MINERAL POLICY SECTOR
SECTEUR DE LA POLITIQUE MINÉRALE

1991 CANADIAN MINERALS YEARBOOK

REVIEW AND OUTLOOK

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

Canada

THE ENERGY OF OUR RESOURCES - THE POWER OF OUR IDEAS

L'ÉNERGIE DE NOS RESSOURCES - NOTRE FORCE CRÉATRICE

Available in Canada through

Associated Bookstores

and other booksellers or by mail from

Canada Communication Group—Publishing

Ottawa, Canada K1A 0S9

Catalogue No. M38-5/40E
ISBN: 0-660-14678-9

La version française intitulée

Annuaire des minéraux du Canada

est aussi disponible

(n° de catalogue : M38-5/40F)

The year 1992 marks the 150th anniversary of the Geological Survey of Canada. The Mineral Policy Sector is pleased to recognize one of Canada's oldest scientific agencies and its distinguished record of public service.

FOREWORD

Each year, the Mineral Policy Sector of Energy, Mines and Resources Canada completes a comprehensive review of developments in the industry for the year just ended and publishes the results as the Canadian Minerals Yearbook. The Yearbook series forms a continuing record from year to year, with this edition reporting on the activities of the minerals and metals industry during 1991. It contains detailed industry statistics and includes separate chapters devoted to each of the major minerals and metals.

The subject matter spans all stages of mineral industry activity from geoscience and exploration, through mining and processing, to markets, consumption and recycling. Although domestic matters receive the greatest attention, international developments are also reviewed because of the global nature of the minerals industry and the potentially significant impact that such developments could have on the Canadian industry. Some chapters of the Yearbook are intended to be general enough to be of interest to a broad readership, while others are more technical and will appeal to individuals who are more closely associated with the industry.

The year 1991 saw a continuation of the recession that had begun in the previous year. As with other sectors of the economy, the minerals industry was not immune to the negative effects of the economic downturn, such as lower levels of employment, reduced operating revenues and decreased investment on plant and equipment. Commodity prices were on a general downward trend during 1991 and had a major impact on the overall value of mineral production. In particular, average nonferrous metal prices in 1991 were much lower than in 1990. Some commodities also recorded lower volumes of production. The total value of Canadian mineral production (including mineral fuels) fell to $34.8 billion in 1991 from $40.8 billion in 1990, with declines occurring in all four commodity groups: metals, nonmetals, structural materials, and fuels.

For some leading minerals, in excess of 80% or 90% of production is exported, thereby making the total value of mineral exports very important to the Canadian economy. Including fuels, mineral and mineral product exports account for about one quarter of the country's total exports. In this regard, the industry faces challenges such as those presented by free trade, increased global competition, and growing environmental restrictions. It is anticipated, however, that the industry will meet these challenges successfully and will continue to be a major contributor to the Canadian economy.

The 1991 Yearbook begins with a general review highlighting the importance of the industry in the context of the Canadian economy. This chapter provides a summary of the overall volume and value of Canadian mineral production, along with a brief overview and production statistics for Canada's leading minerals. It is followed by chapters that focus on: the international scene; the regional outlook; labour and employment; mine reserves, investment, new projects and promising deposits; and mineral exploration. The 33 commodity chapters in this edition feature economic and policy developments and data specific to each commodity in respect of markets, prices, production, trade and consumption. These commodity reviews also provide an outlook of the industry's future position.

The Statistical Report at the end of the Yearbook is comprised of over 90 tables which provide a detailed statistical overview of the minerals industry. These tables are grouped according to the following topics: production; trade; consumption; prices; principal statistics; employment; mining, exploration and drilling; transportation; investment and finance; and research and development. Although the tables focus on the most recent data available, many of the tables also include an historical series covering past years.

The basic statistics on Canada's mineral and metal production, trade and consumption were collected by the Mineral and Metal Statistics Division, Mineral Policy Sector, and by Statistics Canada, unless otherwise noted. Market quotations were taken mainly from published marketing reports. Corporate data presented in the various chapters of this Yearbook were obtained by the authors directly from company officials through surveys or correspondence, or were taken from annual reports. Energy, Mines and Resources Canada is grateful to everyone who has contributed information used in the preparation of this Yearbook.

Additional copies of the 1991 Yearbook may be purchased from the Canada Communication Group - Publishing (telephone: (819) 956-4802) and associated bookstores. Previous editions of the Canadian Minerals Yearbook have been deposited in various libraries across Canada.

Reprints of individual chapters, as well as copies of Map 900A, Principal Mineral Areas of Canada, may be obtained free of charge from:

Publications Distribution Office
Mineral Policy Sector
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

July 1992

Production Manager: J. Bureau
Coordinator/Editor: E. Godin
Graphics: T.-C. Young
Make-Up: I. Van Zeeland

Typesetting and Layout: S. O'Malley
K. Angyal
L. Leclerc-Rocheleau

CHAPTERS

1. **General Review**
2. **International Scene**
3. **Regional Outlook**
4. **Labour and Employment**
5. **Canadian Reserves, Mine Investment, New Projects and Promising Deposits**
6. **Canadian Mineral Exploration**
7. **Canadian Mine Openings and Closures**
8. **Aluminum**
9. **Arsenic**
10. **Asbestos**
11. **Bismuth**
12. **Cadmium**
13. **Cement**
14. **Chromium**
15. Clays
16. **Coal**
17. **Cobalt**
18. Columbium
19. **Copper**
20. Fluorspar
21. **Gold**
22. **Graphite**
23. **Gypsum and Anhydrite**
24. **Iron Ore**
25. **Lead**
26. **Lime**
27. **Magnesium**
28. Manganese
29. **Mercury**
30. **Mineral Aggregates**
31. Nepheline Syenite and Feldspar
32. **Nickel**
33. **Peat**
34. Platinum Metals
35. **Potash**
36. **Primary Iron, Steel and Ferrous Scrap**
37. **Salt**
38. **Selenium and Tellurium**
39. **Silica**
40. **Silver**
41. **Sodium Sulphate**
42. Specialty Metals
43. **Stone**
44. **Sulphur**
45. Talc, Steatite and Pyrophyllite
46. Tantalum
47. **Tin**
48. Titanium
49. Tungsten
50. **Uranium**
51. Vanadium
52. **Zinc**
53. **Principal Canadian Nonferrous Precious Metal Mine Production in 1990, with Highlights for 1991**
54. **Statistical Report**

Note: Commodities shown in bold type are covered in this issue. The other commodities listed have appeared in previous editions.

General Review

A.B. Siminowski

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 943-8096

THE CANADIAN ECONOMY IN 1991

The year 1991 was the first year since 1982 that Canada failed to achieve real economic growth on a year-to-year basis. Gross Domestic Product (GDP) in 1991 was estimated to have declined by about 1.5% in real terms. The economy began the year in the midst of a recession and continued to decline during the first quarter of the year. After a strong but temporary rebound in the second quarter, economic growth weakened, resulting in only marginal growth in the third quarter and a decrease in the last quarter. In general, the economy was characterized by high unemployment, low consumer and business confidence, weak spending by consumers, plant layoffs and shut-downs, depressed levels of business investment, and record numbers of business and personal bankruptcies.

Consumer caution due to high unemployment, the accumulation of consumer debt and the decline in real disposable income over the past year accounted for weak consumer spending. Despite a temporary upturn in the second quarter, personal spending on goods and services was down by 1.1% in real terms for the year overall. The unemployment rate, which averaged 10.3% in 1991 compared to 8.1% in 1990, was the highest jobless rate in six years; about 1.4 million people were out of work in 1991 compared to 1.1 million in 1990. The total number of housing starts fell by 14% in 1991 to its lowest level since 1984.

The rate of increase in the Consumer Price Index (CPI) peaked in January 1991 at 6.8% on a year-over-year basis, reflecting the introduction of the federal government's Goods and Services Tax at the beginning of the year. Since then, the inflation rate trended downward, ending the year 3.8% above the December 1990 CPI level. For 1991 overall, the average inflation rate was 5.6% compared with 4.8% in 1990.

Business investment in plant and equipment continued to be depressed, reflecting extremely low corporate profit levels coupled with weak aggregate demand. Business remained cautious in the face of weak market demand and stiff import competition, keeping inventory levels low and cutting back on employment levels. Business expenditures on plant and equipment were down by 1.9% in real terms in 1991. Capacity utilization rates in manufacturing industries averaged only 71% during the first nine months of the year, well below the 80% average of the past 10 years. Some 300 000 jobs have been lost in the manufacturing sector since the beginning of the recession in April 1990.

Merchandise trade is typically a source of strength to the Canadian economy. However, merchandise exports were down by 3.3% in 1991, showing the effects of weak export markets and a high Canadian dollar. Merchandise imports were down by 0.9%, reflecting a weak Canadian economy. On balance, Canada recorded a merchandise trade surplus of about $7.4 billion, considerably lower than the $10.9 billion surplus achieved in 1990.

Canada exports nearly 25% of everything that is grown, extracted or manufactured in the country. Exports will play a key role in Canada's economic recovery and much will depend on the revival of demand for goods in the United States. With three quarters of Canada's merchandise exports going to the United States, the importance of the American economy's performance and its impact on Canada's economic health is significant. Like the Canadian economy, the American economy was having difficulty climbing out of the recession and maintaining an upward surge. In fact, it appeared to have fallen back into a downturn toward the end of the year, into a so-called "double-dip" recession, with industrial production, housing starts and employment all declining. Overall, real GDP in the United States was estimated to have declined by 0.7% in 1991.

THE MINERALS INDUSTRY IN 1991

The minerals industry encompasses more than just the production of basic ores and concentrates, as the output from mining and concentrating becomes the input for subsequent processing. In addition, activities associated with recycling are an important and integral part of mineral industry operations. In broad terms, the industry is often described in terms of four stages of processing activity which are defined as follows:

- Stage I - Primary Mineral Production (mining and concentrating);
- Stage II - Metal Production (smelting and refining);
- Stage III - Minerals and Metals-Based Semi-Fabricating Industries; and
- Stage IV - Metal-Fabricating Industries.

Including all four stages of activity, the minerals industry accounted for about 4.4% of Canada's GDP in 1991 (including the coal and uranium industries, but excluding oil and natural gas). The mining and concentrating stage alone accounted for about one third of the minerals industry's GDP. In 1991, the minerals industry contributed about $21.9 billion (at 1986 prices) to Canada's GDP. This was a decrease from the 1990 level of $23.2 billion, resulting from declines in the semi-fabricating and fabricating stages of the industry.

Preliminary estimates for 1991 indicated that total employment in the minerals industry was about 330 000, down 12.7% from 378 000 in 1990. This reflected an overall weakness in economic activity and a general downward trend in employment in the various sectors of the Canadian economy. Overall, the industry accounts for about 3% of total national employment. All stages of the minerals industry experienced a decline in employment during the year, particularly in the semi-fabricating and fabricating mineral industries.

The total number of employees in Stage I (metal mining, nonmetal mining, quarrying and coal mining) was estimated at 72 000, down from 75 000 in 1990. Employment in Stage II (nonferrous smelting and refining and the primary steel industries) was estimated at 67 000, down from 71 000 in 1990. Employment in Stages III and IV (semi-fabricating and fabricating mineral industries) declined to 191 000 in 1991 from 232 000 in 1990. The decline in Stages III and IV was 17.6% compared with a decrease of 4.9% in the total for Stages I and II.

The mining industry in Canada operated at a capacity utilization rate of about 88% during the first two quarters of the year, not much different from the 1990 level of about 90%. Within the manufacturing sector of the economy, the capacity utilization rates in the mineral and metal-based industries maintained an upward trend. Capacity utilization in the primary metals industries rose to 84.2% in the third quarter of 1991 from 76.7% in the first quarter, and fabricated metal products industries rose to 68.4% from 66.2%. With residential construction activity expanding, capacity utilization in the nonmetallic mineral products industries rose to 67.8% in the third quarter from 61.3% in the first quarter.

Operating revenues in the minerals industry have been substantially more volatile than in the overall economy. Revenues in the metal mining and primary metals industries (Stages I, II and III) increased sharply in 1983 following the recession of 1982, but then remained fairly flat for several years. However, with the strengthening of metal prices during the period 1987-89, revenues increased dramatically by 65% between the end of 1986 and the beginning of 1989. Since peaking in early 1989, metal prices have fallen considerably, causing revenues in this sector to fall more than revenues in industry as a whole. Based on the first three quarters of data, operating revenues in 1991 were projected to be about 11% lower than in 1990. Operating revenues for nonmetallic minerals appear to be as volatile as for the metallic industries. Since the beginning of 1989, revenues have trended downward, but they recovered somewhat in the second quarter of 1991.

The return on assets in the metal mining and primary metals industries, which peaked at about 16% in the third quarter of 1989 and subsequently declined to become negative in the third quarter of 1990, continued to be weak in 1991. The return on assets in metal mining and primary metals averaged just over 2% in mid-1991. For nonmetallic minerals, the return on assets since mid-1987 has exceeded the return in the metals sector, as well as in industry as a whole. While the return on assets in the nonmetallic minerals industries was nearly 20% in 1988, it has declined to about 5% in 1991.

The level of debt in the metal mining and primary metals industries was about $14.0 billion at the end of the third quarter of 1991, about 10% higher than in 1990. This was a return to its 1985 level, after having declined somewhat since that year. The level of debt in this sector had grown substantially during the early 1980s, doubling between 1980 and 1985. The debt-to-equity ratio was about 0.45 in mid-1991 compared to its peak of 0.67 in 1985. For nonmetallic minerals, the debt-to-equity ratio has been quite volatile, rising from 0.74 at the beginning of 1988 to 1.10 at the end of 1990, then declining to 0.60 by the third quarter of 1991. This was mainly the result of changes in the level of equity, rather than in the level of debt which has remained relatively stable since 1988.

Preliminary estimates of capital expenditures by the minerals industry (excluding the petroleum and natural gas industries) totalled $4.9 billion in 1991. This represented a decrease from the $6.2 billion spent on plant and equipment in 1990, with all stages of the industry recording lower expenditures in 1991. Including outlays for repairs, total spending by the minerals industry for capital investment and repair was $9.1 billion for 1991 compared to $10.9 billion in 1990. This level of spending represented 5.6% of total capital and repair expenditures within the Canadian economy in 1991.

Expenditures on retrofit facilities and equipment for pollution abatement and control purposes have become a major focus of capital spending by industry. Statistics Canada recently reported on the results of its first comprehensive Pollution Abatement and Control Survey (PAC), based on the year 1989. The survey evaluated the financial commitment of selected organizations to the reduction and elimination of pollutants and wastes, i.e., air pollutants, water pollutants, contained liquids and solid wastes. The organizations surveyed within the mining and primary metals manufacturing industries (including smelting and refining) reported some $301 million of capital spending for 1989, as well as an additional $317 million of corresponding operating and maintenance expenditures. Revenues from the sales of recovered materials and savings made from using these materials accounted for over $43 million as a result of these initiatives in the primary metals manufacturing industries.

Research and development (R&D) spending intentions by the minerals industry (excluding the petroleum and natural gas industries) totalled $301 million for 1991, an increase from $278 million in 1990. This level of R&D spending represented 5.8% of total R&D expenditures planned by Canadian industries in 1991. Metal mines were expected to account for 21% ($64 million) of mineral industry R&D spending in 1991. The level of spending in metal mining R&D has almost doubled since 1988. Spending intentions of the primary metals manufacturing industries (ferrous and nonferrous) represented 53% ($161 million) of the mineral industry R&D total for 1991, a slight increase from the 1990 level of $157 million.

Total spending on exploration for nonfuel minerals in 1991 was estimated to have been between $530 million and $580 million, compared to $750 million in 1990 and $828 million in 1989. The 1991 estimate was lower than the $646 million of intended exploration spending indicated by federal-provincial surveys carried out in late 1990 and early 1991, reflecting the marked decline in flow-through share financing.

MINERAL PRODUCTION

The value of Canadian mineral production (including mineral fuels) totalled $34.8 billion in 1991 compared with $40.8 billion in 1990, representing a decrease of 14.6%, or about $6.0 billion. Although this drop was mainly precipitated by lower prices, reduced volumes of output were also recorded by some commodities. Declines in the value of output occurred in all four commodity groups: metals, nonmetals, structural materials and fuels.

Commodity prices were on a general downward trend throughout 1991. In particular, nonferrous metal prices averaged out at much lower levels than in 1990. By year-end, the Raw Materials Price Index for nonferrous metals had fallen by 16.1% from its December 1990 level. Over the same period, the Raw Materials Price Index for ferrous materials fell by 4.5%, and for nonmetallic minerals by 3.3%.

Similarly, the Industrial Product Price Index for primary metal products continued the downward slide that had begun in the last quarter of 1990. By December 1991, after 15 consecutive monthly declines, the primary metal products index was 8.2% below its

December 1990 level, falling to its lowest point since April 1987. On the other hand, the Industrial Product Price Indexes for fabricated metal products and for nonmetallic mineral products remained relatively constant over the course of the year.

Significant decreases in the average prices of crude petroleum and metallic minerals accounted for most of the decrease in the overall value of production. The nonfuels sector as a group (metals, nonmetals and structurals) saw the total value of production fall by 15.9% to $15.0 billion in 1991 from $17.8 billion in 1990. The value of production is summarized below, by commodity group:

THE CANADIAN MINERALS INDUSTRY VALUE OF PRODUCTION, 1990 AND 1991

	1990	1991	Change
	($ millions)		(%)
Metals	12 500.0	10 425.3	-16.6
Nonmetals	2 492.2	2 250.5	-9.7
Structurals	2 796.0	2 286.7	-18.2
Total Nonfuels	17 788.2	14 962.4	-15.9
Fuels	22 989.9	19 851.8	-13.6
Total	40 778.0	34 814.2	-14.6

Note: Numbers may not add to totals due to rounding.

The total value of metallic mineral production fell by 16.6% to $10.4 billion in 1991 from $12.5 billion in 1990. Metallic minerals, led by gold, copper, nickel, zinc and iron ore, accounted for 29.9% of the total value of mineral production in 1991.

The value of output of the nonmetallics, which include minerals such as asbestos, potash, salt and sulphur, declined by 9.7% to $2.3 billion in 1991 from $2.5 billion in the previous year. The nonmetals group accounted for 6.5% of the total value of mineral output in 1991.

The value of production for the structural materials group, which includes sand and gravel, stone, cement and lime, fell to $2.3 billion from $2.8 billion, a decrease of 18.2%. The value of structural materials produced in 1991 represented 6.6% of the overall mineral total.

In the fuels sector, which includes crude petroleum, natural gas, natural gas by-products and coal, the value of production decreased by 13.6% to $19.9 billion in 1991 from $23.0 billion in 1990. This decrease of $3.1 billion was largely the result of lower petroleum prices, and brought the overall value of fuels production back to its 1989 level. In 1991, the average price for crude oil was much lower than in 1990, which had seen a temporary escalation of prices in the latter half of the year caused by the Persian Gulf crisis.

Although the volume of petroleum production fell by only 0.6% in 1991, the lower average price caused the overall value of petroleum production to decrease by 18.9%, or about $2.5 billion, from the 1990 level. While petroleum, natural gas and natural gas by-products all experienced declines in the value of production, coal recorded increases in both volume and value of output. Overall, the fuels sector accounted for 57.0% of the total value of mineral production in 1991.

On a provincial basis, Alberta's contribution to total Canadian mineral output (including fuels) represented the largest share, amounting to $16.1 billion, or 46.4% of the total in 1991. Ontario was second with a value of $5.1 billion, or 14.5% of the total. British Columbia accounted for $3.8 billion (10.8%), Quebec for $2.9 billion (8.4%), Saskatchewan for $2.9 billion (8.2%), and Manitoba for $1.1 billion (3.2%). The other provinces and the territories accounted for the remaining 8.5%.

The top ten commodities in terms of value of output in 1991 were: crude petroleum ($10.6 billion), natural gas ($5.2 billion), gold ($2.4 billion), natural gas by-products ($2.1 billion), copper ($2.1 billion), coal ($1.9 billion), nickel ($1.8 billion), zinc ($1.4 billion), iron ore ($1.3 billion), and potash ($0.9 billion).

MINERAL TRADE

The minerals industry continued to make a significant contribution to Canada's merchandise trade surplus in 1991. Mineral and mineral product exports, including fuels, totalled $27.8 billion for the first three quarters of 1991. This represented 27.1% of total domestic exports. Imports of minerals and mineral products over the same period totalled $13.9 billion, or 13.8% of all Canadian imports. In terms of net trade, a mineral trade surplus of approximately $14.0 billion, including fuels, was recorded for the first three quarters of 1991, illustrating the importance of the minerals industry in Canada. Over the first nine months of 1991, 70.4% of total mineral exports went to the United States, 8.8% to the European Community and 6.9% to Japan.

