1	6.2	(3)	(4)
	1978	7.2	19.0	16.2	42.4	19.9	62.3	5.6	33.0	38.6	100.9	3.1	(3)	(4)
	1979p	8.2	20.3	25.6	54.1	33.4	87.5	5.2	43.8	49.0	136.5	6.2	18.5	161.2
Iron	1977	(2)	(2)	(2)	265.8	(2)	(2)	18.8	225.1	243.9	(2)	(4)	(3)	(4)
	1978	(2)	(2)	(2)	71.1	32.5	103.6	17.7	196.0	213.7	317.3	(4)	-	(4)
	1979p	(6)	81.5	15.5	97.0	40.3	137.3	27.5	268.4	295.9	433.2	(4)	-	(4)
Other metal mining	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
	1978	13.6	162.8	69.7	175.0	58.4	233.4	16.7	98.4	115.1	348.5	14.5	1.5	364.5
	1979p	11.5	140.5	96.1	248.1	104.7	352.8	17.3	131.1	148.4	501.2	(4)	(4)	(4)
Total metal mining	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)
	1978	33.7	248.8	117.1	399.6	167.6	567.2	53.7	487.6	541.3	1,108.5	(4)	2.4	(4)
	1979p	(6)	384.1	220.5	604.6	279.7	884.3	70.3	631.7	702.0	1,586.3	29.6	19.7	1,635.6
Nonmetal mining														
Asbestos	1977	2.0	43.8	20.6	66.4	37.3	103.7	7.5	73.1	80.6	184.3	(4)	(5)	(4)
	1978	1.5	43.9	26.6	72.0	31.0	103.0	5.8	88.3	94.1	197.1	(4)	(5)	(4)
	1979p	0.5	49.8	19.0	69.3	29.7	99.0	5.6	93.8	99.4	198.4	0.4	(5)	(5)
Other non-metal mining	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)
	1978	11.6	52.1	51.8	115.5	205.4	320.9	12.4	200.8	213.2	534.1	9.5	(5)	(4)
	1979p	12.4	76.9	89.0	178.3	170.5	348.8	8.8	235.7	244.5	593.3	10.2	(5)	(5)

Total non-metal mining	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	13.1	96.0	78.4	187.5	236.4	423.9	18.2	289.1	307.3	731.2	(4)	6.5	(4)
	1979P	12.9	126.7	108.0	247.6	200.2	447.8	14.4	329.5	343.9	791.7	10.6	8.6	810.9
Metal and nonmetal mining	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	7.3	0.3	0.1	7.7	1.7	9.4	-	-	-	9.4	160.5	4.4	174.3
	1979P	(6)	1.0	1.0	2.0	1.7	3.7	-	0.4	0.4	4.1	210.5	2.8	217.4
Total mining	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	54.1	345.1	195.6	594.8	405.7	1,000.5	71.9	776.7	848.6	1,849.1	194.9	13.3	2,057.3
	1979P	49.4	475.3	329.5	854.2	481.6	1,335.8	84.7	961.6	1,046.3	2,382.1	250.7	31.1	2,663.9

[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 49. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY, BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRACTORS, 1976 AND 1977

		1976			1977		
		Exploration	Other	Total	Exploration	Other	Total
		(metres)					
Metal mining							
Gold-quartz	Own equipment	12 393[r]	2 749	15 142[r]	9 579	5 557	15 136
	Contractors	125 026[r]	15 862[r]	140 888[r]	138 704	21 803	160 507
	Total	137 419[r]	18 611[r]	156 030[r]	148 283	27 360	175 643
Copper-gold-silver	Own equipment	99 815	16 492	116 307	100 082	1 158	101 240
	Contractors	170 179	11 069	181 248	221 166	17 357	238 523
	Total	269 994	27 561	297 555	321 248	18 515	339 763
Nickel-copper	Own equipment	184 285	-	184 285	150 924	319	151 243
	Contractors	25 780	-	25 780	24 774	-	24 774
	Total	210 065	-	210 065	175 698	319	176 017
Silver-lead-zinc and silver-cobalt	Own equipment	34 505	12 172	46 677	53 269	17 269	70 538
	Contractors	118 237	1 452	119 689	142 741	-	142 741
	Total	152 742	13 624	166 366	196 010	17 269	213 279
Iron mines	Own equipment	-	-	-	-	-	-
	Contractors	19 486	-	19 486	20 322	-	20 322
	Total	19 486	-	19 486	20 322	-	20 322
Miscellaneous metal mining	Own equipment	4 921	-	4 921	13 387	-	13 387
	Contractors	73 328	-	73 328	90 620	-	90 620
	Total	78 249	-	78 249	104 007	-	104 007
Total metal mining	Own equipment	335 919[r]	31 413[r]	367 332[r]	327 241	24 303	351 544
	Contractors	532 036[r]	28 383[r]	560 419[r]	638 327	39 160	677 487
	Total	867 955[r]	59 796[r]	927 751[r]	965 568	63 463	1 029 031
Nonmetal mining							
Asbestos	Own equipment	-	-	-	-	-	-
	Contractors	13 847	58	13 905	65 309	-	65 309
	Total	13 847	58	13 905	65 309	-	65 309
Feldspar and quartz	Own equipment	-	-	-	-	-	-
	Contractors	-	-	-	-	-	-
	Total	-	-	-	-	-	-
Gypsum	Own equipment	-	-	-	-	-	-
	Contractors	1 881	-	1 881	7 269	-	7 269
	Total	1 881	-	1 881	7 269	-	7 269

Salt	Own equipment	1 308	-	1 308	1 528	-	1 528
	Contractors	-	-	-	-	-	-
	Total	1 308	-	1 308	1 528	-	1 528
Miscellaneous nonmetal mining	Own equipment	3 865	-	3 865	2 245	-	2 245
	Contractors	-	-	-	-	-	-
	Total	3 865	-	3 865	2 245	-	2 245
Total nonmetal mining	Own equipment	5 173	-	5 173	3 773	-	3 773
	Contractors	15 728	58	15 786	72 578	-	72 578
	Total	20 901	58	20 959	76 351	-	76 351
Total mining industry	Own equipment	341 092	31 413	372 505	331 014	24 303	355 317
	Contractors	547 764	28 441	675 205	710 905	39 160	750 065
	Total	888 856	59 854	948 710	1 041 919	63 463	1 105 382

- Nil; r Revised.