Excluding petroleum and natural gas, but including coal, the total value of mineral exports was estimated at $17.8 billion for the first nine months of 1991. This included crude minerals, smelted and refined products, semi-fabricated and fabricated forms, as well as waste and scrap for recycling. The output from the mining and metallurgical extraction industries (i.e., Stages I and II) accounts for roughly three quarters of this total. Imports were estimated at about $9.5 billion, resulting in a trade surplus for minerals (excluding petroleum and natural gas, but including coal) of $8.3 billion for the first three quarters of 1991.

LEADING MINERALS

Gold

Canada is the world's fifth largest producer of gold. Gold production in Canada was estimated at 177 tonnes (t) in 1991, an increase of 5.6% over the 1990 production level of 167 t. Although gold prices fell in 1991, the increase in production volume held the decrease in the total value of gold output to only 2.2%. With total output valued at $2.4 billion, gold took over as the leading metal in 1991 in terms of the value of production. Gold prices drifted lower in 1991, averaging US$362/oz compared to US$384/oz in 1990. Rising world production and relatively low inflation rates have been factors leading to lower gold prices. Expectations of a moderate increase in world gold production for the next two years or so are keeping a downward pressure on the price of gold.

Copper

Canada ranks fourth in the world in the mine production of copper. Copper production in Canada increased slightly by 0.3%

to 774 000 t in 1991 from 771 000 t in 1990. The value of production, however, fell by 13.5% to $2.1 billion, reflecting a lower average price of US$1.06/lb on the London Metal Exchange (LME) in 1991 compared to US$1.21/lb in 1990. While labour and production problems at several locations in the world had the effect of keeping copper prices above the US$1.00/lb level, industrial demand for copper was generally weak and was expected to remain so for most of 1992. Assuming no major supply disruptions, it is expected that there will be a downward pressure on prices, particularly in light of the continued overall growth of world copper output.

Nickel

Canada is the world's second largest producer of nickel, topped only by Russia. Canada's nickel production decreased by 3.0% to 189 000 t in 1991 from 195 000 t in 1990, while the value of production declined by 9.8% to $1.8 billion. In response to weak nickel prices, production cutbacks in the fourth quarter were announced by the two major producers at their Sudbury operations. In 1991, nickel prices averaged US$3.70/lb on the LME, a decrease from the 1990 average of US$4.03/lb. For the first eight months of the year, prices had averaged US$3.90/lb. However, as a result of increased supply in combination with flat demand, prices were much lower in the latter part of the year, falling as low as US$3.23/lb on average in December. Stainless steel demand, which accounts for over 60% of nickel consumption, remained strong for most of 1991. Demand in this sector is expected to increase in 1992 as the major world economies begin to improve.

Zinc

Canada is the world's largest producer of zinc concentrates. Zinc production in Canada was estimated at 1.1 million tonnes (Mt) in 1991, a decrease of 8.4% from the 1990 level of 1.2 Mt. The reduced production was the result of labour disputes and mine closures. The combination of lower volumes and much lower prices caused the value of production to fall by 40.6% to $1.4 billion in 1991. Zinc prices averaged US$0.51/lb on the LME in 1991, considerably lower than the 1990 average of US$0.69/lb. This fall in prices was the result of growing surpluses in the concentrate market, fewer production disruptions, the downturn in world economies and high levels of stocks of zinc metal. After peaking in April, with an average price of US$0.57/lb, zinc prices began to fall slowly but steadily, although they did turn upward in the last two months of 1991, closing the year at an average December price of US$0.54/lb. However, because increased demand is not expected to be sufficient to eliminate the surplus of zinc metal created by increased mine production, high stock levels, and increased imports from the Commonwealth of Independent States, downward pressure on zinc prices is expected during 1992.

Lead

Canada ranks fifth in the world in the mine production of lead. After three years of decline, lead production increased to 240 000 t in 1991, an increase of 2.7% over the 1990 level of 233 000 t. This increase was due to the resolution of a number of production disruptions ranging from labour disputes to technical problems. However, lower prices precipitated a 27.0% decline in the value of lead production to $204 million in 1991 from $279 million in

1990. Lead prices on the LME averaged US$0.25/lb in 1991, considerably lower than the 1990 average of US$0.37/lb when tight markets prevailed. In 1991, however, as a result of increased production and surplus stocks, there was a general downward trend in lead prices throughout the year. A modest surplus is forecast through 1992 as demand is expected to remain soft.

Silver

Canada is the world's fifth largest producer of silver. Production of silver in Canada fell to an estimated 1240 t in 1991, a decrease of 10.2% from the 1990 production level of 1381 t. This was the result of mine closures as well as declining production at some mines. The combination of reduced volumes and lower prices caused the value of production to fall by 25.8% to $185 million. The price of silver, which has declined over the past decade because of relatively weak demand and high by-product output, fell to a 17-year low of US$3.58/oz in February 1991. Since then, prices found support around the US$4.00/oz level, largely as a result of increased demand from the fabricating sector. Silver prices averaged US$4.06/oz for the year compared to US$4.83 in 1990; only a slight increase is expected in 1992. Silver is now viewed more as an industrial metal as opposed to a precious metal.

Iron Ore

Iron ore production in Canada increased by 0.8% to 36.0 Mt in 1991 from 35.7 Mt in 1990, with the value of iron ore output rising to $1.3 billion, an increase of 3.9%. Of the leading metallic minerals, iron ore was the only commodity to achieve an increase in the value of production. Canada ranks seventh in production among world iron ore producers. Although the worldwide market for steel was weak in 1991, iron ore prices increased, but not as much as in the previous two years when the market for iron ore had tightened. The closure of two small iron ore mines in Ontario in 1990, and the scheduled closure of a third mine in 1992, will leave only three iron ore mines in Canada with a total annual production capacity of 45 Mt/y. About 75% of Canada's iron ore output is exported, with about 43% going to Europe. With expectations of an improved market for steel in 1992, the tight iron ore market in Europe could bring another price increase for 1992 deliveries.

Asbestos

Asbestos production in Canada was estimated at 670 000 t in 1991, a decrease of 2.2% from 686 000 t in 1990. The value of output, however, rose slightly by 0.9% to $275 million. The international regulatory issues associated with this commodity, and the ongoing debate regarding its use, continued to have an adverse impact on some world markets for asbestos products. Canada is the world's second largest producer of asbestos.

Potash

Potash production in Canada was estimated at 7.0 Mt in 1991, a decrease of 4.5% from 7.3 Mt in 1990. Correspondingly, the value of output decreased by 4.8% to $919 million. Due to world overcapacity, the Canadian industry operated at about 70% of effective capacity. Nevertheless, Canada remains the world's second largest producer of potash, exceeded only by the Commonwealth of Independent States. Canada is by far the largest exporter of potash, accounting for about 40% of world trade in that commodity. Extended shut-downs in the summer of 1991 gave rise to price stabilization in offshore markets.

Coal

Coal production increased by 3.9% to 71 Mt in 1991 from 68.3 Mt in 1990, with the value of production increasing by 4.5% to $1.9 billion. Approximately 45% of Canada's coal production is exported, with the main market being Japan. Preliminary trade data for the first nine months of the year indicated that the value of coal exports was down by about 13% from the corresponding period in 1990.

Structural Materials

The total value of structural materials fell by 18.2% to $2.3 billion in 1991 from $2.8 billion in 1990. Lower shipments of primary construction materials, such as cement, stone, sand and gravel, reflected the general slowdown in the construction industry. The total number of housing starts in 1991 fell by about 14% from the previous year's level. A continuing weakness in the economy was seen to further delay recovery in both the residential and non-residential sectors of the industry. Canada produces more tons of aggregate per capita per year than any other country in the world. Based on a 1990 report, more than 16 tons of sand, gravel and crushed stone are processed annually per capita population.

CHALLENGES FOR THE INDUSTRY

Increasingly tough competition will continue to be a challenge to Canadian industry. In this regard, the federal government officially launched its "Prosperity Initiative" in October 1991, fulfilling an undertaking that had been announced in its Speech from the Throne earlier in the year. This initiative is a major consultative process designed to obtain input and build a consensus among Canadians in responding to Canada's present and future economic challenges. The announcement was accompanied by the publication of two discussion papers for widespread public use in the consultations. These documents, entitled "Prosperity Through Competitiveness" and "Learning Well . . . Living Well," examined the key factors that must be addressed in the process, such as improvements in productivity, training and education.

Consultations with the metals and minerals industry (jointly sponsored by Energy, Mines and Resources Canada and Industry, Science and Technology Canada) were to be led by The Mining Association of Canada. Sessions were scheduled for early 1992 in Halifax, Toronto and Vancouver, with a final report to be produced shortly thereafter.

Environmental matters also continue to be an important area of concern for industry, government and individual Canadians. These include a broad spectrum of environmental issues such as global warming, ozone depletion, air/water emissions, recycling, waste management, environmental liability, etc. The mining industry is specifically affected by the increasing costs associated with meeting environmental commitments. Because of the global effects and the cross-jurisdictional nature of environmental issues, the industry faces the added burden of having to deal with uncoordinated environmental regulations. There is a need to work together internationally as well as domestically with all levels of government, business, industry and other interested parties. The many environmental issues affecting the minerals sector are being addressed in various fora by the industry and governments to ensure that the minerals and metals industry can operate responsibly within environmental guidelines while still remaining competitive in an international market.

While many issues demanded attention in 1991, concerns over land access, environmental assessment reviews, mine-site reclamation and waste management were at the forefront. Access for mineral exploration and development to large tracts of land that might be set aside as protected areas, or for native land claims, has become a dominant issue. The industry is concerned that its ability to develop and explore for new mineral deposits will be threatened, and that its resource base will be adversely affected. Issues such as environmental assessments and mine-site reclamation are currently being discussed by the various interested parties concerned with the extent of government regulations and the costs associated with them.

Waste management concerns are international in scope. Discussions concerning the implementation of the 1989 Basel Convention on the Transboundary Movement of Hazardous Waste raised real concerns over the ability of the recycling industry to move scrap metal across borders. Other international involvement includes the Organization for Economic Co-operation and Development's (OECD) Risk Reduction Program on Lead, Cadmium and Mercury, and the upcoming Brazil '92 convention sponsored by the United Nations Conference on the Environment and Development (UNCED), which is expected to be a highlight of the environmental agenda in 1992.

OUTLOOK FOR 1992

The Canadian economy entered the year 1992 on a very sluggish note, with no clear indication that the recession had ended. In general, economists were predicting a gradual, strengthening recovery during the year, aided by lower interest rates and falling inflation. Although there was some uncertainty regarding the pace and intensity of the recovery in 1992, economic growth was forecast to be in the general order of only 2% to 3% for the year overall, which is relatively slow for an economy coming out of a recession.

The recovery was not expected to make much of an impact on the unemployment rate, which was projected to remain at about the 10% level. Growth in consumer spending was forecast to be modest in light of high unemployment and modest wage gains. Business investment was still seen to be restricted by the weak state of corporate earnings. Capital spending by the business sector as a whole was expected to fall by about 1.5% in 1992, continuing the downward trend of the previous two years.

The extent of the recovery and its timing is linked to a considerable degree to economic developments in the United States. Predictions at the beginning of the year generally indicated that the U.S. economy would remain stagnant for at least the first three months of 1992, with perhaps little chance of improvement before the summer. As a result of the economic slowdown in the United States, as well as in the global economies, commodity prices were expected to remain depressed, thus keeping pressure on Canadian producers to improve productivity and to remain competitive.

Canada's mineral resources have long been a source of strength to the economy. With significant development over the years, the minerals-based industry has become technologically sophisticated and is far from being considered a sunset industry. Many nations of the world lack the richness of mineral resources that Canada enjoys. Furthermore, in light of the potential demand in newly industrializing countries for basic minerals and mineral products, opportunities exist for further development of the minerals industry at all stages of processing activity, and not just further up the scale of value-added manufacturing.

For several years, Canada's minerals industry (excluding oil and natural gas) has accounted for an average of about 4.7% of Canada's GDP, over 3% of total national employment, and 18%-19% of total Canadian exports. Expenditures by the minerals industry for capital investment and repair, as well as for R&D, have represented major spending within the economy. Despite the current economic slowdown and ever-broadening challenges such as those presented by environmental protection and international competitiveness, it is anticipated that the Canadian minerals industry will continue to be a source of strength to Canada's economy.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. CANADA, PRODUCTION OF LEADING MINERALS, 1990 AND 1991

		1990	1991p	Percent Change 1991/1990	1990	1991p	Percent Change 1991/1990
		(000 tonnes except where noted)			($ millions)		
METALS							
Gold	kg	167 372.5	176 720.1	5.6	2 407.7	2 355.3	-2.2
Copper		771.4	773.6	0.3	2 428.9	2 101.2	-13.5
Nickel		195.0	189.2	-3.0	2 027.9	1 828.2	-9.8
Zinc		1 179.4	1 079.9	-8.4	2 272.6	1 351.0	-40.6
Iron ore		35 670.0	35 961.1	0.8	1 258.8	1 307.9	3.9
Uranium	tU	9 720.2	7 813.3	-19.6	888.0	472.1	-46.8
Lead		233.4	239.6	2.7	279.3	203.9	-27.0
Silver	t	1 381.3	1 239.9	-10.2	249.7	185.3	-25.8
Platinum group	kg	11 123.4	10 955.4	-1.5	189.4	141.8	-25.1
Molybdenum	t	12 188.5	11 292.0	-7.4	84.7	70.4	-16.9
NONMETALS							
Potash (K_2O)		7 344.6	7 012.0	-4.5	964.9	919.0	-4.8
Asbestos		685.6	670.4	-2.2	272.1	274.5	0.9
Salt		11 191.4	11 585.3	3.5	240.9	258.6	7.3
Sulphur, elemental		5 822.1	6 029.0	3.6	368.9	244.1	-33.8
Peat		774.6	737.1	-4.8	89.7	91.7	2.2
Sulphur in smelter gas		789.8	726.4	-8.0	81.2	76.6	-5.7
STRUCTURALS							
Cement		11 745.2	9 395.9	-20.0	991.4	816.8	-17.6
Sand and gravel		244 315.8	200 497.1	-17.9	817.3	631.4	-22.7
Stone		111 351.8	85 784.8	-23.0	662.9	512.8	-22.6
Lime		2 340.7	2 335.8	-0.2	188.3	186.3	-1.1
Clay products		. .	. .	. .	136.0	139.4	2.5
FUELS							
Petroleum	000 m^3	90 278.6	89 702.6	-0.6	13 103.4	10 629.5	-18.9
Natural gas	million m^3	98 770.8	103 393.4	4.7	5 692.0	5 191.0	-8.8
Natural gas by-products	000 m^3	23 862.7	24 705.1	3.5	2 370.8	2 125.5	-10.3
Coal		68 332.0	71 000.0	3.9	1 823.7	1 905.9	4.5

Sources: Energy, Mines and Resources Canada; Statistics Canada.
. . Not available; p Preliminary.
Note: Figures have been rounded.

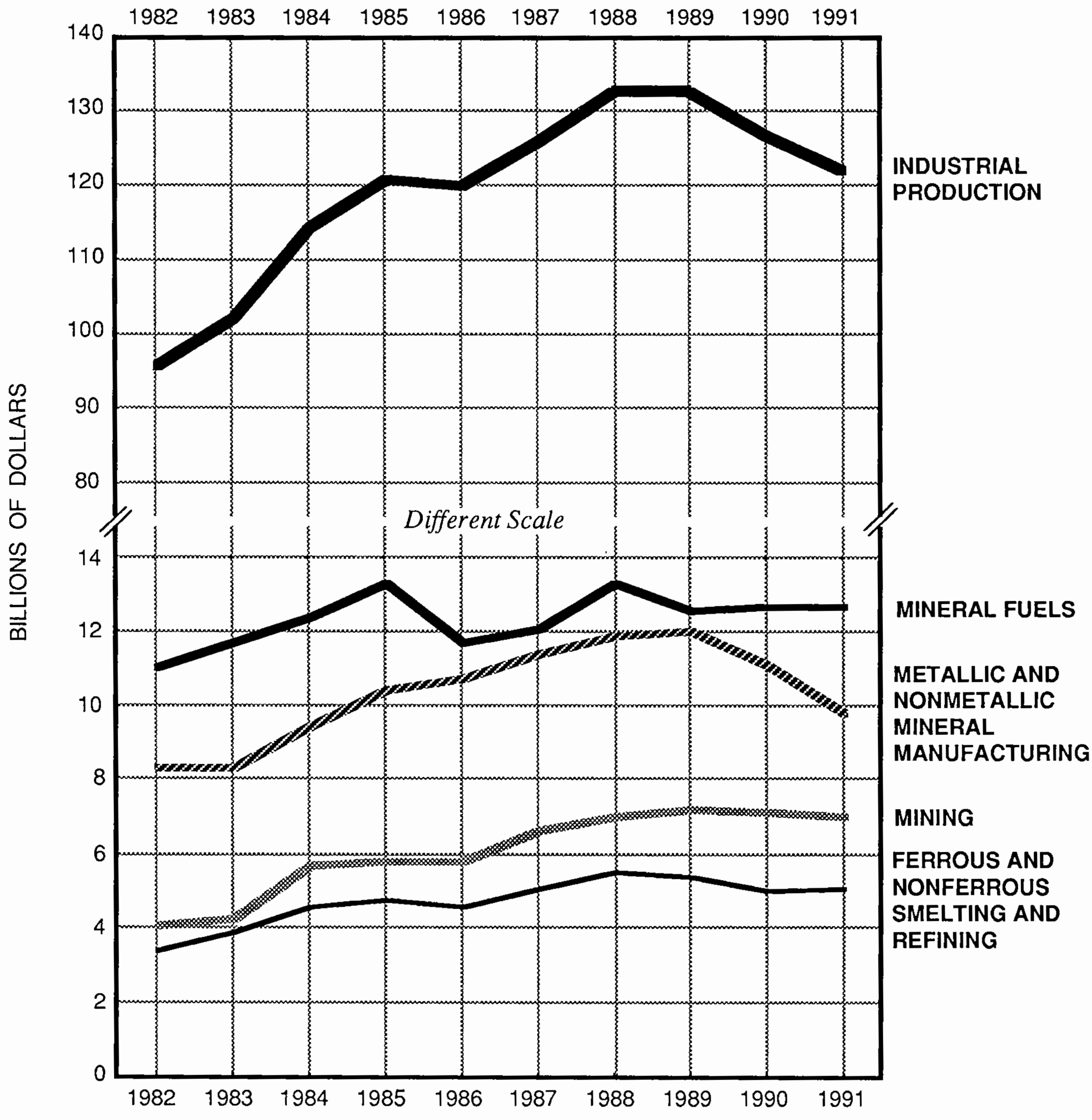
TABLE 2. CANADA, VALUE OF EXPORTS OF MINERALS, METALS AND THEIR PRODUCTS FOR 1991 (9 MONTHS)

Chapter[1]	Description	United States	EEC	Japan	Mexico	Other	Total
				($000)			
25	Salt; sulphur; earths and stone, plastering material, lime and cement	385 557	113 504	47 919	26 049	443 314	1 016 343
26	Ores, slag and ash	292 006	775 746	540 551	1 155	205 769	1 815 227
27	Mineral fuels, oils and products of their distillation; bituminous substances; mineral waxes[2]	9 786 844	341 430	905 061	16 161	580 018	11 629 514
28	Inorganic chemicals; compounds of precious metals, radioactive elements, etc.	941 404	105 590	17 648	230	86 596	1 151 468
31	Fertilizers	717 325	19 680	47 102	2 463	392 722	1 179 292
68	Articles of stone, plaster, cement, asbestos, mica or similar materials	230 672	9 775	1 489	164	6 440	248 540
69	Ceramic products	25 619	886	307	38	5 693	32 543
70	Glass and glassware	216 147	30 309	4 103	35	15 050	265 644
71	Natural/cultured pearls, precious stones and metals, coins, etc.	1 255 948	116 902	37 612	711	654 329	2 065 502
72	Iron and steel	1 052 224	64 266	20 520	28 661	432 804	1 598 475
73	Articles of iron or steel	1 113 834	23 174	2 412	969	114 295	1 254 684
74	Copper and articles thereof	594 028	364 172	9 284	141	126 352	1 093 977
75	Nickel and articles thereof	564 015	173 837	17 268	673	329 463	1 085 256
76	Aluminum and articles thereof	1 849 880	276 272	238 733	143	241 648	2 606 676
78	Lead and articles thereof	40 650	7 336	3 707	–	6 497	58 190
79	Zinc and articles thereof	425 875	16 927	22 365	–	109 065	574 232
80	Tin and articles thereof	4 939	233	212	–	518	5 902
81	Other base metals; cermets; and articles thereof	85 246	14 032	1 965	6	37 430	138 679
	Total	19 582 213	2 454 071	1 918 258	77 599	3 788 003	27 820 144
	Total Domestic Exports	76 770 220	8 393 455	5 345 647	275 106	11 914 853	102 699 281

Source: Statistics Canada, Catalogue 65-003 (Quarterly).
[1] Chapter refers to a group of commodities covered in a specified chapter of the "Harmonized Commodity Description and Coding System," as of January 1, 1988. Canadian external trade statistics are classified according to the Harmonized System. [2] Total value of coal exports included in Chapter 27 is $1617 million.
– Nil.

Figure 1

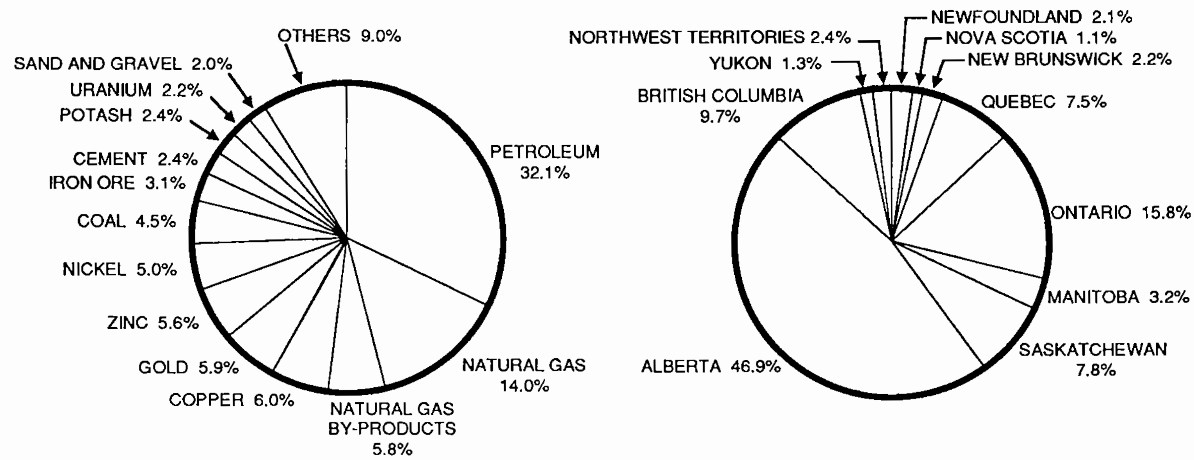
GROSS DOMESTIC PRODUCT AT FACTOR COST AT 1986 PRICES



Note: Data for 1991 are estimated.
Source: Statistics Canada.

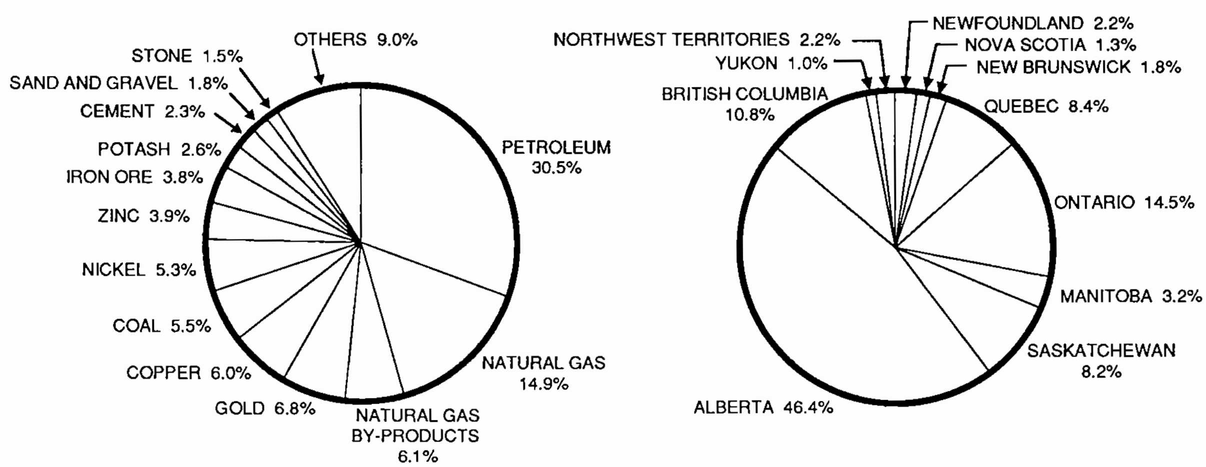
Figure 2

VALUE OF MINERAL PRODUCTION IN 1990
$40.8 BILLION
(% SHARES BY COMMODITY AND BY PROVINCE)



% OF TOTAL BY COMMODITY   % OF TOTAL BY PROVINCE

VALUE OF MINERAL PRODUCTION IN 1991
$34.8 BILLION
(% SHARES BY COMMODITY AND BY PROVINCE)



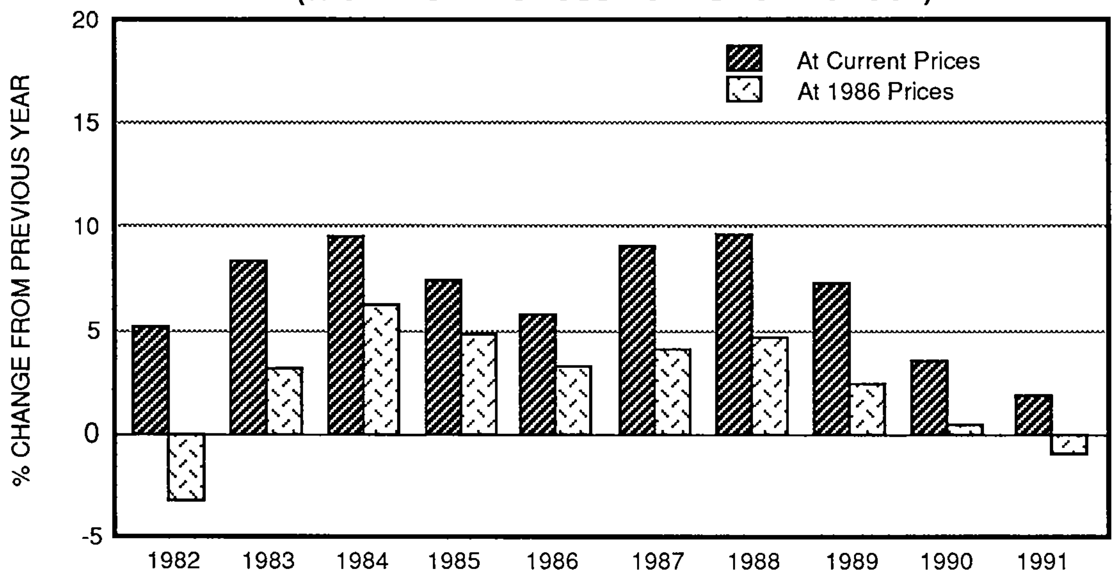
% OF TOTAL BY COMMODITY   % OF TOTAL BY PROVINCE

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

Figure 3

TRENDS IN CANADIAN ECONOMIC ACTIVITY

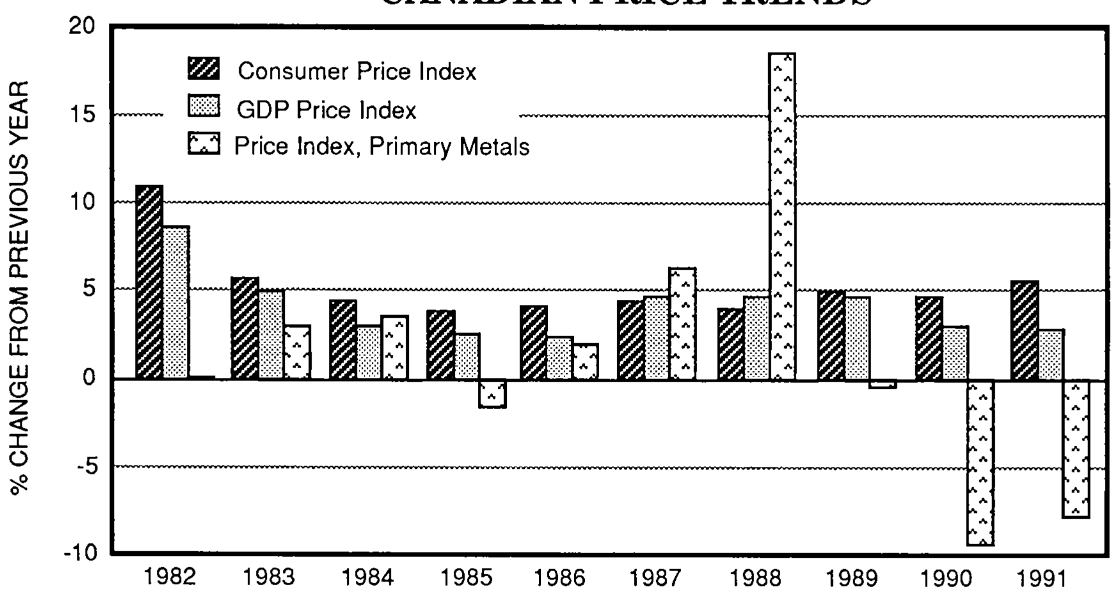
(% CHANGE IN GROSS DOMESTIC PRODUCT)



Note: Data for 1991 are estimated.
Source: Statistics Canada.

Figure 4

CANADIAN PRICE TRENDS



Note: Data for 1991 are estimated.
Source: Statistics Canada. Based on 1986 Price Indexes = 100.

International Scene

Winston Chambers

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 995-0276

The international review usually examines institution-specific or bilateral events of interest to the Canadian mining industry. This year a more macro-level approach is taken to speculate on emerging issues in trade policy and investment decisions.

INDUSTRY PERFORMANCE

The growth performance of the Canadian minerals industry, measured in terms of output, exports and movements in market shares, was disappointing. But this was to be expected given the unfavourable international economic climate of 1991.

The growth performance of the Canadian minerals industry is determined largely by three factors:

- the cost and price competitiveness of the industry in all markets (domestic and foreign) for minerals and metals;
- the domestic demand for minerals and metals; and
- changes in levels of global economic activity and the associated pattern of demand for minerals and metals.

Throughout 1991, all three determinants of the demand for Canadian minerals and metals were adversely affected by a number of factors, including a domestic interest rate policy aimed at curbing inflationary pressures.

NEW TRADING ENVIRONMENT

The world economy is in the throes of a recession. Successions of business failures, the persistence of much idle productive capacity, protracted high levels of unemployment, and the deceleration of the growth of international trade are some of the adverse consequences of a major cyclical economic contraction.

Throughout most of the post-war period, recessions, especially those that were primarily cyclical in nature, were usually short-lived. They responded favourably to appropriate Keynesian fiscal and monetary policy prescriptions. This is, however, no longer the case.

During the past decade and a half, the internationalization of economic activity has altered the way the world economy functions in such a way that economic stabilization has become complex and difficult. By linking national economies through financial, commodity and product markets, the internationalization process enmeshes national economies in a web of interdependent economic relationships which facilitates the transmission of economic disturbances among countries. No country can effectively insulate itself from disequilibrating external shocks or disturbances which are transmitted rapidly throughout all trading countries.

The persistence of the current recession is therefore due, in part, to the difficulties inherent in harmonizing desirable domestic economic growth policies with those required to stimulate global economic growth and development. As serious as the consequences of the recession are, the attendant challenges for the mineral and other industries in the near future seem minor in comparison to those which are emerging from the interplay of certain political and economic factors which are currently transforming the world economy.

In recent years, industrially advanced economies have been actively promoting economic globalization. This calls for the liberalization of trade policies, foreign investment laws, taxation systems and mining laws. Globalization, it is argued, will facilitate the free movement of capital, technology, goods and services among countries, and will in the process lead to a more efficient allocation of resources and an improvement in world economic welfare. From this, it follows that the successful outcome of the current negotiations of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) would constitute a major advance towards ultimate globalization.

Several developing countries, which have traditionally maintained high tariff schedules in order to generate government revenues and provide protection to domestic industry, embraced the concept of globalization. Consequently, they liberalized their tariff regimes by simplifying tariff structures, reducing rates and increasing the share of duty-bound items in the GATT. In this regard, the process of tariff reduction in Latin America has been significant. Bolivia, Costa Rica, Chile, Mexico and Venezuela bound their tariff schedules to the GATT.

SOURCES OF POLICY ISSUES

Throughout this decade, policy-makers will face challenges from the interaction of three phenomena which are transforming global patterns of investment flows, technology transfers and trade.

The first phenomenon, which may be described as rising protectionism, is the emergence of regional economic blocs relative to the multilateral rules-based trading system of the GATT. Decades of slow multilateral leveling down of trade barriers are being challenged by a trading bloc system: the Americas, the European Community and the Asian-Pacific region centred around Japan. This can be expected to affect the geographical pattern of international investment flows.

The second phenomenon is the economic and political restructuring of Central and Eastern Europe in the aftermath of the Cold War and the collapse of the U.S.S.R. The restructuring from state-controlled to market-ruled economies will call for large investment outlays and could, consequently, result in the diversion of investment capital away from other countries. The establishment, by the World Bank, of a European Bank for Reconstruction and Development attests to the immediacy, magnitude and significance of this restructuring problem.

The third phenomenon is the environment and sustainable development. Environmental protection and sustainable development policies are likely to affect production costs, profits, sectoral patterns of investment, and international capital movements.

Taken together, these phenomena will pose new and difficult problems for the efficient allocation of scarce investment capital and other factors of production.

REGIONALISM–ITS RATIONALE AND FUTURE

The phenomenon of trading blocs can be traced to three things:

- a widespread disillusionment with the GATT on matters of surveillance, power of enforcement and clarity of rules;
- the need for large captive markets; and
- the quickening of technological changes, the associated rapid shifts in comparative advantage, and the attendant adjustment costs.

Although the GATT was established to facilitate multilateral trade through the lowering of trade barriers, its surveillance and enforcement powers were limited from the outset. In practice, the powers of surveillance and enforcement proved to be even more limited as tariff barriers and other restrictive trade practices became more significant as nominal tariffs were lowered through successive negotiating rounds. On this subject, Morris Miller, in his recent publication *Debt and the Environment: Converging Crisis (1991)* commented that: "the non-tariff barriers of industrialized countries remained higher against manufactured third world exports than against those of other industrialized countries and in many cases have been insurmountable beyond a limited quota. The developing countries have thus come to question the underlying rationale of the GATT, and "trade liberalization" has come to be seen as an empty box with misleading labels."

The disillusionment over the GATT is not confined to developing countries. During the 1980s, the U.S. government changed its trade policy from a single overriding commitment to the GATT to a multi-track policy on unilateralism, bilateralism and plurilateralism. The first major unilateralism initiative was launched in 1985 through more active use of the administration of Section 301 of the *1974 Trade Act* under which the United States alone decides other countries' unfair trading practices on special items, identifies violators, implements retaliation and secures compliance. The idea of unfair trade practices was later extended in the *1988 Omnibus Trade Act* to cover trade practices of whole countries (Super 301). Bilateralism was first endorsed in the 1985 U.S.-Israel Free Trade Agreement, followed by the much larger Canada-U.S. Free Trade Agreement in 1989. The current free trade negotiations with Canada and Mexico herald plurilateralism.

In light of these initiatives, it is now unlikely that the United States will resume its role as a guarantor of the multilateral trading system. Moreover, the other two major trading powers, the European Community and Japan, are apparently not prepared to give unqualified support to the multilateral trade system.

If the GATT is being questioned, how should it respond? Some economists are advocating a "Super GATT" and the resurrection of the International Trade Organization (ITO) that was discussed in 1944 at the same time the World Bank and the International Monetary Fund (IMF) were conceived.

For some governments, the formulation of regional trading blocs represents a second best option. There are, however, those who contend that strengthened regional arrangements represent moves away from multilateralism in trade and will be stumbling blocks to any attempt to reconstitute an open trading system. Conversely, others argue that regional liberalization will promote freer trade globally by setting precedents which can later serve as a basis for multilateral agreements by breaking new ground in

Regional Outlook

M.K. McMullen

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 995-6760

The year 1991 was one of the worst experienced by the Canadian minerals industry. The value of production of metals, nonmetals, structural materials and coal in 1991 was $16.9 billion, a decrease of $2.7 billion over 1990, or 14%. Metals decreased nearly 17%, nonmetals dropped by 9.7%, and structurals dropped by 18%. Coal was a bright spot, increasing by 4.3%. When natural gas, natural gas by-products and crude petroleum are included, the value of production was $34.8 billion, a decrease of 14.7% over 1990.

Price declines were evident for most commodities and particularly for major metals such as copper, lead, zinc, nickel and aluminum. While the minerals industry in Canada is driven by international markets for its products, the impacts of its operations are local and regional. Total mine employment declined by 4.2% to approximately 71 750 employees as companies closed mines or reduced operations. This, combined with reduced exploration, especially for gold, brought mining activity to a standstill in some regions. However, through all of this, there were pockets of intense exploration, new mines were brought into production, and mine expansions occurred.

To help put in place the information base and to set the stage for a recovery, new federal-provincial Mineral Development Agreements (MDAs) were signed with Ontario, Manitoba, Saskatchewan, the Yukon and the Northwest Territories during 1991. As well, negotiations were under way for new MDAs with Alberta, British Columbia, Quebec and Nova Scotia.

NEWFOUNDLAND AND LABRADOR

In 1991, the estimated value of mineral production from Newfoundland and Labrador was $793 million, a decrease of 8.4% from 1990. Iron ore accounted for approximately 93% of the total. All major indicators (claims staked, claims in good standing, diamond drilling and exploration expenditures) showed a decrease in activity from the previous year. Furthermore, employment decreased 22% to approximately 3450.

The mining industry in Newfoundland continued to suffer setbacks in 1991. St. Lawrence Fluorspar Limited was placed in receivership and Baie Verte Mines Inc. closed its asbestos mine. However, the assets of Baie Verte Mines Reprocessing Inc. were purchased by Teranov Mining Corporation, who continued to operate the new wet process mill to recover asbestos from tailings. Operations at BP Canada Inc.'s Hope Brook Gold Inc. were suspended early in the year and subsequently offered for sale. In December, Royal Oak Resources Ltd. signed a letter of intent to purchase the entire assets of Hope Brook Gold Inc. and hope to bring the mine back into production.

Also on a positive note, Newfoundland Goldbar Resources Inc. discovered some interesting gold values on its Glover Island property. NovaGold Resources Inc. acquired International Corona Corporation's interest in the Pine Cove deposit. Reserves at this deposit stand at 2.1 million tonnes (Mt) grading 3.01 g/t gold.

As well, new high-purity limestone deposits were found and others were developed during the year. The Newfoundland Resources & Mining Company Limited developed a high-purity limestone deposit close to its current operation in western Newfoundland. In 1992, Aguathuna Mining Inc. is expected to proceed with production from a high-purity limestone and dolomite quarry east of the Newfoundland Resources operation.

In contrast to the island of Newfoundland, grassroots exploration increased in Labrador.

With the signing of the $12.4 million Canada-Newfoundland Cooperation Agreement on Mineral Development in September 1990, the provincial and federal governments expect to spend approximately $6.4 million on geoscience, mineral technology and economic development activities designed to attract investment and improve productivity in the Newfoundland minerals industry.

NOVA SCOTIA

In 1991, the value of mineral production, including coal, is estimated at $445 million, down approximately 3% from 1990 levels. Mineral exploration and development work in Nova Scotia demonstrated a significant decrease in the level of activity from the previous year, with expenditures for 1991 estimated at $2 million-$3 million compared to $5.5 million in 1990. A total of 1900 new and re-issued claims were staked in 1991. Similarly, the amount of exploration drilling was also lower in 1991 with the completion of approximately 12 500 metres (m) compared to a total of 16 700 m in 1990.

Curragh Resources Inc. officially opened its Westray coal mine at Stellarton. Production is estimated to be 700 000 t in 1992. Kelly Rock Limited opened a surface mine north of Sydney which will produce limestone for use at the Point Aconi power-generating plant.