TABLE 53. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1977 AND 1978

	1977	1978		1977	1978
	(000 tonnes)			(000 tonnes)	
Metallic minerals					
Alumina and bauxite	2 585	2 682	Salt, rock	986	818
Copper ores and concentrates	2 220	1 963	Salt, nes	157	141
Iron ores and concentrates	57 288[r]	42 595	Sand, industrial	1 277[r]	1 262
Iron pyrite	24	10	Sand, nes	41[r]	25
Lead ores and concentrates	625[r]	695	Silica	18	23
Lead-zinc ores and concentrates	41	41	Sodium carbonate	390[r]	629
Manganese ores	10	8	Sodium sulphate	459[r]	459
Nickel-copper ores and concentrates	5 214	3 479	Stone, building, rough	16	10
Nickel ores and concentrates	1 172	571	Stone, nes	487	400
Tungsten ores and concentrates	2	2	Sulphur, liquid	1 340	1 384
Zinc ores and concentrates	2 143	1 882	Sulphur, nes	3 295	4 009
Metallic ores and concentrates, nes	43[r]	82	Nonmetallic minerals, nes	295[r]	176
Total metallic minerals	71 367[r]	54 010	Total, nonmetallic minerals	30 164[r]	32 252
Nonmetallic minerals			**Mineral fuels**		
Abrasives, natural	69	57	Coal, anthracite	180	185
Asbestos	790[r]	699	Coal, bituminous	17 968[r]	20 331
Barite	63	61	Coal, lignite	1 124[r]	603
Clay	621[r]	705	Coal, nes	6	7
Gravel	928[r]	139	Natural gas and other crude		
Gypsum	4 359	4 876	bituminous substances	19	15
Limestone, agricultural	83	68	Oil, crude	283	291
Limestone, industrial	311	339	Total mineral fuels	19 580[r]	21 432
Limestone, nes	3 196	3 581	Total crude minerals	121 111[r]	107 694
Nepheline syenite	402	397	Total revenue freight moved		
Phosphate rock	1 884	2 294	by Canadian railways	247 247[r]	238 824
Potash (KCl)	8 719	9 690	Per cent crude minerals of		
Refractory materials, nes	14	10	revenue freight	49.0	45.1

nes Not elsewhere specified; [r] Revised.

TABLE 54. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1969-78

	Total Revenue Freight	Total Crude Minerals	Crude Minerals as % of Total Revenue Freight		Total Revenue Freight	Total Crude Minerals	Crude Minerals as % of Total Revenue Freight
	(million tonnes)				(million tonnes)		
1969	189.0	81.9	43.4	1974	246.3	115.3	46.8
1970	211.6	97.5	46.1	1975	226.0	110.6	49.0
1971	214.5	95.6	44.6	1976	238.5	116.6	48.9
1972	215.8	89.4	41.4	1977	247.2[r]	121.1	49.0
1973	241.2	113.1	46.9	1978	238.8	107.7	45.1

[r] Revised.

TABLE 55. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1977 AND 1978

	1977	1978
	(000 tonnes)	
Metallic mineral products		
Ferrous mineral products		
Ferroalloys	129r	129
Pig iron	63	87
Ingots, blooms, billets, slabs of iron and steel	258	338
Other primary iron and steel	38	36
Castings and forgings, iron and steel	237r	253
Bars and rods, steel	654	837
Plates, steel	341r	442
Sheet and strip, steel	1 114r	1 137
Structural shapes and sheet piling, iron and steel	332	421
Rails and railway track material	132r	91
Pipes and tubes, iron and steel	401r	461
Wire, iron or steel	35	49
Iron and steel scrap	1 458r	1 806
Slag, dross, etc.	99	97
Total ferrous mineral products	5 291r	6 184
Nonferrous mineral products		
Aluminum paste, powder, pigs, ingots, shot	118	212
Aluminum and aluminum alloy fabricated material, nes	278	250
Copper matte and precipitates	2	1
Copper and alloys, in primary form	436	396
Copper and alloys, nes	69	60
Lead and alloys	162	156
Nickel and nickel-copper matte	137	92
Nickel and alloys	34	28
Tin and alloys	4	1
Zinc and alloys	395	444
Other nonferrous base metals and alloys	11r	28
Nonferrous metal scrap	87	116
Total nonferrous mineral products	1 733	1 784
Total metallic mineral products	7 024r	7 968
Nonmetallic mineral products		
Natural stone basic products, chiefly structural	200	221
Bricks and tiles, clay	57	52
Fire brick and similar shapes	117	107
Dolomite and magnesite, calcined	82	72
Refractories, nes	33r	30
Glass basic products	140	108
Asbestos and asbestos-cement basic products	20	27
Portland cement, standard	1 931	2 006
Concrete pipe	38	33
Cement and concrete basic products, nes	378	405
Plaster	25	18
Gypsum wallboard and sheathing	62	68
Gypsum basic products, nes	2r	7
Lime, hydrated and quick	441r	454
Nonmetallic mineral basic products, nes	747	817
Fertilizers and fertilizer materials, nes	1 952	2 139
Total nonmetallic mineral products	6 225r	6 564