Rio Algom Limited announced its intention to close the East Kemptville tin mine in Yarmouth County on January 3, 1992. Mining activities will cease at that time; however, reclamation work will extend well into the year. As well, Westminer Canada Limited suspended operation at its Gays River mine and has advertised the property for sale. These two closures mean that there is now no production of base and precious metals in the province.

With a new *Mineral Resources Act* coming into effect in March 1992, this year also saw extensive consultations with industry. This new act, complete with regulations, does away with development licences and has a two-tier structure. One area deals with exploration and the other with mining leases. Licenced ground may now be held for an indefinite period of time. A new item in the act is the issuance of prospectors' ID cards, and reporting requirements are better defined.

The current Canada-Nova Scotia Cooperation Agreement on Mineral Development expires on March 31, 1992, and discussions have begun for a successor agreement.

NEW BRUNSWICK

In 1991, the value of mineral production in New Brunswick, including coal, is estimated at $617 million, a drop of nearly

30% from 1990 levels. As of November 31, 31 408 mineral claims and 8400 claim equivalents were in good standing in the province. Energy, Mines and Resources Canada has forecast that $21.7 million will have been spent on exploration in 1991.

Mine development in New Brunswick during 1991 was limited, with metal prices far below those of 1990, and it is expected that any recovery will have to be linked to positive changes in the economy over the coming year.

The 10-month strike at Brunswick Mining and Smelting Corporation Limited (BMS) finally ended in May 1991 and the company moved quickly to re-establish full production. It has embarked on a program to increase productivity and reduce costs. To date, it has realized a 30% increase in productivity and a 15% decrease in costs. Heath Steele Mines Ltd. (a wholly owned subsidiary of BMS) continued to operate during the strike and is currently looking for a partner in a joint venture to fund an expansion of their C-zone. BMS has indicated that it may also consider selling the entire Heath Steele property, if the price is right.

Stratabound Minerals Corp. entered into an agreement with Heath Steele Mines Ltd. for the milling of ore from Stratabound's Captain North Extension deposit. This arrangement was finalized following the successful milling of their bulk sample at the Heath Steele mill and the completion of a positive feasibility study. Stratabound has also entered into an exploration/joint venture agreement with Teck Corporation which will include all of Stratabound's New Brunswick properties except the Captain North Extension pit. Teck can acquire a 51% interest in the properties if it spends $3 million on exploration over four years.

East West Caribou Mining Limited has seen limited activity since its closure in October 1990. The site has been maintained by a complement of 15 employees who are responsible for ensuring the infrastructure is preserved for immediate start-up and assuring the environmental integrity of any effluent leaving the site. The property is for sale and the parent company, Breakwater Resources Ltd., is actively seeking a potential buyer. Marshall Minerals Corp.'s Restigouche deposit is also for sale following the sharp downturn in zinc prices and the closure of Caribou, where it was hoped that their ore would be custom milled.

Murray Brook Resources Incorporated (a wholly owned subsidiary of NovaGold Resources Inc.) continues to operate its gold mine at its rated design capacity and to achieve gold recoveries of 85% year-round. Two important developments are being considered by NovaGold Resources Inc. for New Brunswick. NovaGold has acquired the technology rights from the Canada Centre for Mineral and Energy Technology (CANMET) for the development of the Ferric Chloride Leach process, and the province is evaluating its application for a 500-t/d demonstration plant for the Murray Brook copper-silver deposit. NovaGold is also looking at re-opening the Mount Pleasant mine for the recovery of tin and other valuable metals such as indium. The company is in the process of acquiring property/mineral rights from LAC Minerals Ltd. and Billiton Metals Canada Inc., and plans to initiate a feasibility study.

Since the signing of the $10 million Canada-New Brunswick Cooperation Agreement on Mineral Development in September 1990, approximately $1.6 million is expected to have been spent by the end of 1991 on a variety of geological, mineral processing and economic studies in New Brunswick.

QUEBEC

The year 1991 was relatively difficult for Quebec's mining sector, as it was for the rest of the economy. The value of mineral production fell from its record high in 1990, dropping by 3.38% to $2934.2 million. The slowdown in the construction industry, combined with an almost universal reduction in base-metal prices, was the main factor in this decline which, in the final analysis, remains modest in relation to the sharp reductions observed in the other provinces. The 18% increase in gold production allowed Quebec to post this higher result.

The deterioration of the mining sector did not just affect mineral production; investment in exploration, fixed assets and equipment also fell. This situation has also had an effect on the employment level, which dropped from the previous year. These declines, which were generally based on economic circumstances rather than structural factors, should not permanently affect the mining sector's relative importance to the province's economy. The Abitibi, North Shore and Northern Quebec (Matagami, Chapais-Chibougamau) regions will continue to depend heavily on the mining sector for their economic development.

Development prospects in the mining sector, and for the regions which depend on it, are generally positive in that major mineral development projects could be carried out in the next few years, thereby substantially diminishing the impact of recent closings. It is highly possible that the Louvicourt, Frotet, Mobrun-lentille 1100, Grevet, Raglan and Eastmain projects will be completed within the next five years. It should be noted that, except for the Eastmain gold project, these mining projects involve developing polymetallic base-metal deposits. This situation is somewhat paradoxical considering the large amounts of money spent on gold exploration over the last five years.

The Canada-Quebec Subsidiary Agreement on Mineral Development expired in March 1991. This agreement will have allowed both levels of government to invest nearly $112 million in the province's mining sector over the course of seven years. The agreement is expected to be renewed during 1992. The Financial Assistance Program for Mineral Prospecting in eastern Quebec was renewed in 1991 on the basis of its past success. Prospectors in the Lower St. Lawrence and Gaspé regions will therefore have access to $1.25 million each year to carry out various mineral exploration and mineral prospecting projects in eastern Quebec.

ONTARIO

For 1991, the total value of Ontario's nonfuel mineral production is estimated at $4.98 billion, down 22% from 1990. Metals contributed $3.73 billion, down 24% from 1990; nonmetals contributed $239 million, up 9% from 1990; and structural materials contributed $1.01 billion, down 19% from 1990.

In 1991, the Ontario mining industry saw another net loss in direct mine employment, with Northern Ontario being the hardest hit. Mine closures at Timmins (Canamax Resources Inc., St. Andrew Goldfields Ltd. and Roseval Silica Inc.), Kirkland Lake (Eastmaque Gold Mines

Ltd.), Renabie (American Barrick Resources Corporation/Corona Corporation) and Sturgeon Lake (Noranda Minerals Inc.), together with production cutbacks at the Sudbury operations of Inco Limited and Falconbridge Limited (which included closure of the Creighton No. 3, Whistle, Garson and Falconbridge mines), explain the drop in provincial production levels. The large drop in the value of production can be attributed to declining metal prices, and particularly to the drop in uranium production.

The few bright spots in Ontario included the opening of the Cheminis gold mine (Northfield Minerals Inc.) and the Langmuir nickel mine (Timmins Nickel Inc.), the expansion of the Kerr mill (Deak Resources Corporation/GSR Mining Corporation), and the opening of the first flash furnace (Inco Limited) and the pressure oxidation plant at the Campbell mine (Placer Dome Inc.). Falconbridge Limited continued development of the Craig and TL deposits.

Across the province there was also a general reduction in exploration activity. Nevertheless, several exploration plays did attract attention, namely the Hemlo Gold Mines Inc./Freewest Resources Inc. Lightning zone near Matheson, and the Fort Knox Gold Resources Inc. nickel-copper discovery in the Shining Tree area. Inco Limited announced two new discoveries in the Sudbury area: one near the McCreedy East mine and the other near the deep Victor deposit.

However, several advanced projects were put on hold, for example, the Hemlo Gold Mines Inc./Central Crude Ltd. Eagle River gold deposit, the Hemlo Gold Mines Inc./Storimin Exploration Limited/Tandem Resources Ltd. Moss Lake gold deposit, the Inco Limited McCreedy East nickel mine, the Madeleine Mines Ltd. Lac des Îles palladium-platinum mine, and the Consolidated Professor Mines Limited Shoal Lake deposit. The latter two suspensions were due principally to environmental concerns.

The provincial government continued to encourage mineral exploration through the Ontario Prospectors Assistance Program (OPAP) and the Ontario Mineral Incentive Program (OMIP). Both programs were fully subscribed. In mid-year, Ontario announced the extension of OMIP enhancements to the entire Northern Ontario region.

In June 1991, the regulations for the new *Ontario Mining Act* came into force. Of particular interest are new regulations dealing with mineral development, site rehabilitation and mine closure.

In November, Canada and Ontario announced a new, jointly funded Northern Development Agreement, which includes a minerals component. The $30 million minerals component is designed to provide technical support for exploration, to promote productivity, competitiveness and environmental protection, and to diversify the region's minerals industry.

MANITOBA

In 1991, the value of Manitoba's nonfuel mineral production is estimated at $1.0 billion, a decrease of 14% from 1990 figures. Overall, exploration is projected to have increased slightly over 1990 to $37 million, roughly equivalent to the 1989 value. This increase is felt to represent a slightly stronger industry interest in exploration oriented towards base metals instead of precious metals.

Despite a decline in the value of production, investment in new mine and refining capacity accelerated with the expansion of Inco Limited's nickel mining operation in Thompson and the announcement, in December, of a loan to Hudson Bay Mining and Smelting Co., Limited (HBMS) by the federal government and the governments of Manitoba and Saskatchewan. The governments will provide $80 million of the $187 million required to modernize the Flin Flon smelter. Of this total, Manitoba will contribute $47.2 million to the program. The program is aimed at cutting acid rain emissions by 25% and airborne particulates by 50% by 1994.

Attempts to stimulate the province's minerals industry came to fruition on June 28 when a new federal-provincial five-year Canada-Manitoba Partnership Agreement on Mineral Development was announced. It replaces the former Mineral Development Agreement which expired in 1989. The new agreement provides for $10 million of cost-shared programs, the bulk of which will be spent on geoscience, technology and economic development.

The provincial government has been active in stimulating the industry directly on two fronts. First, a Manitoba Mineral Exploration Incentive Program has been announced. This $12.5 million program, which will come into effect early in 1992, will offer investors a 25% grant for eligible exploration expenditures which, if fully utilized, would generate $50 million in expenditures. The grant will supplement existing federal flow-through share incentives to qualifying investors in new exploration activities by junior exploration companies in Manitoba. Only investments in ventures financed under flow-through share agreements or limited partnership interests marketed by registered Manitoba Mineral Exploration Investment Corporations will qualify for this new program. Secondly, Manitoba has passed a new *Mines and Minerals Act* and regulations concerning mineral dispositions, drilling, and pit and quarry operations. Both the act and regulations have been reviewed and amended following extensive consultations with industry. Within the provincial government, regulatory overlap between the Mines Branch and Environment Canada has been reduced. The new act and the three sets of regulations will be proclaimed early in 1992; a new regulation dealing with mine closure is also slated to be drafted during 1992.

SASKATCHEWAN

In 1991, the value of nonfuel mineral production in Saskatchewan is estimated at $1.2 billion, a decrease of 2% from 1990 figures. Much of this decrease is related to low prices and high world stockpiles of uranium and potash, and low prices for gold and base metals. Exploration also declined slightly in response to these depressed market conditions.

The weak provincial exploration picture was somewhat brightened by the announcement that Cameco Corporation and Uranerz Exploration and Mining Limited have discovered gem-quality macrodiamonds from kimberlitic material in the Fort a la Corne area. The largest diamond weighed 0.49 carats; exploration on a large number of kimberlitic bodies is continuing. Test mining of uranium ore is also under way at the Cigar Lake mine, and gold production commenced at Claude Resources Inc.'s Seabee mine.

Seasonal layoffs, due to low market demand and high inventory levels, were reported at several Saskatchewan potash mines.

In order to assist the Saskatchewan mining industry, the federal and provincial governments announced on May 30, 1991, a new, five-year Canada-Saskatchewan Partnership Agreement on Mineral Development to replace the former Mineral Development Agreement which expired in 1989. The new agreement provides for $10 million of cost-shared programs aimed mainly towards geoscience and technology development. In addition, in December, a loan agreement to HBMS from the federal government and the governments of Saskatchewan and Manitoba was announced. Saskatchewan will contribute $7.8 million of the governments' share of $80 million to the $187 million modernization program.

In June, the provincial government sold 10.4 million shares of the federal-provincial Crown corporation, Cameco Corporation, for a price of $130 million; this was followed, in September, by the sale of 5 333 334 Cameco warrants for $87.6 million. A potential $39.3 million in Cameco warrants remains to exercised.

Industry research activity was given a boost in March when the Saskatchewan Potash Producers Association announced a five-year, $8 million program for research and development activities involving six potash mining companies. The investigations, which fall into the categories of: Availability and Security of Supply, Environmental Protection, Breakthrough Production Technology, Transportation and Handling, and Offshore Product Quality, are partly supported by a contribution of $2.9 million from the federal Western Economic Diversification office, and were further supported by the provincial government through the research and development incentive provisions within the provincial potash tax regulations.

Optimism was also generated within the stagnant provincial sodium sulphate industry. Ormiston Mining and Smelting Co. Ltd. announced that it had successfully demonstrated, at pilot-plant scale, a process for producing sodium carbonate and ammonium sulphate from sodium sulphate salt glaubers. The company has also developed a process to produce sodium hydroxide from salt glaubers and is presently doing bench-scale tests. Both processes promise to enlarge and diversify the present market for sodium sulphate.

ALBERTA

The value of mineral production in Alberta in 1991 is estimated at $16.2 billion, a decrease of 15% from the previous year's figures. Included in the amount is $15.7 billion for mineral fuels of which amount coal accounted for $541 million. These figures mainly reflect lower sales volumes and prices for natural gas, petroleum and coal. Although sales for sulphur remained constant, prices were lower.

Non-energy minerals production declined due to low prices, reduced demand and the closure of several plants. Operations at Agassiz Resources Ltd.'s Metiskow Lake sodium sulphate plant were suspended due to weak market product demand and to the receivership of the parent company. Operations at the Magcan (Magnesium Company of Canada Ltd.) magnesium plant at Aldersyde were suspended due to process problems and the plant was placed in receivership following the withdrawal of $80 million by one of the project partners. Operations were also suspended at the Carbovan Inc. V_2O_5 and carbon black plant at Fort McMurray due to poor product demand and low product prices. Attempts are currently being made to sell Agassiz Resources Ltd.'s Metiskow Lake plant and Carbovan Inc..'s Fort McMurray plant.

On a more positive note, phase two of Alberta Power's 400-megawatt Genesee power plant at Wabamun Lake has been given regulatory approval; construction of the new phase is expected to begin in the fall of 1992 and to be completed in two years. This $300 million phase is expected to require about 4.5 Mt/y of coal. Industrial minerals exploration was given a boost when a deposit of $10 per hectare (ha) was paid for 680 000 ha of metallic mineral exploration permits in the Valleyview-Peace River area by Monopros Limited, a subsidiary of DeBeers Consolidated Mines Ltd.

In order to assist in the development of a healthier and more diversified provincial minerals sector, the federal and provincial governments are currently negotiating the terms of a Canada-Alberta Agreement on Mineral Development; a final agreement, which will be Alberta's first mineral development agreement, is expected to be completed in early 1992. In addition, the province is undertaking a substantial amendment to the Coal Mines Safety Regulations, which is intended to reflect recent changes in technology and mine practices and to generally bring the regulations up-to-date.

Within the private sector a comprehensive $4 million research program on valley dumping is being developed under the leadership of the Coal Association of Canada. This program includes participation of the mining industry, the federal Western Economic Diversification office, CANMET, and the governments of British Columbia and Alberta. Although the results of this effort were originally intended for use in coal mines, the program has been expanded and several non-coal companies are now involved as well.

BRITISH COLUMBIA

In 1991, the estimated value of British Columbia's mineral production was $3.7 billion, a decline of 5% from the previous year. Included in this amount is $1.8 billion for fuels, of which coal accounted for $1.0 billion. The decline in value of production was due to low market prices and reduced sales of base metals, precious metals, coal, sulphur, petroleum and natural gas. Mineral exploration expenditures were projected by the province at $167 million, a 25% decrease from the 1990 value. The majority of this decline is directly attributable to a drastic decrease in gold exploration as a result of low gold prices.

Over the past year, the provincial government has attempted to revitalize the mining sector through a series of initiatives. In April the provincial government announced that it would provide financial assistance to facilitate the construction of the common usage portion of the mine access road into the Iskut Valley. Construction on the road began in June with the intention of building the common use portion to Volcano Creek by year-end. Prime Resources Group Inc. will, itself, construct a link from Volcano Creek to the Eskay Creek deposit.

In addition, a new *Mine Development Assessment Act* was proclaimed. This act formalizes the former Mine Development Review Process (MDRP), which is now the Mine Development Assessment Process (MDAP). Projects entering the MDAP will be required to obtain a mine development certificate; proposed mine developments which were under the MDRP and defined as "reviewable mine developments" under the act will be subject to the act unless, within 60 days of the act coming into force, the provincial Cabinet has exempted the development from some or all provisions of the new act.

Negotiations on a new Canada-British Columbia Agreement on Mineral Development to replace the former Mineral Development Agreement have been essentially completed; it is expected that signing of the new agreement will take place in early to mid-1992. As well, the province has proceeded with mineral potential evaluations of three provincial recreation areas in support of the government's policy of assessing subsurface resources prior to creating new provincial parks. Evaluations are being undertaken of the Kakwa, Babine and Cascade recreation areas.

A further aid to the industry was the printing and distribution to industry of the Interim Guidelines for Mine Dump Design and Investigation, and the Interim Guidelines for Mine Dump Operations produced by the B.C. Waste Dump Research Committee.

The overall provincial metal mining environment was depressed with several mine suspensions, closures and development cancellations. Equity Silver Mines Limited continued to reduce staff with the expected closure of the mine slated for October 1992. The use of the new Trail QSL lead smelter was delayed pending the results of tests on the process and equipment modifications. Teck Corporation announced that it was suspending operations at the Beaverdell mine, but could resume operations if the price of silver improves. The Sulphurets project, jointly owned by Newhawk Gold Mines Ltd. and Granduc Mines Limited, was judged to be uneconomic. Westmin Resources Limited and Pioneer Metals Corporation have reduced ore reserves at the Premier project. The Blackdome mine closed at the end of 1990. Placer Dome Inc. dropped its plans to develop the Eskay Creek gold mine due to a decrease in calculated ore reserves; however, International Corona Corporation may still proceed with the development. Finally, the provincial park service and environmental groups are lobbying for the creation of a park in the area of Geddes Resources Limited's Windy Craggy property.

On a more positive note, development of the Windy Craggy property by Geddes Resources Limited is awaiting provincial approval and, in December, Geddes announced a 57% increase in reserves to make the deposit the largest copper and cobalt deposit in Canada. Cominco Ltd. and Prime Resources Group Inc. proceeded with the Snip gold project. Development was completed and production commenced at Princeton Mining Corporation's McDame underground asbestos mine. Modifications to Cominco Ltd.'s zinc plant at Trail were completed in March and, at full capacity, the plant is expected to treat more than 500 000 t of zinc concentrates. In December, Westmin Resources Limited was given approval, following a public hearing, to conduct a drilling program on its lease in Strathcona Park. Earlier in November, the B.C. Supreme Court awarded an undetermined amount to Cream Silver Mines Ltd. as a result of the expropriation by the province of Cream's mineral claims in Strathcona Park.

With respect to coal, a similar mixed picture emerged. In July, Crows Nest Resources Limited sold its Line Creek coal mine to Manalta Coal Ltd. Esso Resources Canada Limited continued to seek a buyer for the Byron Creek coal mines and, in June, Fording Coal Limited received approval to proceed with its Henretta Creek dragline exploration. Teck Corporation replaced Denison Mines Limited as manager of Quintette Coal Limited in June, and attempts to restructure the existing debt and to maintain Quintette's operations continued.

NORTHWEST TERRITORIES

In 1991, the estimated value of mineral production was down 23% to $757 million. This figure includes $258 million for fuels. Seven mines were in production in the Northwest Territories in 1991. The Colomac mine, which opened in 1990, was forced to close due to lower-than-anticipated production and financing difficulties. The value of metals produced was down 25% due mainly to decreased values for metals.

Indian and Northern Affairs Canada officials report that exploration expenditures were slightly higher than in 1990. Expenditures concentrated mainly on gold projects in the western portion of the Territories. One of the highlights of the year was the location of a diamond-bearing kimberlite on the BHP-Utah Mines Ltd./Dia Met Minerals Ltd. Point Lake property where 81 small diamonds were recovered from diamond drill core. An underground bulk sample is scheduled for early 1992. Advanced exploration was carried out on a number of other promising properties in the Slave Province, including those at Nicholas Lake, George Lake, and the Ulu property in the High Lake area, as well as on uranium properties near Baker Lake and on gold properties near Rankin Inlet.