(Continued on following page)

TABLE 55. (cont'd)

	1977	1978
	(000 tonnes)	
Mineral fuel products		
Gasoline	1 773	1 720
Aviation turbine fuel	87	67
Diesel fuel	3 216	3 053
Kerosene	5	6
Fuel oil, nes	1 220	1 108
Lubricating oils and greases	373	412
Petroleum coke	516[r]	656
Coke, nes	938[r]	951
Refined and manufactured gases, fuel type	3 146	2 606
Asphalts and road oils	124	269
Bituminous pressed or molded fabricated material	2	2
Other petroleum and coal products	1 034	821
Total mineral fuel products	12 434[r]	11 671
Total fabricated mineral products	25 683[r]	26 203
Total revenue freight moved by Canadian railways	247 247[r]	238 824
Fabricated mineral products as a percentage of total revenue freight	10.4	11.0

nes Not elsewhere specified; [r] Revised.

TABLE 56. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY, 1978 AND 1979

	Montreal-Lake Ontario Section		Welland Canal Section	
	1978	1979	1978	1979
	(tonnes)			
Crude minerals				
Coal	853 116	455 325	4 906 242	7 067 442
Iron ore	12 285 257	13 441 896	14 224 586	13 714 946
Aluminum ores and concentrates	118 750	161 999	118 750	161 999
Clay and bentonite	16 987	237 380	16 963	237 380
Gravel and sand	13 759	27 845	76 930	284 152
Petroleum, crude	-	11 254	-	11 254
Stone, ground or crushed	96 478	335 378	1 193 433	1 379 422
Stone, rough	3 844	9 195	5 145	7 414
Salt	677 651	756 422	1 258 237	1 354 097
Phosphate rock	49 776	75 225	17	27 243
Sulphur	6 544	138 700	6 544	138 700
Other crude minerals	934 746	756 378	893 031	466 332
Total crude minerals	15 056 908	16 406 997	22 699 878	24 850 381
Fabricated mineral products				
Coke	2 255 841	2 103 300	2 291 341	2 270 269
Gasoline	98 778	171 284	95 488	210 704
Fuel oil	1 712 743	2 110 957	826 258	1 519 327
Lubricating oils and greases	131 876	67 394	133 304	60 393
Other petroleum products	206 369	139 244	122 273	98 147
Tar, pitch and creosote	29 315	27 352	44 882	32 111
Pig iron	219 923	120 302	209 830	111 350
Iron and steel: bars, rods, slabs	327 412	128 365	301 982	119 588
Iron and steel: nails, wire	35 290	23 907	32 985	22 799
Iron and steel: manufactured	2 939 135	2 589 384	2 790 274	2 400 906
Scrap iron and steel	580 443	524 197	535 990	494 846
Cement	20 873	21 014	374 402	522 314
Total fabricated minerals	8 557 998	8 026 700	7 759 009	7 862 754
Total crude and fabricated minerals	23 614 906	24 433 697	30 458 887	32 713 135
Total all products	51 657 530	50 187 359	59 575 722	60 023 466
Crude and fabricated minerals as a per cent of total	45.7	48.7	51.1	54.5

- Nil.

TABLE 57. CANADA, CRUDE MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1978

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
	(tonnes)							
Metallic minerals								
Copper ore and concentrates	50 488	-	318	50 806	50 488	-	318	50 806
Iron ore and concentrates	3 415 135	3 145 449	-	6 560 584	1 051 706	5 508 878	-	6 560 584
Lead ore and concentrates	5 139	-	-	5 139	5 139	-	-	5 139
Manganese ore	500	-	-	500	-	500	-	500
Titanium ore	2 059 439	-	-	2 059 439	2 059 439	-	-	2 059 439
Zinc ore and concentrates	17 395	-	4 796	22 191	17 395	-	4 796	22 191
Ores and concentrates, nes	6 176	-	891	7 067	18	6 158	891	7 067
Iron and steel scrap	13 767	11 522	8 188	33 477	16 489	8 800	8 188	33 477
Nonferrous metal scrap	38	-	-	38	38	-	-	38
Total metals	5 568 077	3 156 971	14 193	8 739 241	3 200 712	5 524 336	14 193	8 739 241
Nonmetallic minerals								
Asbestos	45	-	-	45	45	-	-	45
Bentonite	14 054	-	-	14 054	14 054	-	-	14 054
China clay	75	-	-	75	75	-	-	75
Dolomite	27	19 898	-	19 925	19 925	-	-	19 925
Gypsum	641 456	-	10 614	652 070	510 628	130 828	10 614	652 070
Limestone	4 662	2 070 962	662 934	2 738 558	4 662	2 070 962	662 934	2 738 558
Phosphate rock	25 401	-	-	25 401	25 401	-	-	25 401
Salt	308 092	1 115 040	35 397	1 458 529	916 147	506 985	35 397	1 458 529
Sand and gravel	188 755	-	2 575 571	2 764 326	188 755	-	2 575 571	2 764 326
Crushed stone	77	33	-	110	77	33	-	110
Stone, crude, nes	-	433 073	4 733	437 806	38 226	394 847	4 733	437 806
Sulphur in ores	10 034	5 400	12 140	27 574	15 434	-	12 140	27 574
Crude nonmetallic minerals, nes	200	-	-	200	200	-	-	200
Total nonmetals	1 192 878	3 644 406	3 301 389	8 138 673	1 733 629	3 103 655	3 301 389	8 138 673
Mineral fuels								
Coal, bituminous	912 879	151 674	326 721	1 391 274	356 957	1 030 302	4 015	1 391 274
Oil, crude	48 805	-	-	48 805	48 805	-	-	48 805
Total mineral fuels	961 684	151 674	326 721	1 440 079	405 762	1 030 302	4 015	1 440 079
Total crude minerals	7 722 639	6 953 051	3 642 303	18 317 993	5 340 103	9 658 293	3 319 597	18 317 993
Total, all commodities	19 493 397	24 790 481	16 384 213	60 668 091	28 000 475	16 583 891	16 083 725	60 668 091
Crude minerals as a per cent of all commodities	39.6	28.0	22.2	30.2	19.1	58.2	20.6	30.2

- Nil; nes Not elsewhere specified.