With the release of the Northwest Territories Transportation Strategy, attention has focused on possible new Northwest Territories transportation links. Base-metal deposits in the Coronation Gulf area could benefit from a possible port near Coppermine with road links to the deposits. Work is under way to study possible sites and the feasibility for a port.

Substantial progress was also made on native land claims, which have been seen by the mining industry as a source of uncertainty. The Gwich'in comprehensive native land claim, which covers the north portion of the Mackenzie Valley, was ratified by the native people of the area in September. Provisions include payment of $75 million and title to about 24 000 km^2, including subsurface title to about one quarter of this area. Work has started on negotiations for the Sahtu claim, which is located to the south of the Gwich'in claim.

Agreement was reached on the Tungavut Federation of Nunavut (TFN) land claim in late 1991. Provisions include payment of $580 million and title to 350 000 km^2 of land, which includes 36 300 km^2 of mineral rights. Access by non-Inuit to settlement lands is governed by provisions in the final agreement. Discussions and negotiation of an accord dealing with political powers are expected to lead to the establishment of a Nunavut territory covering the eastern Arctic. The agreement will require ratification by the Inuit, expected in April 1992, which will be followed by Parliamentary approval.
A new $8.2 million Canada-Northwest

Territories Economic Development Cooperation Agreement with a mineral initiatives component replaced the Mineral Development Agreement which expired in March. The term of the agreement is five years and most of the money is earmarked for geoscience activity. As the agreement was signed in July, field work was not possible on all projects. Initial work started on a computerized data base of mineral showings and field work took place on eleven projects, one of which produced a sample with 15% nickel and associated gold, silver and cobalt.

Work is presently under way to revise the present *Northern Inland Waters Act* and divide it into two separate pieces of legislation, one of which will be the *Northwest Territories Inland Waters Act*. Work is expected to be completed in 1992.

YUKON TERRITORY

In 1991, the value of mineral production was down 36%. Lower zinc prices in the latter part of the year have put pressure on Curragh Resources Inc., which requires additional resources to remove overburden from new mining areas to enable the Faro mill to maintain continuous operation.

Approximately $16 million was spent on exploration, with work directed mostly at base metals. Although expenditures rose in 1991, the overall mood for exploration was fairly pessimistic as grassroots work suffered. Advanced projects on which work took place include Brewery Creek, Blende, and Clear Lake, and also in the MacMillan Pass area where Cominco Ltd.. continued work on the Tom deposit.

A new $9 million Canada-Yukon Mineral Resources Cooperation Agreement was signed in May to replace the previous Mineral Development Agreement, which has been extended to March 1991. A significant development with the signing of this agreement is the increased participation of the Yukon government in the delivery of the agreement. The Yukon government plans to hire geological personnel early in 1992 for the first full year of field work.

There has been significant progress on comprehensive land claim negotiations. Four bands out of thirteen from the Council of Yukon Indians have completed agreements with the federal and territorial governments. Negotiations are continuing and additional progress is expected during the coming year.

Changes are necessary to modernize legislation in the Yukon to bring it in line with environmental legislation. This issue has been a source of concern and uncertainty to the industry, which has been working to resolve the issue. The Yukon Mining Advisory Committee, a group formed of government and industry representatives, has worked on revisions to the Yukon mining legislation to comply with the Environmental Assessment Review Process (EARP) Guidelines. Affected legislation includes: the *Northern Inland Waters Act,* which is expected to be replaced by the *Yukon Inland Waters Act* in 1992; the *Yukon Quartz Mining Act*; and the *Yukon Placer Mining Act.*

Note: Information in this review was current as of January 31, 1992.

TABLE 1. VALUE OF LEADING MINERALS IN THE PROVINCES, TERRITORIES AND CANADA, 1990 AND 1991

	Value of Production			
	1990f	1991p	Change 1991/1990	1991p Proportion of Provincial Total
	($ million)		(percent)	
NEWFOUNDLAND				
Iron ore	708.4	737.7	4.1	93.0
Gold	x	x	x	x
Sand and gravel	14.5	11.7	–19.3	1.5
Stone	9.9	5.0	–49.5	0.6
Asbestos	29.0	4.0	–86.2	0.5
Total	866.0	793.3	–8.4	100.0
PRINCE EDWARD ISLAND				
Sand and gravel	3.3	2.5	–24.2	100.0
Total	3.3	2.5	–24.2	100.0
NOVA SCOTIA				
Coal	204.5	238.0	16.4	53.5
Gypsum	52.8	52.3	–0.9	11.8
Salt	x	x	x	x
Tin	28.4	29.2	2.8	6.6
Cement	x	x	x	x
Stone	39.5	23.6	–40.3	5.3
Total	459.5	444.6	–3.2	100.0
NEW BRUNSWICK				
Zinc	450.8	212.5	–52.9	34.4
Potash (K_2O)	x	x	x	x
Lead	67.3	50.2	–25.4	8.1
Coal	37.2	34.2	–8.1	5.5
Peat	23.8	26.9	13.0	4.4
Total	877.9	617.0	–29.7	100.0
QUEBEC				
Gold	585.1	692.4	18.3	23.6
Iron ore	x	x	x	x
Copper	312.3	299.3	–4.2	10.2
Stone	243.6	206.2	–15.4	7.0
Titanium dioxide	x	x	x	x
Zinc	232.4	143.7	–38.2	4.9
Total	3 037.0	2 934.2	–3.4	100.0
ONTARIO				
Nickel	1 345.6	1 237.7	–8.0	24.4
Gold	1 150.3	1 025.6	–10.8	20.3
Copper	861.0	723.2	–16.0	14.3
Cement	475.2	388.5	–18.2	7.7
Zinc	532.1	276.5	–48.0	5.5
Stone	300.6	222.3	–26.0	4.4
Total	6 445.8	5 062.2	–21.5	100.0

TABLE 1 (cont'd)

	Value of Production			
	1990f	1991p	Change 1991/1990	1991p Proportion of Provincial Total
	($ million)		(percent)	
MANITOBA				
Nickel	682.3	590.6	–13.4	52.6
Copper	174.8	154.6	–11.6	13.8
Zinc	149.4	98.4	–34.1	8.8
Petroleum, crude	114.9	92.1	–19.8	8.2
Total	1 311.5	1 107.8	–16.2	100.0
SASKATCHEWAN				
Petroleum, crude	1 557.8	1 259.2	–19.2	44.1
Potash (K_2O)	x	x	x	x
Uranium (U)	260.7	307.1	17.8	10.8
Natural gas	306.0	307.0	0.3	10.8
Total	3 182.5	2 852.0	–10.4	100.0
ALBERTA				
Petroleum, crude	10 822.5	8 783.8	–18.8	54.4
Natural gas	4 841.6	4 306.5	–11.1	26.7
Natural gas by-products	2 297.6	2 044.1	–11.0	12.7
Coal	482.0	541.1	12.3	3.4
Sulphur, elemental	319.7	200.3	–37.3	1.2
Total	19 110.4	16 147.7	–15.6	100.0
BRITISH COLUMBIA				
Coal	1 000.6	997.3	–0.3	26.6
Copper	1 051.3	895.1	–14.9	23.9
Natural gas	491.0	519.3	5.8	13.8
Petroleum, crude	316.1	261.7	–17.2	7.0
Gold	231.7	248.7	7.3	6.6
Zinc	114.4	154.2	34.8	4.1
Sand and gravel	140.6	120.7	–14.2	3.2
Total	3 954.4	3 750.0	–5.2	100.0
YUKON				
Zinc	325.4	178.3	–45.2	51.5
Lead	124.7	81.0	–35.0	23.4
Gold	66.7	67.1	0.6	19.4
Silver	15.2	12.9	–15.1	3.7
Total	541.8	346.2	–36.1	100.0
NORTHWEST TERRITORIES				
Zinc	420.5	279.0	–33.7	36.9
Gold	223.8	220.7	–1.4	29.2
Petroleum, crude	247.7	196.3	–20.8	25.9
Lead	55.8	26.7	–52.2	3.5
Total	987.9	756.7	–23.4	100.0

TABLE 1 (cont'd)

	Value of Production			
	1990f	1991p	Change 1991/1990	1991p Proportion of Provincial Total
	($ million)		(percent)	
CANADA			**(Proportion of Canada Total)**	
Petroleum, crude	13 103.4	10 629.5	–18.9	30.5
Natural gas	5 692.0	5 191.0	–8.8	14.9
Gold	2 407.7	2 355.3	–2.2	6.8
Natural gas by-products	2 370.8	2 125.5	–10.3	6.1
Copper	2 428.9	2 101.2	–13.5	6.0
Coal	1 823.7	1 905.9	4.5	5.5
Nickel	2 027.9	1 828.2	–9.8	5.2
Zinc	2 272.6	1 351.0	–40.6	3.9
Iron ore	1 258.8	1 307.9	3.9	3.8
Potash (K_2O)	964.9	919.0	–4.8	2.6
Grand total	40 778.0	34 814.2	–14.7	100.0

Source: Energy, Mines and Resources Canada.
f Final; p Preliminary; x Confidential.

Labour and Employment

Paul Monfils and Nancy Porter

The authors are with the Mineral Policy Sector, EMR Canada. Telephone: (613) 995-5115 and (613) 995-1507, respectively.

OVERVIEW

Poor economic conditions throughout the world reduced demand for minerals and metals during 1991. Lower commodity prices, the recent strong Canadian dollar and higher production costs led to reduced output at operations in Canada. Closures and workforce cuts reduced minerals and metals employment to historically low levels. Average preliminary wage settlements in mining exceeded those of 1990 and the cost-of-living increase, although settlements in primary metals were lower than both. However, these settlements do not apply to all workers in the industry. In terms of average weekly earnings including overtime, real earnings have decreased.

This chapter examines labour market developments in the minerals and metals industry. It reviews the year's events in labour earnings, industrial relations and health and safety, and provides legislative highlights.

LABOUR MARKET DEVELOPMENTS

Energy, Mines and Resources Canada (EMR) forecasts show that the decline in minerals and metals employment that began in 1990 continued in 1991. Workforce reductions brought 1991 direct employment in mining and primary metals to 138 343 jobs, down 5% from 1990. This is the lowest level since 1961 (Figures 1 and 2).

At 43 134, employment in metal mines was also at its lowest in 30 years. This figure represents a 6% decline from the 1990 level. Among metal mine commodity groups, only gold, at 12 341 employees, showed a modest 3% increase (Figure 3).

A 1% drop brought nonmetal mining employment to 11 583 in 1991. Jobs in structural materials fell for the third year to 4990 in 1991, 8% lower than in 1990. Employment in coal mining, on the other hand, has been on the rise since 1987. At 12 045, the 1991 coal workforce increased by 3% over 1990 and stands at its highest level since 1985.

Forecasted employment reached a 28-year low in both iron and steel mills and nonferrous smelting and refining. The 1991 iron and steel workforce was 38 072, down 5% from the previous year. Nonferrous smelting and refining employed 28 519 workers, 6% fewer than in 1990.

The 1991 employment in non-fuel semi-fabrication sank to 79 345, a one-year fall of 13%. A 20% drop brought metallic mineral manufacturing jobs to 112 344. Forecasted employment in mining diamond drilling remained stable at 1856.

These dramatic reductions are serious for those who are directly affected and those preparing for future employment activity. Nevertheless, a comparison with the restructuring that took place during the recession of the early 1980s places them in perspective. From 1981 to 1983, minerals and metals jobs fell by 35 128. The forecasted loss in 1991 is 7180. Mining and mineral manufacturing combined streamlined their employment from 1981 to 1983 by 77 129, a reduction of 18%. The 1991 forecasted contraction is 47 964 jobs.

Part of the reduction in mine employment is due to closures. Thirty-three mines suspended operations or closed during 1991, ending some 3300 jobs. Most of these closures and suspensions involved metal mines, particularly gold mines, in Quebec, Ontario and British Columbia. Partly offsetting these were new and re-opened mines, most of them gold mines, and most in the same regions. Eighteen mining operations came into production during the year, providing jobs for 1300 employees.

In addition, workforce reductions continued at mines that remained in operation. Companies eliminated at least 2800 jobs through attrition, transfers, early retirement incentives and layoffs. Most of these losses were at metal mines in Ontario, Atlantic Canada and British Columbia. While important in retaining existing jobs, mine expansions do not necessarily increase jobs. Large workforce contractions also continued at smelting and refining operations.

In June 1991, Employment and Immigration Canada (EIC) announced a major government-industry study of human resources in Canada's mining industry. The study will assess current human resource requirements. It will also determine future employment and skills requirements, and provide insights into possible courses of action. Its scope includes metal, nonmetal and coal mining, nonferrous metal smelting and refining, non-conventional crude oil extraction, and mine exploration services. A consulting firm is carrying out the work, guided by a steering committee. EIC Commissioners representing employers and workers co-chair the steering committee, which includes representatives of business, labour, educational institutions and both levels of government. The study should be completed by the end of 1992.

COMPENSATION

Average earnings in mining are among the highest of all industrial classifications. For 1990, average weekly earnings (including overtime) for hourly paid employees were $842.18 for metal mines and $677.11 for the nonmetals, in contrast to $546.09 in manufacturing and $655.16 in construction.

At the time of writing, data for 1991 were available to the end of September. Over the one-year period ending in September 1991, average weekly earnings were up by 1.7% in metal mines, by 3.5% in nonmetals, and by 4.1% in the coal industry.

The data indicate that real average weekly earnings (based on the CPI: 1986=100) showed a decrease in all of the three sub-sectors over the reporting period. For the period September 30, 1990 to September 30, 1991, real earnings decreased by 3.7% in metal mining, by 1.9% in nonmetals, and by 1.3% in the coal industry. Over the same period, real earnings in all industries decreased by 1.0%.

In 1990, the last year for which data are available, average annual labour income in current dollars (wages and salaries plus supplementary labour income) in mines, quarries and oil wells was $50 054. This was well above the average labour income of $32 937 for all industries. It should be noted that labour income estimates for the period 1987-89 were revised in June 1991. The revised averages for 1989 are $48 209 for mines, quarries and oil wells, and $30 995 for all industries. The 1990 figures represent increases of 3.8% and 6.3% respectively over 1989 revised estimates.

INDUSTRIAL RELATIONS

The 1991 collective bargaining calendar for minerals and metals was busy, although less so than that of 1990. Some 24 agreements were signed between January 1 and September 1, 1991, covering 18 814 employees in metal and nonmetal mines, and in the smelting and refining sector. Of these settlements, six were in Atlantic Canada, eight in Quebec, six in Ontario, two in the Prairies, one in British Columbia, and one in the Yukon.

Twelve major wage settlements covering bargaining units of over five hundred employees were reached during the first eight months. They represent half the agreements reached and 83% of the employees covered by agreements signed during the period. Many of these settlements were at steel producers: Sydney Steel Corporation (Sysco) in Nova Scotia; Sidbec-Dosco Inc. in Quebec; and Atlas Specialty Steels, div. of Sammi Atlas Inc., Lake Ontario Steel Company, a div. of Co-Steel Inc., and Slater Industries Inc. in Ontario. Also included are the smelting and refining plant of QIT-Fer et Titane Inc. in Quebec; the metal mining operations of Brunswick Mining and Smelting Corporation in New Brunswick, and at Inco Limited and Falconbridge Limited in Ontario; and the asbestos mines of J M Asbestos Inc. and LAB Chrysotile Inc. in Quebec.

Over the life of major contracts, the average annual wage increase (including cost-of-living adjustments) was 6.9% in metal mines during the first eight months of 1991. This was slightly more than the 6.4% average negotiated during the full year of 1990. Increases in nonmetal mines averaged 3.9% in 1991, up from 2.8% in 1990, while no major agreements occurred in coal mines in 1991. Average settlements in iron and steel mills were 4.3% in 1991, down from 6.0% in 1990. The 1991 average of 4.4% in nonferrous smelting and refining was much lower than the 7.1% 1990 average. Increases at combined mines, mills, smelting and refining averaged 5.8%. This was slightly below the 6.2% average for all primary industries, and somewhat above that of 5.1% for all manufacturing. Corresponding 1990 averages were 6.0% in combined mines, mills, smelting and refining, 5.6% in primary industries, and 6.0% in manufacturing.

Wage settlements were relatively generous in Ontario and New Brunswick. The mining plus smelting and refining sectors negotiated average annual increases of 6.7% in Ontario and 5.7% in New Brunswick. The 7.1% average in Ontario's metal mines strongly influences averages weighted by number of employees. Increases in Quebec were lower, averaging 4.6%. Nova Scotia legislation froze the wages of public and para-public workers in that province, including those at Sysco, for two years.

Major minerals and metals agreements signed during 1991 averaged 34.6 months in duration. This exceeded the average 31.7-month length of major manufacturing agreements and surpassed the 16.6-month average duration of contracts in all industries.

Most common non-wage changes included improved early retirement incentive plans, pension indexing and other pension improvements, enhanced seniority, job security, training, and severance benefits.

Certain novel articles are particularly interesting. The Atlas Steels agreement in Quebec grants a hiring preference for local workers, and no strike or lock-out for six years. Employees at J M Asbestos Inc. now have 25% ownership and one third of director positions in their company. Inco Limited in Ontario has a new joint union-management environmental awareness committee. Curragh Resources Inc. in the Yukon reduced employees' housing and bussing costs. An arbitrated first contract at the Placer Dome Inc. Dona Lake mine in Ontario includes equity hiring and training measures for local native workers.

The 1992 bargaining calendar predicts that fewer agreements will expire at mines and none will expire at iron and steel mills. Several nonferrous smelter and refinery operators will be negotiating with many employees in Quebec, Alberta and British Columbia. Agreements also expire at Nova Scotia and British Columbia coal mines, a British Columbia lead-zinc mine, small gold mines in Quebec, Alberta and the Northwest Territories, and a Saskatchewan potash mine.

In 1990 there were 15 work stoppages in mining: 11 in metals, 2 in nonmetals, 2 in coal, and none in quarries. There were 7381 workers involved and 396 510 person-days lost. The primary metals sub-sector lost 1 296 580 person-days, more than in any year since 1981.

While aggregate data are not yet available for 1991, the number of strikes and days lost appears to have disrupted minerals and metals operations less than in previous years (Table 1). Lead-zinc mining, smelting and refining operations in New Brunswick, smelting, refining and coin-minting plants in Ontario and Manitoba, copper and asbestos mines in British Columbia, and a lead-zinc mine in the Yukon, experienced work stoppages.

SAFETY AND HEALTH

Once again in 1991, the issue of health and safety in the workplace was a priority for the mining industry and for government authorities responsible for legislation and regulations in this area. A number of efforts were made by the mining companies, in cooperation with workers of the mining sector and the union organizations representing them, to improve the industry's performance in terms of occupational health and safety. In addition, several governments amended their legislation and regulations applying to occupational health and safety.

EMR's survey of chief inspectors of mines in the provinces and territories showed that there were 26 fatalities in mining accidents in 1991 (Table 2). The number of mining fatalities was down in 1991 from the 29 reported in 1990. The 1991 figure is 26% lower than the annual average of 35 recorded in the 10 preceding years from 1981 to 1990, and is the lowest number of mining fatalities reported over the last 14 years.

The latest available statistics for time-loss injury and illness claims (including fatalities) accepted by Workers' Compensation Boards suggest that claims in mines, quarries and oil wells fell by about 10% from 1989 to 1990 (Table 3). This reduction is greater than the 2.4% decline observed in employment data reported by Statistics Canada's Survey of Employment, Payrolls and Hours. The 9230 time-loss injuries and illnesses recorded in 1990 represent a reduction of 19% in the annual average of 11 443 accepted claims, calculated over the preceding five years

(1985-89), which is nearly three times the decline of 6.5% in employment calculated for the same period. Also, there were 4873 injuries and illnesses in the metal and nonmetal mines in 1990. This was 7% less than the 5263 claims recorded in 1989 (compared to a decline of 5% in employment according to Census of Mines), and 4% less than the annual average of 5070 claims calculated over the preceding five years, 1985-89 (compared to a corresponding decline of 3% in employment according to Census of Mines).

Estimated rates per one hundred workers express time-loss injuries in terms of level of employment (Table 4). The statistics indicate a downward trend in time-loss injuries and illnesses for mines, quarries and oil wells. The estimated rate has lost 1.3 percentage points over the 1983-90 period, a reduction of 17% in the rate. Estimated rates show that the mines, quarries and oil wells sector ranks sixth among industrial groups, presenting a record which compares favourably with those of the forestry, construction and manufacturing industries. The series of rates estimated for mines, quarries and oil wells is significantly above that for the industrial aggregate, which can be considered as a nationwide industrial average. Yet, the gap between rates for mines, quarries and oil wells and those for all industries has narrowed over the eight-year period. That difference fell by 79% from 2.4 injuries and illnesses per one hundred workers in 1983 to 0.5 per one hundred in 1990.