TABLE 58. CANADA, CRUDE MINERALS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1977 AND 1978

	1977		1978	
	Loaded	Unloaded	Loaded	Unloaded
	(tonnes)			
Metallic minerals				
Alumina, bauxite ore	21 470	3 705 030	-	3 388 740
Copper ores and concentrates	816 235	-	678 868	35 208
Iron ore and concentrates	44 229 617	2 654 560	33 519 200	5 415 103
Lead ore and concentrates	97 693	15 571	98 224	-
Manganese ore	77 593	175 454	9 079	277 525
Nickel-copper ore and concentrates	108 219	29 548	44 685	18 517
Titanium ore	104 106	-	112 601	-
Zinc ore and concentrates	897 889	-	890 239	-
Ores and concentrates, nes	51 233	157 609	89 760	132 765
Iron and steel scrap	141 599	465	454 632	1 344
Nonferrous metal scrap	3 558	-	10 197	46
Slag, dross, residue	596 311	43 261	667 367	43 761
Total metals	47 145 523	6 781 498	36 574 852	9 313 009
Nonmetallic minerals				
Asbestos	269 620	2 313	316 566	1 637
Barite	74 569	-	46 950	-
Bentonite	-	259 813	9 551	155 331
China clay	-	32 428	-	45 463
Clay materials, nes	166	36 182	54	30 137
Dolomite	874 670	-	1 143 594	14 154
Fluorspar	10 990	122 477	9 979	214 974
Gypsum	4 940 953	16 419	5 472 451	112 536
Limestone	899 270	2 890 795	1 111 317	2 896 475
Phosphate rock	-	1 281 826	27 497	1 420 347
Potash (KCl)	1 397 449	18 623	1 717 967	27 297
Salt	1 282 034	950 145	1 590 162	968 154
Sand and gravel	11 641	1 264 920	233 535	1 297 394
Stone, crude, nes	41 415	13 339	74 656	9 771
Stone, crushed			18	-
Sulphur	2 649 403	12 031	2 412 609	5 171
Crude, nonmetallic minerals, nes	109 877	29 587	65 871	10 361
Total nonmetals	12 562 057	6 930 898	14 232 777	7 209 202
Mineral fuels				
Coal bituminous	9 952 375	15 302 598	11 087 496	13 443 184
Coal, nes	-	297 743	-	247 295
Oil, crude	597 273	16 402 728	395 850	15 772 012
Total fuels	10 549 648	32 003 069	11 483 346	29 462 491
Total crude minerals	70 257 228	45 715 465	62 290 975	45 984 702
Total, all commodities	119 770 049	58 882 220	116 521 506	61 792 786
Crude minerals as a per cent of all commodities	58.6	77.6	53.5	74.4

- Nil; nes - Not elsewhere specified.

TABLE 59. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1977 AND 1978

	1977		1978	
	Loaded	Unloaded	Loaded	Unloaded
	(tonnes)			
Metallic products				
Aluminum	248 141	5 183	392 695	1 729
Copper and alloys	89 210	4 173	50 449	5 401
Ferroalloys	32 087	50 669	807	36 607
Iron and steel, primary	70 719	52 927	161 838	41 513
Iron, pig	439 057	7 418	505 384	2 562
Iron and steel, other				
bars and rods	20 411	199 474	16 818	126 638
castings and forgings	15 657	39 756	283	6 372
pipes and tubes	12 331	101 059	17 955	44 616
plates and sheet	174 364	327 742	106 243	249 725
rails and track material	27 651	6 606	78 051	4 877
structural shapes	51 943	226 255	58 569	301 058
wire	2 773	13 438	1 774	7 591
Lead and alloys	34 922	2	19 224	3
Nickel and alloys	2 982	998	1 562	515
Zinc and alloys	56 632	8 219	100 046	1 070
Nonferrous metals, nes	1 274	5 960	9 708	5 740
Metal fabricated basic products	7 218	18 501	7 135	20 755
Total metals	1 287 372	1 068 380	1 528 541	856 772
Nonmetallic products				
Asbestos basic products	937	77	28	-
Building brick, clay	2	178	-	-
Bricks and tiles, nes	9 259	5 533	9 342	6 654
Cement	1 069 330	61 425	1 542 891	137 458
Cement basic products	2 684	1 133	4 573	511
Drain tiles and pipes	-	5	-	30
Glass basic products	2 001	5 864	1 947	4 540
Lime	4 292	463	4 022	-
Nonmetallic mineral basic products	6 102	6 776	5 996	12 709
Fertilizers, nes	130 759	185 974	142 277	271 472
Total nonmetals	1 225 366	267 428	1 711 076	433 374
Mineral fuel products				
Asphalts, road oils	169	16 439	27	2 635
Coal tar, pitch	64	81 104	4 169	69 322
Coke	233 622	873 014	169 401	680 497
Fuel oil	2 596 932	1 612 211	3 363 319	1 559 443
Gasoline	362 460	432	540 964	4 237
Lubricating oils and greases	571	20 403	708	22 590
Petroleum and coal products, nes	272 044	94 336	238 157	119 924
Total fuels	3 465 862	2 697 939	4 316 745	2 458 648
Total fabricated mineral products	5 978 600	4 033 747	7 556 362	3 748 794
Total, all commodities	119 770 049	58 882 220	116 521 506	61 792 786
Fabricated mineral products as a per cent of all commodities	5.0	6.9	6.5	6.1

- Nil; nes Not elsewhere specified.

TABLE 60. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1977

	Corporations		Assets		Equity		Sales		Profits		Taxable Income	
	(number)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)
Metal mines												
Reporting corporations												
50% and over non-resident	43	28.9	5,127	38.0	2,569	37.6	2,514	45.9	225	26.7	35.7	···
Under 50% non-resident	69	46.3	7,565	56.1	4,064	59.5	2,881	52.6	613	72.6	104.3	···
Government business enterprise	3	2.0	x	x	x	x	x	x	x	x	-	-
Other corporations	34	22.8	x	x	x	x	x	x	x	x	x	x
Total, all corporations	149	100.0	13,478	100.0	6,832	100.0	5,479	100.0	844	100.0	x	100.0
Mineral fuels												
Reporting corporations												
50% and over non-resident	217	21.6	10,791	60.0	6,224	65.0	8,636	77.9	2,133	75.3	1,875.5	89.2
Under 50% non-resident	379	37.8	6,117	34.0	2,951	30.8	2,143	19.3	641	22.6	224.5	10.7
Government business enterprise	6	0.6	1 047	5.8	401	4.2	285	2.6	57	2.0	-	-
Other corporations	402	40.0	29	0.2	-14	..	20	0.2	3	0.1	2.9	0.1
Total, all corporations	1,004	100.0	17,985	100.0	9,562	100.0	11,084	100.0	2,834	100.0	2,102.9	100.0
Other mining (including mining services)												
Reporting corporations												
50% and over non-resident	208	7.1	2,506	56.7	1,410	63.8	1,527	56.0	374	78.7	205.9	..
Under 50% non-resident	1,007	34.4	1,748	39.5	764	34.6	1,076	39.5	101	21.3	90.3	..
Government business enterprise	2	0.1	x	x	x	x	x	x	x	x	-	-
Other corporations	1,708	58.4	x	x	x	x	x	x	x	x	x	x
Total, all corporations	2,925	100.0	4,423	100.0	2,211	100.0	2,727	100.0	475	100.0	x	100.0
Total mining												
Reporting corporations												
50% and over non-resident	468	11.5	18,424	51.3	10,203	54.8	12,678	65.7	2,732	65.8	2,117.0	83.1
Under 50% non-resident	1,455	35.7	15,430	43.0	7,780	41.8	6,100	31.6	1,355	32.6	419.0	16.5
Government business enterprise	11	0.2	1,864	5.2	627	3.4	380	2.0	66	1.6	-	-
Other corporations	2,144	52.6	167	0.5	-5	···	132	0.7	-1	···	11.1	0.4
Total, all corporations	4,078	100.0	35,886	100.0	18,605	100.0	19,290	100.0	4,152	100.0	2,547.1	100.0

Note: Footnotes for Table 61 apply to this table. Figures may not add to totals due to rounding.

[1] Classification of the industry is the same as in Table 25.

- Nil; ··· Amount too small to be expressed; .. Not available or not applicable; x Confidential.

TABLE 61. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1977

	Corporations[2]		Assets[5]		Equity[6]		Sales[7]		Profits[8]		Taxable Income[9]	
	(number)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)
Primary metal products												
Reporting corporations[2]												
50% and over non-resident	53	10.9	1,215	14.0	739	18.1	1,433	17.6	134	27.7	70.1	50.1
Under 50% non-resident	238	48.9	7,045	81.3	3,457	84.7	5,776	71.0	422	87.4	68.7	49.1
Government business enterprises[3]	2	0.4	x	x	x	x	x	x	x	x	–	–
Other[4]	194	39.8	x	x	x	x	x	x	x	x	1.2	0.8
Total, all corporations	487	100.0	8,670	100.0	4,084	100.0	8,135	100.0	483	100.0	140.0	100.0
Nonmetallic mineral products												
Reporting corporations[2]												
50% and over non-resident	115	8.6	2,799	70.0	1,292	73.0	2,094	59.8	200	41.4	111.9	64.8
Under 50% non-resident	599	45.1	1,142	28.6	461	26.1	1,323	37.8	77	15.9	57.1	33.1
Government business enterprises[3]	1	0.1	x	x	x	x	x	x	x	x	–	–
Other[4]	613	46.2	x	x	x	x	x	x	x	x	3.6	2.1
Total, all corporations	1,328	100.0	3,998	100.0	1,770	100.0	3,500	100.0	279	100.0	172.6	100.0
Petroleum and coal products												
Reporting corporations[2]												
50% and over non-resident	17	33.3	12,406	92.3	6,499	93.4	13,509	95.3	1,349	98.7	703.7	..
Under 50% non-resident	23	45.1	x	x	x	x	x	x	x	x	x	..
Government business enterprises[3]	–	–	–	–	–	–	–	–	–	–	–	–
Other[4]	11	21.6	x	x	x	x	x	x	x	x	x	..
Total, all corporations	51	100.0	13,442	100.0	6,956	100.0	14,179	100.0	1,367	100.0	x	100.0
Total mineral manufacturing industries												
Reporting corporations[2]												
50% and over non-resident	185	9.9	16,420	62.9	8,530	66.6	17,036	66.0	1,683	79.1	885.7	..
Under 50% non-resident	860	46.1	x	x	x	x	x	x	x	x	x	..
Government business enterprises[3]	3	0.2	x	x	x	x	x	x	x	x	–	–
Other[4]	818	43.8	x	x	x	x	x	x	x	x	x	..
Total, all corporations	1,866	100.0	26,110	100.0	12,810	100.0	25,814	100.0	2,129	100.0	x	100.0

[1] Classification of industries is the same as in Table 26. [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 non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Non-taxable 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 non-profit 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. [7] For non-financial corporations, sales are gross revenues from non-financial operations. For financial corporations sales include income from financial as well as non-financial sources. [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 or not applicable; x Confidential.