In cooperation with the chief inspectors of mines, EMR is continuing its efforts to complete development of the National Mines Accident Data Base. Currently, four jurisdictions, namely the Northwest Territories, British Columbia, Ontario and Quebec, are taking an active part in this project and, during 1992, New Brunswick may join the project.

An analysis from the data base (Figure 4) shows that the occupations most affected by fatalities in mining accidents are those related to the category of underground drilling production. These occupations include long-hole drillers, mechanized miners and blasters, and represent 31% of fatalities recorded into the data base for the period 1986-90. The next most affected are the occupations associated with the category of underground exploration and development. These occupations include shaft sinkers, drift miners and diamond drillers, and account for 12% of recorded fatalities. The third most affected are the occupations associated with the category of underground muck handling. These occupations include scooptram (LHD) operators, haulage truck drivers, mucking machine operators, slushermen, trammers, motormen and switchmen, and account for 10% of recorded fatalities. In total, 67% of the fatalities recorded in the data base have involved workers who occupied underground occupations. In terms of location, underground access areas such as shafts, level stations, drifts and crosscuts, raises, ramps and ore passes are the most frequent locations coded and account for 32% of fatalities in mining accidents. The stopes and pillars location comes next, accounting for 15% of recorded fatalities. In total, 71% of the fatalities recorded in the data base have occurred in underground locations.

LEGISLATIVE HIGHLIGHTS

The federal jurisdiction for labour matters affecting the mining industry is narrowly defined. Responsibility for most labour legislation, including safety and health, industrial relations and conditions of work, rests with the provinces and territories. A broad range of labour laws and regulations apply to employers and workers across Canada, and specific provisions vary widely across the jurisdictions.

Each year a wide range of amendments to labour legislation may affect the mining industry. This section does not attempt to review all such legislation, but outlines developments at the federal level in 1991, with very brief reference to selected provincial initiatives.

Wage Protection Bill

The federal government has introduced Bill C-22, the *Wage Claim Payment Act*, as part of its package of amendments to the *Bankruptcy Act*. Among the proposed amendments is a national wage protection fund for employees whose employers become bankrupt, which will provide for payment of 90% of employee claims for wages and vacation pay owed, up to a maximum of $2000. The proposed fund will be financed through a payroll tax on employers in the amount of about ten cents per employee per week, on average, to be collected along with federal unemployment insurance premiums.

Regulatory Changes under the Hazardous Materials Information Review Act

An amendment was made to the Hazardous Materials Information Review Regulations and a new Appeal Board Procedures Regulation was adopted. These regulations are part of the Workplace Hazardous Materials Information System (WHMIS). The WHMIS is a national program which requires the disclosure of information on hazardous materials used in the workplace, and balances the worker's right to know with the industry's right to protect confidential business information.

The *Hazardous Materials Information Review Act* established the Hazardous Materials Information Review Commission to rule on claims for exemption from disclosure of confidential business information and to convene independent appeal boards to hear appeals of the decisions and orders made by screening officers of the Commission.

The amendment to the Hazardous Materials Information Review Regulations modifies the fee schedule under this regulation in order to ensure the achievement of full cost recovery in the operations of the Hazardous Materials Information Review Commission. Also, the Appeal Board Procedures Regulation provides the rules of procedure to be followed by the appeal board in hearing an appeal on application.

Amendment of the Canada Occupational Safety and Health Regulations under the Canada Labour Code

This regulation amends Part VII "Levels of Sound" of the Canada Occupational Safety and Health Regulations and prescribes lower maximum permissible levels of sound to which an employee can be exposed in the workplace as well as the duration of this exposure. Whereas the maximum permissible level of exposure had been previously set at 90 decibels (dBA) for 8 hours in any 24-hour period, this has been reduced to 87 dBA. A schedule to the regulation outlines the maximum A-weighted sound pressure levels permissible per duration of exposure in any given period. The regulation also contains other provisions. Hazard investigations must be conducted wherever exposure levels are of 84 dBA or greater for a duration that is likely to endanger an employee's hearing. Employers must apply engineering controls other than hearing protectors to reduce the sound level exposure of every employee who is likely to be exposed to levels of sound in excess of the prescribed limits in the workplace.

Employment Equity

The fourth annual report to Parliament on employment equity explains that equity in the workplace is essential for the economic prosperity of Canada. The full participation of all Canadians in the labour force ensures the employment of the complete range of available skills and talents.

The report assessed federally regulated firms for employment status of designated groups and progress in equitable employment practices during the reporting year, 1990. Included were eight minerals and metals companies employing 11 916 workers. All minerals and metals sector employers received the lowest rank for status of women's employment, except one, which rated medium. Most received medium ratings for progress. Aboriginal employees were well represented in uranium mines and in western Canada, but comprised few or none of the sector's eastern workforce. Progress ranged from highest to lowest rank, averaging medium. Most minerals and metals employers ranked high to medium for status and progress in employing workers with disabilities and members of visible minorities.

The uranium mining company, Cameco Corporation, and a college developed pre-employment courses with support from Employment and Immigration Canada. This training helps Saskatchewan northerners of aboriginal descent qualify for entry-level jobs at the firm's northern operations. Cameco hires graduates as vacancies occur.

During 1991, employers, unions and designated groups were consulted about the *Employment Equity Act's* provisions, operation and effect. A Parliamentary Committee will review the consultation findings and report to the House of Commons by May 1, 1992.

Provincial/Territorial Developments

A number of changes to labour and employment standards legislation took place in 1991. Several jurisdictions legislated increases in minimum wages and amended their employment standards regulations to improve workers' wage protection and parental leave provisions.

There were several changes to legislation on occupational health and safety. In Newfoundland, an Asbestos Abatement Code of Practice under the *Occupational Health and Safety (OHS) Act* was adopted on October 4, 1991. The Code of Practice was developed to provide safe handling procedures to minimize exposure to airborne asbestos fibres released from asbestos-containing material. In New Brunswick, *An Act to amend the OHS Commission Act*, which includes changes to the composition of the Commission, was adopted on May 9, 1991. In Ontario, a new regulation on construction projects made under the *OHS Act* was adopted on June 1, 1991. Part IV of the new regulation concerns tunnels, shafts, caissons and cofferdams works. Also, regulations amending the Mines and Mining Plants Regulation under the *OHS Act* were adopted on November 2,

1991. The amendments cover various aspects and range from reducing the concentration of toxic substances in diesel exhaust emissions to rescue methods and first aid equipment in mines and mining plants. In the Northwest Territories, new Explosives Regulations under the *Explosives Use Act*, which repealed and replaced previous regulations, were adopted on January 22, 1991. Most of the changes made are to reflect contemporary safety standards, for example, prohibiting the use of tape fuse in detonating explosives. In the Yukon Territory, *An Act to amend the OHS Act* was adopted on May 29, 1991. It obliges employers to select health and safety representatives from among the workers who do not exercise managerial functions in workplaces where no joint health and safety committees are required. The authority of the chief mines safety officer to order an employer to proceed with the selection of such representatives is maintained.

OUTLOOK

After months of recession, economic forecasts for 1992 call for a slow recovery. Mineral industry performance is expected to reflect this rebound. Specialists predict that demand for iron, nickel, lead and zinc will pick up over the next year as the manufacturing sector recovers. Since the productivity improvements of the last downturn, mining output growth no longer results in employment growth. Rather, output growth is necessary to slow, or flatten, the employment decline.

Announcements of closures and workforce cutbacks point to a continued drop in minerals and metals employment in 1992. Employment in metal mines in particular is expected to fall. Human resource management and skills development will be more important than ever for employers with smaller workforces. The government-industry human resource study now under way will be helpful to firms as they continue these tasks.

Closures planned for 1992 will affect the 78 remaining employees at the Rio Kemptville Tin Corporation tin mine in East Kemptville, Nova Scotia, 150 at the Minnova Inc. Lac Shortt gold mine near Desmaraisville, and 115 at the Audrey Resources Inc. Mobrun copper-zinc-gold-silver mine in Rouyn, Quebec. In Ontario, the Dofasco Inc. Macleod iron ore mine in Wawa (300 workers) and the Denison Mines Limited uranium mine in Elliot Lake (660) are expected to close. Other announced or potential closures include Manitoba's Hudson Bay Mining and Smelting Co. Limited (HBMS) Spruce Point copper-zinc mine in the Snow Lake area (40), British Columbia's Equity Silver Mines Limited gold-silver-copper mine in Houston (168), Noranda Inc.'s Bell copper mine at Babine Lake (270), Minnova Inc. and Rea Gold Corp.'s Samatosum silver mine near Adams Lake (50), and Cassiar Mining Corp.'s asbestos mine in Cassiar (450). The possible closure of the Curragh Resources Inc. zinc-lead Faro mine at Faro, Yukon, would affect 400 employees.

Jobs at new and re-opening operations will counteract some of these employment contractions. Openings planned in 1992 include Noranda Minerals Inc.'s E-29 copper deposit at Gaspé, Quebec, Inco Limited's 1-D nickel orebody at Thompson, Manitoba, and Curragh Resources Inc.'s Grum lead-zinc deposit at Faro, Yukon. Falconbridge Gold Corporation will re-open its Bell Creek gold mill in Timmins, Ontario. In addition, Aluminerie Alouette Inc. and Aluminerie Lauralco Inc. plan to start production in 1992 at new aluminum smelters in Sept-Îles and Deschambault, Quebec.

Fewer collective agreements expire at minerals and metals operations during 1992, and none expire at iron and steel mills. The year will, however, be significant for many employees at several nonferrous smelters and refineries in Quebec, Alberta and British Columbia. Several coal mines will be negotiating, including the Cape Breton Development Corporation (CBDC) in Nova Scotia, and Fording Coal Ltd. and Quintette Coal Ltd. in British Columbia. Negotiations will also take place at International Mineral & Chemical Corporation (Canada) Limited's (IMCC) potash operations in Saskatchewan, and at several small gold mines in Quebec, Alberta and the Northwest Territories.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. LABOUR DISPUTES, 1991

Employer	Location	Products	Union[1]	Period of Work Stoppage	Employees Involved
NEW BRUNSWICK					
Brunswick Mining and Smelting Corporation Limited	Bathurst	Lead, zinc	USWA	July 1, 1990- May 8, 1991	1 092
Brunswick Mining and Smelting Corporation Limited	Belledune	Refined lead, zinc	USWA	July 21, 1990- May 2, 1991	450
ONTARIO					
Royal Canadian Mint	Ottawa	Refined gold	PSAC	December 5	350
MANITOBA					
Royal Canadian Mint	Winnipeg	Coins	PSAC	October 24	130
BRITISH COLUMBIA					
BHP-Utah Mines Ltd.	Port Hardy	Copper	IUOE	May 24	450
Cassiar Mining Corporation	Cassiar	Asbestos	USWA	March 4-16	330
Princeton Mining Corporation Similco mine	Princeton	Copper, gold, silver	CAIMAW	May 31- October 27	235
YUKON					
Curragh Resources Inc.	Faro	Lead, zinc	USWA	April 5- June 15	360

Sources: Labour Canada; Canadian Labour Views Reports.

[1] CAIMAW Canadian Association of Industrial, Mechanical and Allied Workers
IUOE International Union of Operating Engineers
PSAC Public Service Alliance of Canada
UMW United Mine Workers of America
USWA United Steelworkers of America

TABLE 2. FATALITIES IN THE MINING SECTOR,[1] 1991

Jurisdiction	Employer		Location			Total
	Company	Contractor and Misc.	Underground	Open Pit	Other	
Newfoundland	–	–	–	–	–	–
Nova Scotia	1	–	1	–	–	1
Cape Breton Development Corporation	–	–	–	–	–	–
New Brunswick	2	–	–	–	2	2
Quebec	2[a]	–	–	–	2	2
Ontario	7	2	6	–	3	9
Manitoba	2	–	2	–	–	2
Saskatchewan	3	–	2	–	1	3
Alberta	2	–	1	–	1	2
British Columbia	2	–	–	–	2	2
Northwest Territories	1	1	2	–	–	2
Yukon	–	1	–	1	–	1
Total Canada	22	4	14	1	11	26

Source: Mine fatalities as reported by chief inspectors or corresponding authority of every mining jurisdiction in Canada. Compiled by EMR Canada, January 1992.

– Nil.

[a] These fatalities were workers employed in quarries (preliminary data from the Commission de la santé et de la sécurité du travail).

[1] For the purpose of this table, the mining sector is understood to include quarries and sand pits, with the exception of Newfoundland, New Brunswick and Northwest Territories which have not reported under that category.

Note: The table provides the number of work-related fatalities in 1991 caused by a traumatic accident. It does **not** include deaths resulting from occupational illnesses. Also, off-property and commuting transportation accidents such as highway traffic accidents are not included.

TABLE 3. NUMBER OF TIME-LOSS INJURIES AND ILLNESSES ACCEPTED BY WORKERS' COMPENSATION BOARDS, MINING, 1982-90[1]

	Mines, Quarries and Oil Wells	Metal and Nonmetal Mines	Mineral Fuels	Quarries and Sand Pits	Services Incidental to Mining
	(SIC 051-099)	(051-059, 071-079)	(061-064)	(083-087)	(096-099)
1982	12 425	5 603	3 541	557	2 724
1983	11 717	5 114	3 153	635	2 815
1984	12 322	5 595	2 286	677	3 764
1985	13 471	5 411	3 175	929	3 956
1986	11 105	5 024	2 191	779	3 111
1987	11 103	4 766	1 931	880	3 526
1988	11 258r	4 888r	1 857	921	3 592
1989	10 282	5 263	1 485	997	2 537
1990	9 230	4 873	1 407	925	2 025

Source: Statistics Canada, National Work Injuries Statistics Program (special tabulations).
r Revised.
1 Includes fatalities.

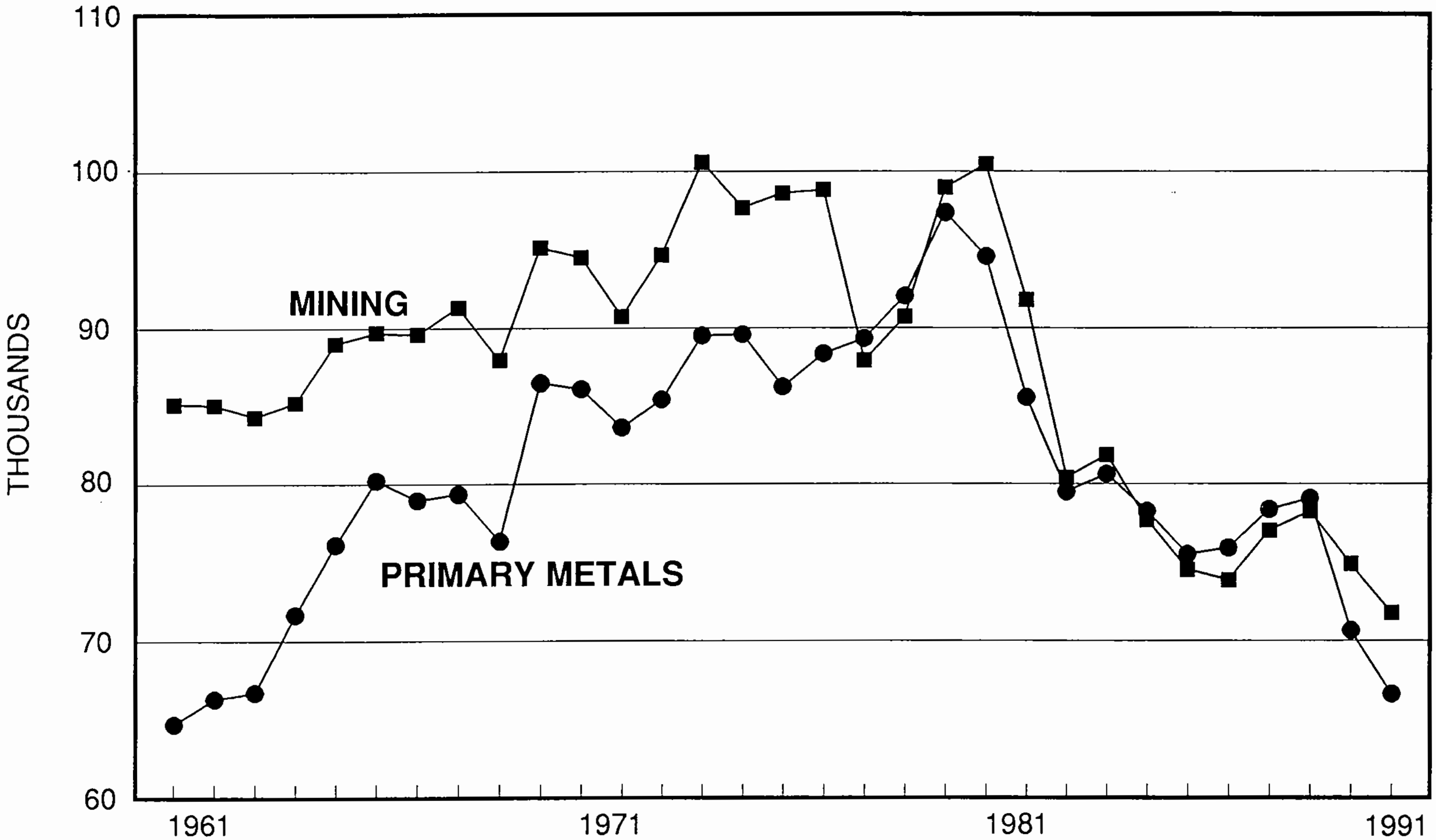
TABLE 4. ESTIMATED RATE OF WORK-RELATED TIME-LOSS INJURIES AND ILLNESSES[1] PER 100 WORKERS BY INDUSTRY,[2] 1983-90

	Forestry	Mining, Quarries and Oil Wells	Manufacturing	Construction	Transportation, Communications and Other Utilities	Trade	Finance	Service	Public Administration	Industrial Aggregate
1983	15.9	7.5	8.3	10.7	5.2	4.2	0.7	2.8	5.1	5.1
1984	16.9	7.7	9.6	11.3	5.3	4.5	0.7	3.0	4.7	5.5
1985	13.8	7.9	10.6	11.6	5.6	4.8	0.7	3.0	5.8	5.8
1986	16.8	7.0	10.9	12.1	6.3	5.1	0.6	3.2	5.6	6.0
1987	16.6	7.2	11.1	12.6	6.3	4.9	0.6	3.2	5.5	6.0
1988	14.5	7.2	11.5	12.5	6.0	5.2	0.6	3.3	5.7	6.0
1989	13.6	6.8	11.2	12.4	6.2	5.1	0.7	3.3	5.2	5.9
1990	13.5	6.2	10.7	12.3	5.9	5.0	0.7	3.4	5.0	5.7

Source: Statistics Canada, National Work Injuries Statistics Program (special tabulations) for number of work-related injuries and illnesses and Survey of Employment, Payrolls and Hours (SEPH) (special tabulations including adjustment for pre-1987 data) for employment series.
1 Includes fatalities. 2 Agriculture and fishing and trapping industries are not covered by SEPH; consequently, rates were not calculated for these sectors.