TABLE 62. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN NON-FINANCIAL INDUSTRIES, BY MAJOR INDUSTRY GROUP AND BY CONTROL, 1976 AND 1977

	Agriculture, forestry, fishing and trapping		Mining		Manufacturing		Construction		Transportation, communication and other utilities		Trade		Services		Total	
	1976	1977P	1976	1977P	1976	1977P	1976	1977P	1976	1977P	1976	1977P	1976	1977P	1976	1977P
	(number)															
Number of corporations																
Foreign control	107	108	479	468	2,426	2,321	191	189	300	308	2,057	2,031	601	598	6,161	6,023
Canadian control	4,182	4,683	1,402	1,455	11,555	12,044	10,608	11,463	3,450	3,878	27,693	30,308	10,871	12,422	69,761	76,253
Other corporations	7,828	8,254	2,187	2,155	15,338	15,550	26,342	28,677	9,978	10,427	56,680	59,933	44,218	49,142	162,571	174,138
Total corporations	12,117	13,045	4,068	4,078	29,319	29,915	37,141	40,329	13,728	14,613	86,430	92,272	55,690	62,162	238,493	256,414
	($ million)															
Assets																
Foreign control	306	305	15,502	18,424	47,084	51,113	2,020	1,905	5,435	6,032	9,679	10,793	3,370	3,723	83,396	92,296
Canadian control	2,585	2,951	13,030	15,430	36,750	39,695	11,620	12,460	23,454	25,259	29,236	32,249	10,174	11,589	126,848	139,634
Other corporations	760	807	1,618	2,031	3,938	4,606	1,821	1,940	43,748	50,371	6,397	6,319	4,914	5,938	63,197	72,011
Total corporations	3,651	4,063	30,149	35,886	87,772	95,414	15,461	16,305	72,636	81,662	45,312	49,360	18,458	21,250	273,440	303,940
Equity																
Foreign control	141	141	8,168	10,203	23,677	25,528	461	492	1,915	2,186	3,516	3,729	1,322	1,435	39,200	43,714
Canadian control	852	973	6,472	7,780	14,542	16,389	2,698	2,965	9,289	10,027	9,454	10,425	2,950	3,353	46,257	51,911
Other corporations	183	186	589	622	911	800	532	541	8,956	10,194	1,537	1,558	794	1,048	13,502	14,948
Total corporations	1,176	1,300	15,230	18,605	39,130	42,717	3,691	3,998	20,160	22,406	14,507	15,710	5,067	5,836	98,958	110,573
Sales																
Foreign control	256	275	9,883	12,678	66,394	73,731	2,813	2,668	2,841	3,614	23,023	25,847	3,548	3,986	108,758	122,798
Canadian control	2,232	2,677	5,321	6,100	48,156	52,829	15,747	17,125	13,455	15,987	74,605	83,220	9,613	11,730	169,130	189,669
Other corporations	681	753	422	512	3,448	3,595	3,469	3,712	10,856	13,220	14,044	14,492	4,365	5,283	37,286	41,567
Total corporations	3,169	3,705	15,626	19,290	117,998	130,156	22,029	23,505	27,152	32,821	111,674	123,559	17,526	20,999	315,174	354,035
Profits																
Foreign control	22	18	2,037	2,732	4,976	4,853	161	150	388	450	709	571	382	435	8,675	9,208
Canadian control	134	175	1,178	1,355	2,418	2,601	809	661	1,405	1,625	1,931	1,962	596	688	8,472	9,069
Other corporations	35	46	58	65	-28	-78	131	104	441	650	1,222	1,241	290	284	2,149	2,313
Total corporations	191	239	3,273	4,152	7,367	7,376	1,101	915	2,235	2,725	3,862	3,775	1,267	1,407	19,296	20,589

Note: Figures may not add to totals due to rounding.
P Preliminary.

TABLE 63. CANADA, CAPITAL AND REPAIR EXPANDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES, 1978-80

	1978			1979P			1980f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Mining industry									
Metal mines									
Gold	36.7	17.8	54.5	47.0	19.3	66.3	66.3	21.4	87.7
Silver-lead-zinc	62.3	38.6	100.9	88.2	42.6	130.8	99.2	45.2	144.4
Copper-gold-silver	131.2	156.1	287.3	202.6	164.5	367.1	356.8	178.6	535.4
Iron	103.6	213.7	317.3	148.8	284.5	433.3	187.2	298.0	485.2
Other metal mines	242.8	115.1	357.9	385.9	109.6	495.5	546.0	127.5	673.5
Total metal mines	576.6	541.3	1,117.9	872.5	620.5	1,493.0	1,255.5	670.7	1,926.2
Nonmetal mines									
Asbestos	103.0	94.1	197.1	105.0	100.2	205.2	94.3	109.5	203.8
Other nonmetal mines[2]	320.9	213.2	534.1	321.7	247.5	569.2	408.1	277.2	685.3
Total nonmetal mines	423.9	307.3	731.2	426.7	347.7	774.4	502.4	386.7	889.1
Mineral fuels									
Oil, crude and gas[3]	2,902.9	489.8	3,392.7	3,973.4	551.2	4,524.6	5,406.6	564.0	5,970.6
Total mining industries	3,903.4	1,338.4	5,241.8	5,272.6	1,519.4	6,792.0	7,164.5	1,621.4	8,785.9
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	309.5	507.6	817.1	353.1	613.6	966.7	617.8	711.5	1,329.3
Steel pipe and tube mills	35.8	37.9	73.7	72.3	39.0	111.3	55.9	44.9	100.8
Iron foundries	37.9	44.1	82.0	39.9	35.1	75.0	26.4	36.2	62.6
Smelting and refining	180.4	232.1	412.5	236.4	227.5	463.9	355.6	260.8	616.4
Aluminum rolling, casting and extruding	18.5	17.0	35.5	24.9	20.2	45.1	27.6	23.0	50.6
Copper and copper alloy rolling, casting and extruding	4.3	11.5	15.8	4.7	3.9	8.6	12.3	5.3	17.6
Metal rolling, casting and extruding	19.7	10.7	30.4	24.0	11.6	35.6	30.5	12.2	42.7
Total primary metal industries	606.1	860.9	1,467.0	755.3	950.9	1,706.2	1,126.1	1,093.9	2,220.0

(Continued on following page)

TABLE 63 (cont'd)

	1978			1979[p]			1980[f]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Nonmetallic mineral products									
Cement	68.9	47.4	116.3	137.2	62.6	199.8	131.4	63.4	194.8
Stone products	1.0	0.7	1.7	0.9	1.3	2.2	1.0	1.1	2.1
Concrete products	21.8	30.6	52.4	40.9	24.7	65.6	30.8	31.7	62.5
Ready-mix concrete	32.7	42.0	74.7	25.5	35.9	61.4	26.6	37.4	64.0
Clay products	5.5	8.7	14.2	7.9	5.1	13.0	7.1	5.4	12.5
Glass and glass products	63.9	23.2	87.1	67.7	18.3	86.0	58.4	17.2	75.6
Abrasives	8.5	11.5	20.0	11.5	14.7	26.2	25.7	14.6	40.3
Lime	4.1	4.8	8.9	5.3	5.9	11.2	4.1	5.1	9.2
Other nonmetallic mineral products	73.5	38.9	112.4	105.6	38.3	143.9	84.8	43.3	128.1
Total nonmetallic mineral products	279.9	207.8	487.7	402.5	206.8	609.3	369.9	219.2	589.1
Petroleum and coal products	315.1	174.9	490.0	277.6	205.9	483.5	356.9	237.8	594.7
Total mineral manufacturing industries	1,201.1	1,243.6	2,444.7	1,435.4	1,363.6	2,799.0	1,852.9	1,550.9	3,403.8
Total mining and mineral manufacturing industries	5,104.5	2,582.0	7,686.5	6,708.0	2,883.0	9,591.0	9,017.4	3,172.3	12,189.7

[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 66.

[p] Preliminary; [f] Forecast.

TABLE 64. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINING INDUSTRY[1], 1970-80

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979[p]	1980[f]
						($ million)					
Metal mines											
Capital											
Construction	335.6	590.8	345.7	357.1	409.6	499.6	597.6	626.8	407.3	584.7	754.0
Machinery	150.3	239.8	313.0	241.3	157.9	215.3	305.3	352.0	169.3	287.8	501.5
Total	485.9	830.6	658.7	598.4	567.5	714.9	902.9	978.8	576.6	872.5	1,255.5
Repair											
Construction	36.6	38.9	26.4	48.0	58.7	63.7	61.5	63.1	53.7	65.4	73.1
Machinery	220.2	240.9	242.4	299.7	383.4	446.7	521.6	536.7	487.6	555.1	597.6
Total	256.8	279.8	268.8	347.7	442.1	510.4	583.1	599.8	541.3	620.5	670.7
Total capital and repair	742.7	1,110.4	927.5	946.1	1,009.6	1,225.3	1,486.0	1,578.6	1,117.9	1,498.0	1,926.2
Nonmetal mines[2]											
Capital											
Construction	107.9	84.6	59.8	67.5	116.0	112.8	161.3	214.8	187.5	201.8	203.8
Machinery	115.9	105.6	81.3	79.7	125.7	209.6	214.6	225.8	236.4	224.9	298.6
Total	223.8	190.2	141.1	147.2	241.7	322.4	375.9	440.6	423.9	426.7	502.4
Repair											
Construction	7.1	7.9	6.2	6.5	13.1	23.8	20.0	20.8	18.2	24.5	26.4
Material	99.9	107.1	116.4	135.2	167.0	184.3	226.2	273.2	289.1	323.2	360.3
Total	107.0	115.0	122.6	141.7	180.1	208.1	246.2	294.0	307.3	347.7	386.7
Total capital and repair	330.8	305.2	263.7	288.9	421.8	530.5	622.1	734.6	731.2	774.4	889.1
Mineral fuels											
Capital											
Construction	552.6	639.4	729.3	851.7	1,060.9	1,355.7	1,598.0	1,998.0	2,520.9	3,524.6	4,807.0
Machinery	86.2	101.3	91.2	83.4	165.3	219.0	564.1	447.5	382.0	448.8	599.6
Total	638.8	740.7	820.5	935.1	1,226.2	1,574.7	2,162.1	2,445.5	2,902.9	3,973.4	5,406.6
Repair											
Construction	93.5	102.7	106.8	138.0	159.0	215.2	287.4	318.3	389.6	333.7	354.7
Machinery	22.5	28.7	35.6	54.2	62.3	68.5	82.9	101.2	100.2	217.5	209.3
Total	116.0	131.4	142.4	192.2	221.3	283.7	370.3	419.5	489.8	551.2	564.0
Total capital and repair	754.8	872.1	962.9	1,127.3	1,447.5	1,858.4	2,532.4	2,865.0	3,392.7	4,524.6	5,970.6

(Continued on following page)