Figure 1

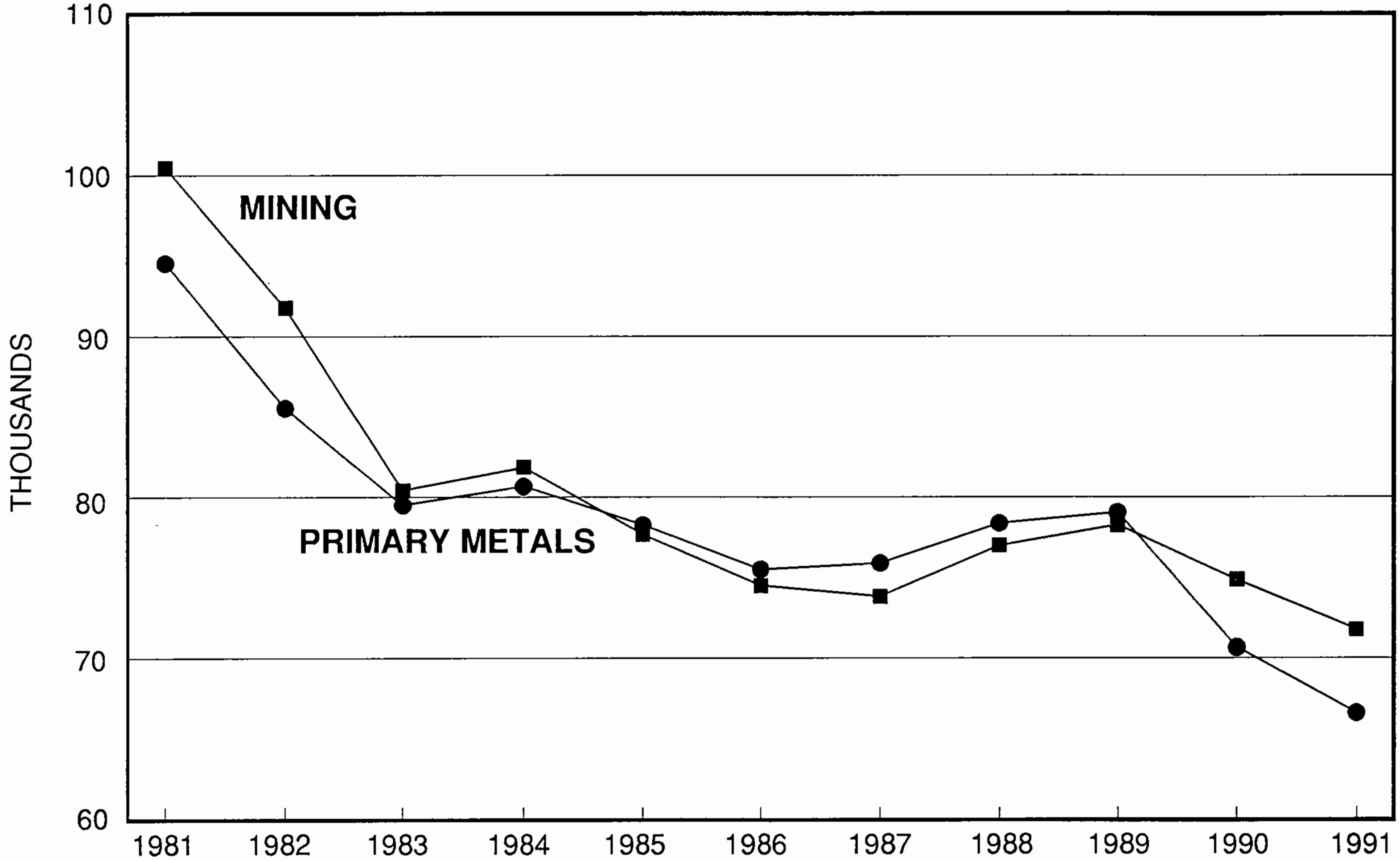
EMPLOYMENT IN MINING AND PRIMARY METALS, 1961-91



Sources: Energy, Mines and Resources Canada for 1991 forecast; Annual Census of Mines; Annual Census of Manufactures; Annual Survey of Manufactures.

Figure 2

EMPLOYMENT IN MINING AND PRIMARY METALS, 1981-91

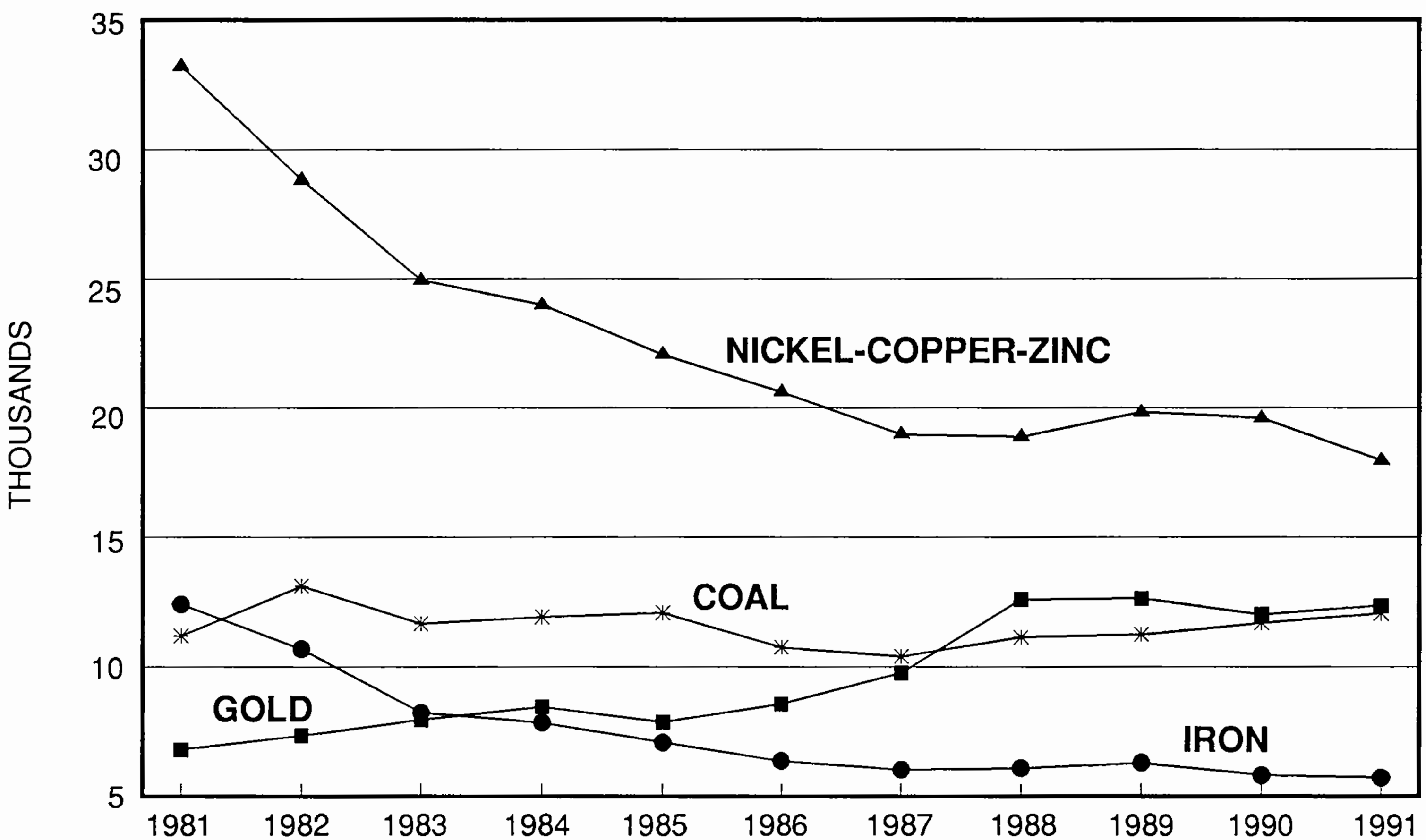


Sources: Energy, Mines and Resources Canada for 1991 forecast; Annual Census of Mines; Annual Census of Manufactures.

Figure 3

EMPLOYMENT BY COMMODITY, 1981-91

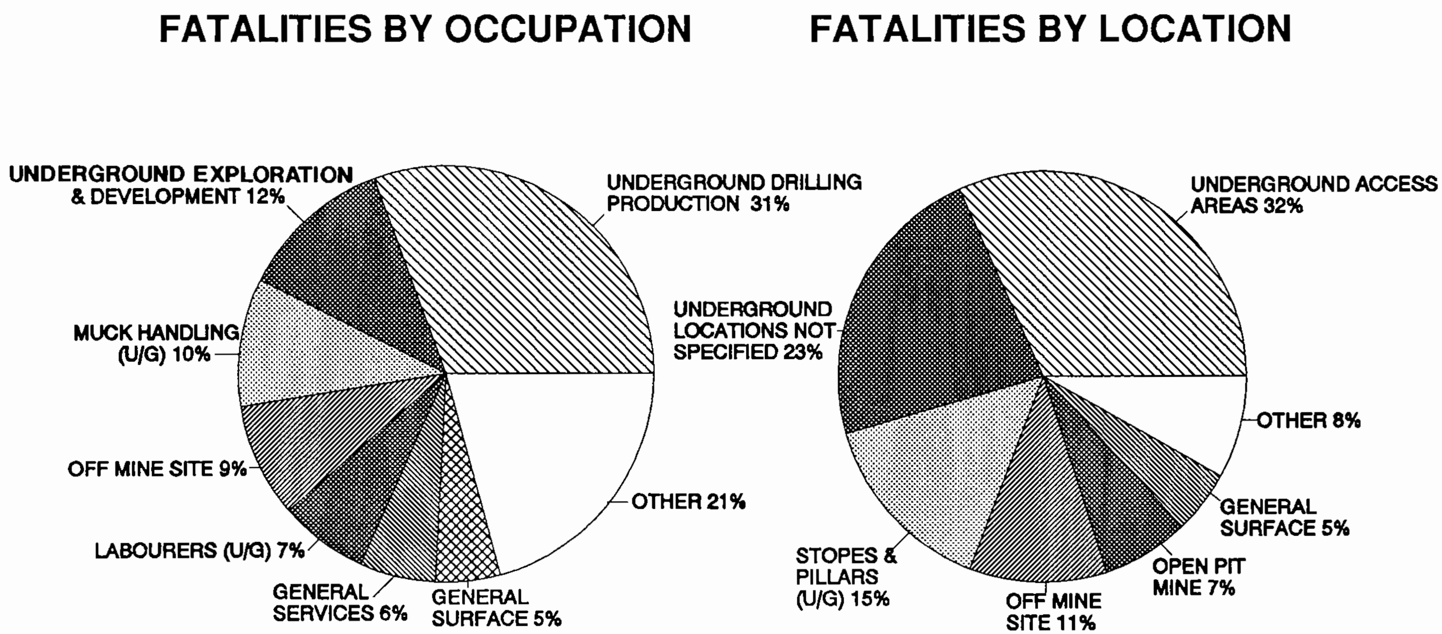
STAGE 1: MINING



Sources: Energy, Mines and Resources Canada for 1991 forecast; Annual Census of Mines.

Figure 4

FATAL INJURIES BY OCCUPATION AND LOCATION, 1986-90



101 RECORDS

Source: National Mines Accident Data Base.

Canadian Reserves, Mine Investment, New Projects and Promising Deposits

André Lemieux

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-2709

RESERVES

Canadian reserves of metals are derived from the responses of mining companies to the Federal-Provincial Survey of Mines and Concentrators, and from information contained in annual and other corporate reports. Canadian reserve totals include only metal contained in ores that are classified by companies as "proven and probable" or their equivalents at producing mines and in deposits that are committed for production. Metal contained in mine ores that are classified as "possible" is not included in the national totals reported here, nor is metal contained in deposits that are under exploration. Where available, only "mineable" ore is included so as to exclude metal lost in the mining process.

The reserves reported here cannot, by themselves, give any indication of whether or not Canada might be running out of economically mineable minerals. Future production will draw not only on the 1991 reserves, but also on additional reserves yet to be developed–from new discoveries, from extensions to known orebodies, and from known but currently marginal or uneconomic material. Energy, Mines and Resources Canada publishes an annual mineral bulletin[1] on Canadian mines that discusses Canada's capability for metal production both from operating mines and from known deposits for which future production can be considered likely.

In most mines, reserves change slightly from year to year; on balance, such changes cancel out in national totals. It is the relatively small number of mines with large changes that affects the overall direction of national trends.[2]

Reserves by Commodity

Gold

In January 1991, more than 1500 t of gold were contained in Canadian reserves of proven and probable ore (Figure 1), down by about 110 t, or over 6%, when compared to revised estimates for 1990. For the second year in a row, there was a decrease in Canadian reserves of gold. Overall, mine-site exploration and additions to reserves resulting from new mines committed to production did not replace all of the gold mined during 1990. This contrasts with the 1980s when gold reserves in Canada experienced strong and sustained growth throughout the decade.

Gold in ores at new mines committed for production during 1990 (Table 1), counted for the first time in Canadian totals, contributed almost 50 t of gross additions to Canadian reserves. The new mines are, in **British Columbia**: Snip, owned by Cominco Ltd. and Prime Resources Group Inc. (about 23 t), and Dome Mountain, owned by Habsburg Resources Inc. (more than 3 t); **in Saskatchewan**: Seabee, owned by Claude Resources Inc. (some 10 t); **in Quebec**, Mouska, owned by Cambior inc. (4 t), Norlartic, owned by Aur Resources Inc. and Nova-Cogesco Resources Inc. (2 t), and Simkar, owned by Ronrico Explorations Ltd. and Louvicourt Gold Mines Inc.

(2 t). As well, a half-dozen established mines in Quebec, Ontario, British Columbia and the Northwest Territories found substantially more gold than they produced during 1990.

In contrast, several mines reduced their gold reserves by more than the quantities that they mined during 1990. The largest decreases in proven and probable reserves occurred at the Campbell mine in Ontario, where the owner, Placer Dome Inc., reported some 1.2 million fewer ounces (about 37 t less) than in the previous year, and in the Northwest Territories at the Colomac mine, owned by Northwest Gold Corp.; production at Colomac was suspended in July 1991.

The net effect of all these changes was a reduction in Canadian gold reserves of over 6% from early 1990 to early 1991.

Silver

In 1991, Canadian reserves of silver stood at over 23 000 t, down by almost 12% from the previous year. More silver was either mined or is now no longer counted in company reserves than was replaced in operating mines or added as a result of production decisions made during 1990.

The most noteworthy gross addition to silver reserves (some 270 t) resulted from the inclusion in national totals of the reserves at the Sa Dena Hes (Mt. Hundere) mine in the Yukon, owned by Curragh Resources Inc. and Hillsborough Resources Limited.

Among the operations with the largest decreases in proven and probable reserves of silver were, in **New Brunswick**: Caribou, owned by Breakwater Resources Ltd., where the company reported a $65 million writedown and closed the mine in October 1990, and Brunswick No. 12, owned by Brunswick Mining and Smelting Corporation Limited, where proven ore, which was previously reported as "mineral inventory," is now reported as mineable ore, thereby resulting in an appreciable reduction in ore tonnage; in **British Columbia**: Samatosum, owned by Minnova Inc. and Rea Gold Corporation, where the reserve grade was reduced by the companies because of operating experience and the presence of a fault that disrupts the continuity of the ore zone, and Premier, now wholly owned by Westmin Resources Limited, where the company dropped over 2 Mt of ore from reserves and where the grade of silver fell significantly; and in **Ontario**: Falconbridge Limited's Kidd Creek operations, where both ore tonnage and grade decreased during 1990.

Zinc

There were two outstanding sources of gross additions to Canadian zinc reserves during 1990. The largest resulted from the inclusion of the reserves at the Sa Dena Hes mine, and the other from an increase in both tonnage and grade at the Heath Steele-Stratmat operation in New Brunswick, owned by Noranda Inc. and Brunswick Mining and Smelting Corporation Limited.

The period from early 1990 to early 1991 saw a number of significant reductions in zinc reserves. The largest reduction occurred at the Brunswick No. 12 mine, due to changes to the reporting method and the fact that zinc mined during 1990 was not replaced with metal in new-found ore. Other sizeable reductions in zinc reserves occurred as a result of the closure of the Caribou mine, drops in tonnage and grade at the Polaris mine in the Northwest Territories (owned by Cominco Ltd. and Pine Point Mines Limited), and because of apparently limited replacement of ore mined at the Kidd Creek operations.

Overall, Canadian reserves of zinc decreased to 20 091 000 t in January 1991, some 949 000 t (over 4%) less than in 1990.

Lead

Canadian reserves of lead fell to 6 317 000 t in January 1991 from 6 702 000 t the previous year, a decrease of over 6%.

The largest gross addition to Canadian reserves of lead, about 160 000 t, was due to the first-time inclusion of the reserves at the Sa Dena Hes mine. The largest gross decreases in lead reserves took place as a result of the apparently unreplaced production at the Faro operations of Curragh Resources Inc. in the Yukon, the closure of the Caribou mine, and the change in the method of reporting proven ore reserves at Brunswick No. 12.

Nickel

There were some 5 792 000 t of nickel in Canadian mine reserves in January 1991. Apart from unreplaced production, a tonnage of nickel, equivalent to about half of what was mined during 1990, was apparently no longer included in mine reserves at the beginning of 1991. Inco Limited's aggregate reserves of nickel in the Sudbury area of Ontario and at Thompson, Manitoba, decreased by some 300 000 t, or about 5% less than in the previous year.

Only a few mines appeared to have maintained or added to their nickel reserves from 1990 to 1991. The reserves at the Langmuir No. 1 mine in Ontario, owned by Timmins Nickel Inc., which are relatively small compared to those of other Canadian nickel mines, were included in the national total for the first time as of January 1991. Falconbridge Limited's East mine in Falconbridge, Ontario, which started production in 1954, closed during 1990 after producing some 590 000 t of nickel metal during its life.

Overall, Canadian reserves of nickel were down by about 6% from 1990 to 1991. However, in Canada, the ratio of reserves to production continues to be substantially higher for nickel than for the other major metals.

Copper

In January 1991, Canadian reserves of copper amounted to 11 203 000 t, down from 12 238 000 t a year earlier.

There were less than a dozen mining operations with apparent net additions to copper reserves during 1990. Only one of these, Bethlehem Resources Corporation and Goldnev Resources Inc.'s Goldstream mine in British Columbia, which was reactivated in 1991 following production financing arranged in principle in late 1990, stood out. The mine had last produced in 1984 when it was owned by what is now Noranda Inc.

In addition to decreases due to production, there were further apparent reductions in copper reserves, notably at Cominco Ltd.'s Highland Valley mine in British Columbia, at the operations of Inco Limited in Ontario and Manitoba, and at those of Falconbridge Limited in Timmins. Taking all Canadian operations into account, reserves at the beginning of 1991 were some 8.5% lower than in 1990.

Molybdenum

Canadian reserves of molybdenum amounted to 193 000 t in early 1991, about 10% less than in early 1990. Only one of the five Canadian mines producing molyb-denum, all located in British Columbia, appears to have replaced a significant portion of the molybdenum that it extracted from its ore reserves during 1990.

Canadian Reserves by Province and Territory

At the beginning of 1991, three provinces held dominant positions in terms of Canada's proven and probable reserves of major metals (Table 2). New Brunswick had 54% of the lead, 43% of the zinc and 41% of the silver; Ontario had 73% of the nickel, 52% of the gold and 45% of the copper; and British Columbia had all of the molybdenum and 40% of the copper. There were no significant shifts in provincial standings in 1991 compared to revised figures for 1990.

When contrasted with revised figures for the previous year, 1991 proven and probable reserves of copper and zinc increased in Manitoba; those for lead and zinc increased in Nova Scotia; those for lead increased in Quebec; and those for zinc increased in British Columbia. Otherwise, reserve levels either decreased or stayed about the same.

Reserve Trends

Reserves of base metals and precious metals generally rose from the mid-1970s to the early 1980s. After that, reserves of base metals generally declined as a result of unreplaced production, write-offs of unprofitable portions of orebodies, the focus on exploration for gold, and closures of uneconomic mines. In contrast, gold reserves continued rising until 1989.

Compared to 1981, Canada's reserves of copper, nickel, zinc and silver in early 1991 were down by about one third. They were down by almost 40% for lead, and down by more than 65% for molybdenum. Although reserves of gold have decreased in each of the past two years, their level in early 1991 was still more than double that of 1981.

MINE INVESTMENT

In 1990, mine investment (including repairs) amounted to some $4.4 billion, almost 85% of the $5.2 billion (Figure 2) spent in total at all mines and on all exploration projects during that year. Compared with revised estimates for 1989, mine investment in 1990 (in constant dollars) was down by 4%. To have added expenditures aimed at finding new mines on producing properties would only have increased the 1990 figures for mine investment by some $116 million. Most (85%) of all non-petroleum mineral exploration carried out in 1990 was conducted on properties that were neither in production nor committed for production.

Investment by Commodity

Gold producers invested $814 million (including repairs) at mine sites in Canada in 1990 (Figure 3), about three quarters (in constant dollars) of what they spent in 1989. Investment by gold producers represents 18% of all mine-site investment made in Canada in 1990, down from 23% in 1989. Producers of base metals invested about $1.5 billion in 1990, about the same (in constant dollars) as in 1989. Together, producers of all metallic mineral commodities invested about $3 billion in 1990, or 67% of the total mine-site investment made in Canada during that year. This was about the same as in 1989.

Producers of nonmetals invested $1.4 billion during 1990, comparable (in constant dollars) to what they invested in each of the previous three years. Of these, coal producers invested $802 million, the most in that group, and almost as much as gold producers.