TABLE 64. (cont'd.)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979p	1980f
	($ million)										
Total mining											
Capital											
Construction	996.1	1,314.8	1,134.8	1,276.3	1,586.5	1,968.1	2,356.9	2,839.6	3,115.7	4,311.1	5,764.8
Machinery	352.4	446.7	485.5	404.4	448.9	643.9	1,084.0	1,025.3	787.7	961.5	1,399.7
Total	1,348.5	1,761.5	1,620.3	1,680.7	2,035.4	2,612.0	3,440.9	3,864.9	3,903.4	5,272.6	7,164.5
Repair											
Construction	137.2	149.5	139.4	192.5	230.8	302.7	368.9	402.2	461.5	423.6	454.2
Machinery	342.6	376.7	394.4	489.1	612.7	699.5	830.7	911.1	876.9	1,095.8	1,167.2
Total	479.8	526.2	533.8	681.6	843.5	1,002.2	1,199.6	1,313.3	1,338.4	1,519.4	1,621.4
Total capital and repair	1,828.3	2,287.7	2,154.1	2,362.3	2,878.9	3,614.2	4,640.5	5,178.2	5,241.8	6,792.0	8,785.9

[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 65. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1970-80

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979p	1980f
	($ millions)										
Primary metal industries[2]											
Capital											
Construction	114.0	89.0	95.3	75.8	148.0	200.5	144.8	171.2	130.7	144.4	223.9
Machinery	311.2	312.4	276.6	328.5	549.7	614.4	496.1	549.1	475.4	610.9	902.2
Total	425.2	401.4	371.9	404.3	697.7	814.9	640.9	720.3	606.1	755.3	1,126.1
Repair											
Construction	28.6	28.4	35.3	38.8	51.6	65.8	63.2	85.3	80.8	91.1	100.7
Machinery	324.6	343.5	383.2	420.1	507.3	563.4	632.4	662.8	780.1	859.8	993.2
Total	353.2	371.9	418.5	458.9	558.9	629.2	695.6	748.1	860.9	950.9	1,093.9
Total capital and repair	778.4	773.3	790.4	863.2	1,256.6	1,444.1	1,336.5	1,468.4	1,467.0	1,706.2	2,220.0
Nonmetallic mineral products[3]											
Capital											
Construction	30.7	21.8	30.7	37.6	29.5	41.1	46.6	63.3	62.0	105.2	67.0
Machinery	104.3	58.5	99.2	151.1	144.7	158.0	195.4	215.5	217.9	297.3	302.9
Total	135.0	80.3	129.9	188.7	174.2	199.1	242.0	278.8	279.9	402.5	369.9
Repair											
Construction	5.4	7.0	8.5	7.5	11.3	14.4	15.4	16.1	17.5	16.8	18.2
Machinery	77.1	80.4	85.7	112.0	130.9	151.8	164.9	169.5	190.3	190.0	201.0
Total	82.5	87.4	94.2	119.5	142.2	166.2	180.3	185.6	207.8	206.8	219.2
Total capital and repair	217.5	167.7	224.1	308.2	316.4	365.3	422.3	464.4	487.7	609.3	589.1
Petroleum and coal products											
Capital											
Construction	213.7	211.3	214.0	229.7	321.7	337.5	255.9	268.2	215.6	187.3	252.4
Machinery	17.4	20.1	29.8	89.1	107.8	112.9	88.3	98.4	99.5	90.3	104.5
Total	231.1	231.4	243.8	318.8	429.5	450.4	344.2	366.6	315.1	277.6	356.9
Repair											
Construction	51.0	51.3	61.3	71.1	83.8	96.1	101.2	125.7	117.5	148.2	168.7
Machinery	9.2	9.8	14.6	17.3	27.0	37.0	35.8	45.8	57.4	57.7	69.1
Total	60.2	61.1	75.9	88.4	110.8	133.1	137.0	171.5	174.9	205.9	237.8
Total capital and repair	291.3	292.5	319.7	407.2	540.3	583.5	481.2	538.1	490.0	483.5	594.7

(Continued on following page)

TABLE 65. (cont'd.)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979p	1980f
						($ millions)					
Total mineral manufacturing industries											
Capital											
Construction	358.4	322.1	340.0	343.1	499.2	579.1	447.3	502.7	408.3	436.9	543.3
Machinery	432.9	391.0	405.6	568.7	802.2	885.3	779.8	863.0	792.8	998.5	1,309.6
Total	791.3	713.1	745.6	911.8	1,301.4	1,464.4	1,227.1	1,365.7	1,201.1	1,435.4	1,852.9
Repair											
Construction	85.0	86.7	105.1	117.4	146.7	176.3	179.8	227.1	215.8	256.1	287.6
Machinery	410.9	433.7	483.5	549.4	665.2	752.2	833.1	878.1	1,027.8	1,107.5	1,263.3
Total	495.9	520.4	588.6	666.8	811.9	928.5	1,012.9	1,105.2	1,243.6	1,363.6	1,550.9
Total capital and repair	1,287.2	1,233.5	1,334.2	1,578.6	2,113.3	2,392.9	2,240.0	2,470.9	2,444.7	2,799.0	3,403.8

[1] Industry groups are the same as in Table 26. [2] Includes smelting and refining. [3] Includes cement, lime and clay products manufacturing.

[p] Preliminary; [f] Forecast.

TABLE 66. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES[1], 1969-80

	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)			
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	2,684.1	312.4	145.6	246.6	315.1	218.8	3,922.6
1979[p]	3,742.5	264.3	137.7	250.0	277.6	230.9	4,903.0
1980[f]	5,060.3	459.3	171.4	286.6	356.9	346.3	6,680.8

[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 63.

[p] Preliminary; [f] Forecast.

Company Index

B

C

D

E

F

G

H

I

J

K

O

P

Q