Investment by Province and Territory

During 1990, some $2.9 billion in mine-site investment, about two thirds of the Canadian total, was made in Ontario, British Columbia and Quebec (Figure 4). These three provinces are the country's leading producers (in that order) of non-petroleum mineral commodities. In 1990, they accounted for 29%, 20% and 16% respectively of total mine-site investment in Canada.

Investment by Category

Four categories are used to record mine-site investment in Canada: i) surface and underground structures, ii) machinery and equipment, iii) ore development, and iv) repairs (non-capitalized) to existing structures, machinery and equipment.

Repairs to structures, machinery and equipment is the largest of the four mine-site investment categories (Figure 5). In 1990, repairs accounted for about $2 billion, or some 47% of total mine-site investment in Canada, up slightly from 1989. Development of deposits for production ($1.2 billion) held second place at 28%, machinery and equipment ($0.7 billion) accounted for 16%, and new structures ($0.4 billion) made up the remaining 9%. The revised value of Canada's non-petroleum mineral production in 1990 amounted to some $19.6 billion. For each dollar's worth of non-petroleum mineral production during that year, the industry invested about 22 cents at mine sites: 11 cents in repairs, 6 cents in development, 3 cents in machinery and equipment, and 2 cents in structures.

Investment Trends

Total mine-site investment in Canada (in constant dollars) generally declined during the 1980s (Figure 5). Mine-site investment in 1990 was about one third lower than in 1981, the year with the highest level in the 1980s. This general decline was largely due to lower investment in new structures, machinery and equipment which, in turn, reflects the lack of large new mines over this period.

From 1983 to 1984, investment in structures (in constant dollars) fell from $1.4 billion to $600 million and did not rise much above $700 million in any year since that time; in 1990, it amounted to $404 million. Investment in machinery and equipment fell from $1.2 billion in 1984 to some $800 million in 1985. Since then, it has been about $700 million annually, except for 1988 and 1989, when it rose to about $900 million.

Over the past ten years, expenditures on repairs and on development, which are more indicative of activity at ongoing operations, have been more stable than those on structures, machinery and equipment. Expenditures (in constant dollars) on repairs to plant and equipment were $2.2 billion in 1981. They subsequently decreased to about $1.8 billion per year; since 1988, they have been about $2 billion annually. Development expenditures have remained steady at over $1 billion annually during the 1980s.

Investment by producers of nonmetals (in constant dollars) rose steadily between 1980 and 1982 to some $2.5 billion, fell each year thereafter until 1987, and subsequently remained steady at less than $1.5 billion annually. In comparison, investment by producers of metals was almost $4.3 billion in 1981. It remained in the range of $2 billion-$3 billion each year until 1988, when it rose to $3.4 billion. Since then, it has been falling to less than $3 billion in 1990. Gold producers were responsible for most of the temporary increase in metal-mine investment during the late 1980s, with an annual investment in each of 1987, 1988 and 1989 of more than $1 billion. Since 1983, annual investment by producers of base metals has been in the $1 billion-$1.5 billion range.

NEW PROJECTS ANNOUNCED DURING 1991

Company investment intentions (Figure 5) published in early 1991 suggest that, relative to 1990, total mine investment in Canada in 1991 could fall by about 10% (in constant dollars). The number of projects announced during 1991 and their sizes also points to declining investment over the next few years for base-metal and precious-metal mines (Table 3). Fewer than a dozen new precious-metal and base-metal mining projects were announced during 1991. These projects represent either relatively small new operations or the development of new zones at established mines. Their number is fewer and their value is significantly lower than the average for the previous ten years.

PROMISING DEPOSITS

Deposits are assessed as promising for possible development into mines in the foreseeable future on the basis of the results of exploration programs at mining properties in Canada published in company reports. This approach is based on the assumption that companies are focusing a good portion of their resources on properties with the best short-term prospects for production. Such a selection process is unavoidably subjective, and may also be biased in favour of those companies that are the most informative.

There are an estimated 7000 mining properties in Canada at various stages of exploration, from raw prospect to bankable feasibility study. The number of precious-metal (mostly gold) and base-metal (mostly polymetallic) deposits in Canada judged promising for possible development into mines in the foreseeable future increased each year from 98 in early 1982 to 268 in early 1990. Since then, the number of such deposits has fallen to 210 in February 1991, and to 150 in January 1992 (Figure 6).

Of the 150 deposits judged, in early 1992, to be promising for future production (Table 4), 94 are precious-metal deposits and 56 are base-metal deposits. British Columbia accounts for 39 (26%) of these promising deposits, Quebec for 36 (24%), and Ontario for 34 (23%).

The number of base-metal deposits judged to be promising for future production has returned to the level of the early 1980s (Figure 7). In the period 1987-89 when gold was the main focus of the Canadian exploration industry, the number of base-metal deposits judged promising for future production declined to about 20. In early 1992, there were 56 promising base-metal deposits, or about the same number as ten years earlier.

In 1992, promising base-metal deposits in Canada accounted for 37% of all promising deposits, up from 28% in early 1991, and up from a low of 13% in early 1989 (Figure 8). In early 1982, base-metal deposits accounted for 56% of all promising deposits.

There were 94 promising precious-metal deposits in early 1992, more than twice as many as in 1982. The number of promising precious-metal deposits increased steadily each year from 1982 to 1990. However, since then, it fell in each year but, nonetheless, remains above the level of the early 1980s (Figure 9).

Based on the in-situ value of contained metals (or, where available, on the mineable value), the largest promising Canadian mineral deposits of base metals and precious metals include, in **British Columbia**: Windy Craggy (copper, gold, silver, cobalt), Fish Lake (copper, gold), Stronsay, previously called Cirque (zinc, lead, silver), Red Dog Hill (zinc, copper, gold, molybdenum), Mt. Milligan (gold, copper), Kerr (copper, gold, silver), South Kemess (gold, copper), Eskay Creek (gold, silver), Tulsequah Chief (zinc, gold, copper, silver, lead), Kutcho Creek (copper, zinc, silver, gold), Copper Canyon (copper, gold, silver), Expo, Hushamu Zone (copper, gold, molybdenum), J&L (gold, zinc, lead, silver), and Mt. Polley, S19 pit (copper, gold); in **Quebec**: Dumont Nickel (nickel), Raglan (nickel, copper), Louvicourt (copper, zinc, gold, silver), and Grevet "M" (zinc, copper, silver); in **Ontario**: Victor, new discovery (nickel, copper), McCreedy East, new discovery (copper, nickel), Victor, 1975 discovery (nickel, copper), Moss Lake (gold), and Lindsley (nickel, copper, gold, silver, cobalt, platinum, palladium); in **Manitoba**: Bucko Lake (nickel) and Minago (nickel); in the **Yukon**: DY, underground (zinc, lead, gold, silver), and Blende (zinc, lead, silver); in the **Northwest Territories**: Isok Lake (zinc, copper, silver, lead); in **Saskatchewan**: Hanson Lake, also known as McIlvenna Bay (zinc, copper, gold, silver); and in **New Brunswick**: Half-Mile Lake (zinc, lead, silver, copper). These 30 deposits account for over 80% of the estimated in-situ value of all deposits considered promising in January 1992. They are mostly polymetallic base-metal deposits, and several of them are new additions to the list of promising deposits. In addition to the 150 deposits judged promising here, there are many more deposits of all types of commodities in Canada that are currently not being mined.[3]

Based on metal prices prevailing at the beginning of 1992, copper accounts for roughly 30% of the gross in-situ value of the estimated mineral inventory reported by companies for these deposits; nickel accounts for about 25%, and zinc and gold each account for about 20%.

OUTLOOK

Compared with the beginning of the 1980s, reserves of base metals are down by one third or more, depending on the metal. However, company interest in evaluating polymetallic base-metal deposits, two dozen of which each have potential mineral inventories valued at $1 billion or more at early 1992 metal prices, appears to have risen appreciably in 1990 and to have continued through early 1992.

Production decisions will eventually be made on some of these deposits. This would significantly change the mineral investment outlook for the next few years and provide the additional reserves required to maintain Canadian base-metal production in the coming years.

REFERENCES

[1] A. Lemieux, L.S. Jen, D.A. Cranstone and G. Bouchard, "Canadian Mines: Perspective from 1990 - Production, Reserves, Development, Exploration," Mineral Bulletin MR 230, 1992, Energy, Mines and Resources Canada, Ottawa, 58 pp.

[2] For the distribution of mine-by-mine net changes in gold reserves during 1988, see: A. Lemieux, "Canadian Reserves, Mine Investment, New Projects and Promising Deposits" in Canadian Minerals Yearbook 1989, Energy, Mines and Resources Canada, pp. 5.1-5.28.

[3] "Canadian Mineral Deposits Not Being Mined in 1989," Mineral Bulletin MR 223, Energy, Mines and Resources Canada, 1990, Ottawa.

Note: Information in this review was current as at February 7, 1992.

TABLE 1. NEW MINING OPERATIONS AND COMMITMENTS TO PRODUCTION ADDED TO CANADIAN RESERVE TOTALS, JANUARY 1991

Operation	Operators and Major Partners	Metals	Province/ Territory
Estrades[1]	Breakwater Resources Ltd. and Brookline Minerals Inc.[2]	Zinc, copper, lead, gold, silver	Que.
Mouska	Cambior inc.	Gold, silver	Que.
Norlartic	Aur Resources Inc. and Nova-Cogesco Resources Inc.	Gold, silver	Que.
Normetmar[3]	Exploration Minière Normétal Inc.	Zinc, silver, lead, gold	Que.
Simkar	Ronrico Explorations Ltd. and Louvicourt Gold Mines Inc.	Gold, silver	Que.
Langmuir No. 1[4]	Timmins Nickel Inc.	Nickel	Ont.
Jasper[5]	Cameco Corporation and Shore Gold Fund Inc.	Gold	Sask.
Seabee	Claude Resources Inc.	Gold	Sask.
Dome Mountain	Timmins Nickel Inc. and Habsburg Resources Inc.[6]	Gold, silver	B.C.
Goldstream	Bethlehem Resources Corporation and Goldnev Resources Inc.	Zinc, copper, silver	B.C.
Nickel Plate open pit– Canty deposit	Corona Corporation	Gold, silver	B.C.
SB-35 zone[7]	Westmin Resources Ltd. and Tenajon Resources Corp.	Gold, silver	B.C.
Snip	Cominco Ltd. and Prime Resources Group Inc.	Gold	B.C.
Sa Dena Hes[8]	Curragh Resources Inc. and Hillsborough Resources Limited	Zinc, lead, silver	Y.T.

Source: Energy, Mines and Resources Canada.
[1] Closed mid-1991. [2] Formerly Golden Hope Resources Inc. and Golden Group Explorations Inc. [3] Closed by the beginning of 1991. [4] Mining suspended early 1992. [5] Closed December 1991. [6] Formerly Teeshin Resources Ltd. [7] Mining completed late 1991. [8] Formerly Mount Hundere.

TABLE 2. CANADIAN RESERVES BY PROVINCE AND TERRITORY, JANUARY 1, 1991
(Metal Contained in Proven and Probable Mineable Ore[1] in Operating Mines and Deposits Committed for Production[2])

Metal	Units[3]	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	B.C.	Y.T.	N.W.T.	Canada[5]
Copper	000 t	–	11	375	775	5 050	538	–	4 454	–	–	11 203
Nickel	000 t	–	–	–	–	4 208	1 584	–	–	–	–	5 792
Lead	000 t	–	29	3 383	28	94	13	–	957	1 358	456	6 317
Zinc	000 t	–	76	8 700	1 224	2 689	1 145	–	1 942	2 419	1 897	20 091
Molybdenum	000 t	–	–	–	–	–	–	–	193	–	–	193
Silver	t	4	–	9 498	1 311	5 027	757	1	4 162	2 339	127	23 227
Gold[4]	t	39	–	59	343	812	34	13	117	26	105	1 548

Source: Energy, Mines and Resources Canada.
– Nil or less than one unit.
[1] No allowance is made for losses in milling, smelting and refining. Excludes material classified as "possible." Includes "geological reserves" for some mines that do not report mineable ore. [2] Includes metal in mines where production has been suspended temporarily. [3] One tonne (t) = 1.1023113 short tons = 32 150.746 troy ounces. [4] Excludes metal in placer deposits. [5] May not balance due to rounding at the provincial level.

TABLE 3. PRECIOUS-METAL AND BASE-METAL MINING PROJECTS ANNOUNCED IN CANADA DURING 1991

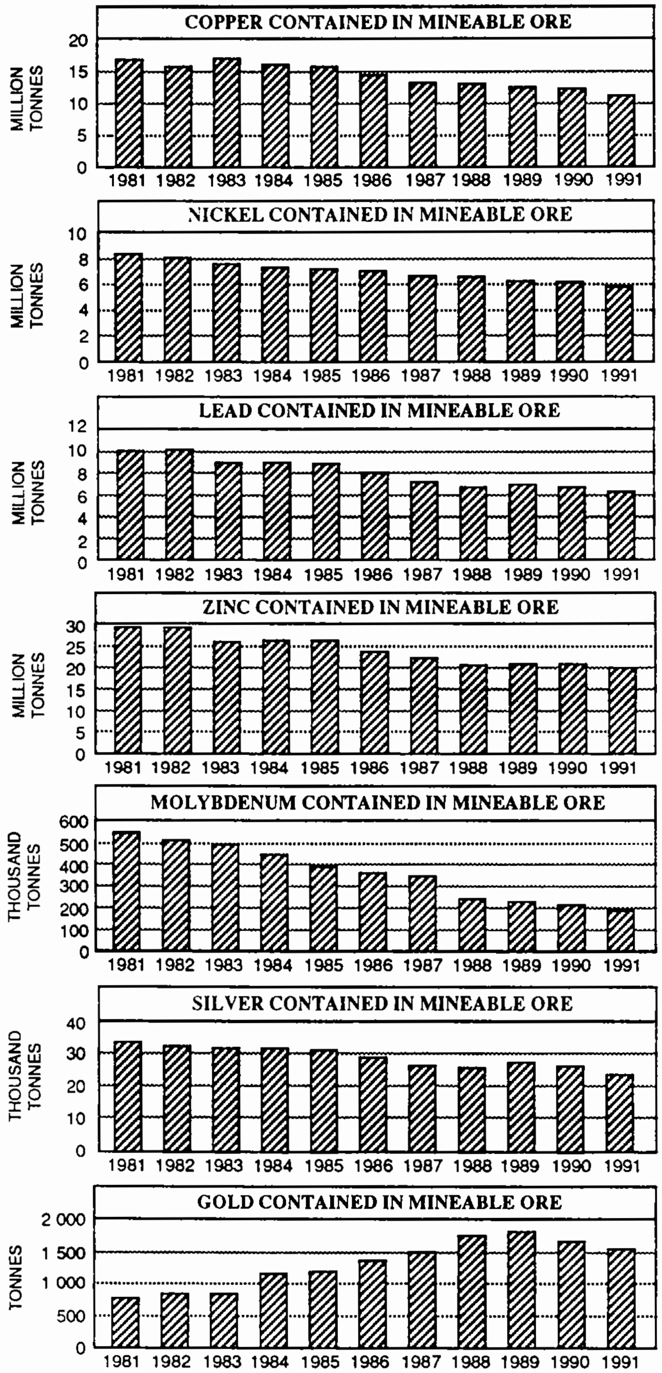
Companies	Projects	Metals	Start-Up Year	Incremental Project Budget
				($ million)
PRECIOUS METALS				
Agnico-Eagle Mines Limited	Development of the Eagle West zone (367 000 t), Eagle-Telbel mine, Joutel area, Quebec	Gold, silver	1991	. .
American Barrick Resources Corporation	Development of the Mattawasaga zone (2 000 000 t), Holt-McDermott mine, Kirkland Lake area, Ontario	Gold, silver	1992	. .
GSR Mining Corporation	New 300 t/d Buffonta underground mine, Virginiatown area, Ontario[1]	Gold, silver	1991	. .
Giant Yellowknife Mines Limited	Reactivation of the Porcupine Peninsular mine (Nighthawk Lake) at 300 t/d, Timmins area, Ontario	Gold, silver	1992	. .
New Privateer Mine Ltd.	Reactivation of the Privateer underground mine at 100 t/d, Zeballos, British Columbia	Gold, silver	1991	. .
Westmin Resources Ltd. and Tenajon Resources Corp.	New 100 000 t SB underground mine, Stewart area, British Columbia[2]	Gold, silver	1991	. .
Subtotal				. .
BASE METALS AND BY-PRODUCTS				
Stratabound Minerals Corp.	New 200-300 t/d Captain North Extension (CNE) open-pit mine, Bathurst area, New Brunswick	Zinc, lead, silver	1991	. .
Minnova Inc. and Rea Gold Corporation	Development of the underground portion (80 300 t) of the Samatosum mine, Adams Lake area, British Columbia	Zinc, copper, lead, silver, gold	1991	. .
Princeton Mining Corp.	Development of the Virginia deposit (14 000 000 t), Similco Mine, Princeton, British Columbia	Copper, silver, gold	. .	. .
Westmin Resources Limited	Development of the "Gap" zone, Myra Falls operation, British Columbia	Zinc, copper, silver, gold, lead	. .	. .
Subtotal				. .
Total, all metals				. .

Source: Energy, Mines and Resources Canada, based on press reports.
. . Not available; • Estimated.
[1] Operations suspended March 1991. [2] Mining completed in late 1991.

Figure 1

CANADIAN RESERVES, 1981-91

Metal contained in proven and probable mineable ore in operating mines and deposits committed for production, as at January 1 of each year

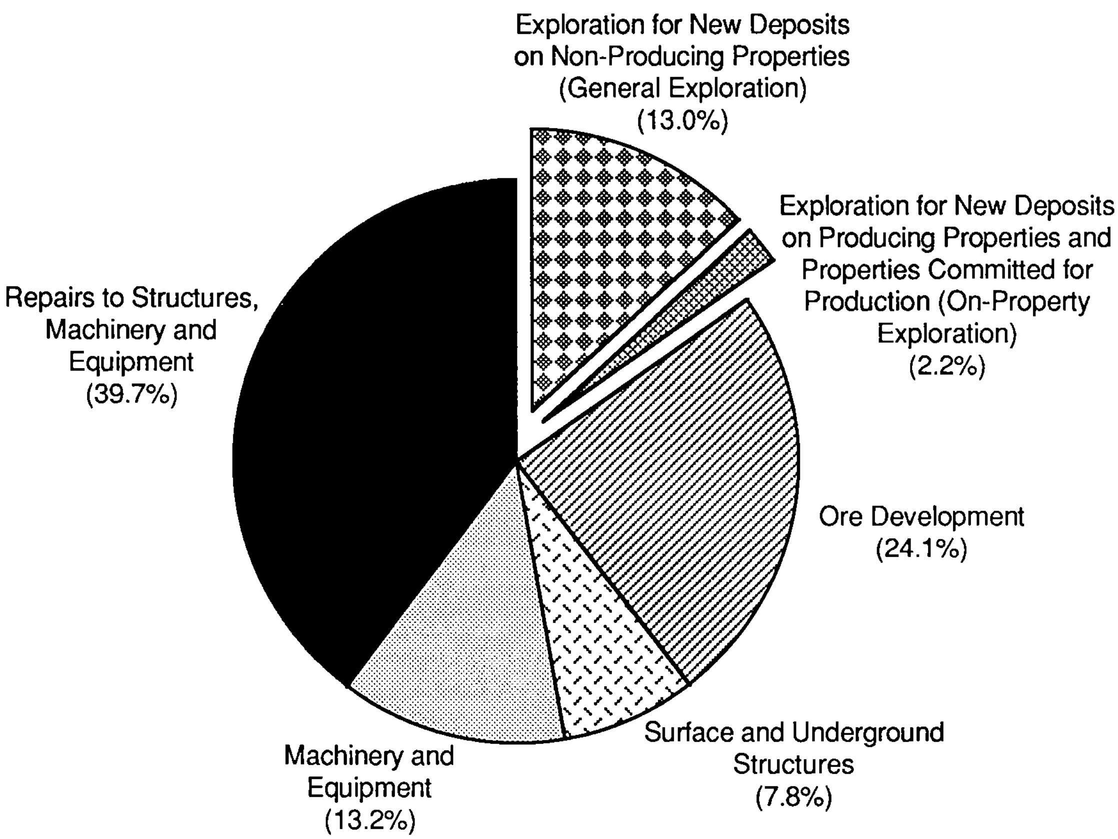


Source: Energy, Mines and Resources Canada.

Figure 2

MINE AND EXPLORATION INVESTMENT IN CANADA, 1990[a]

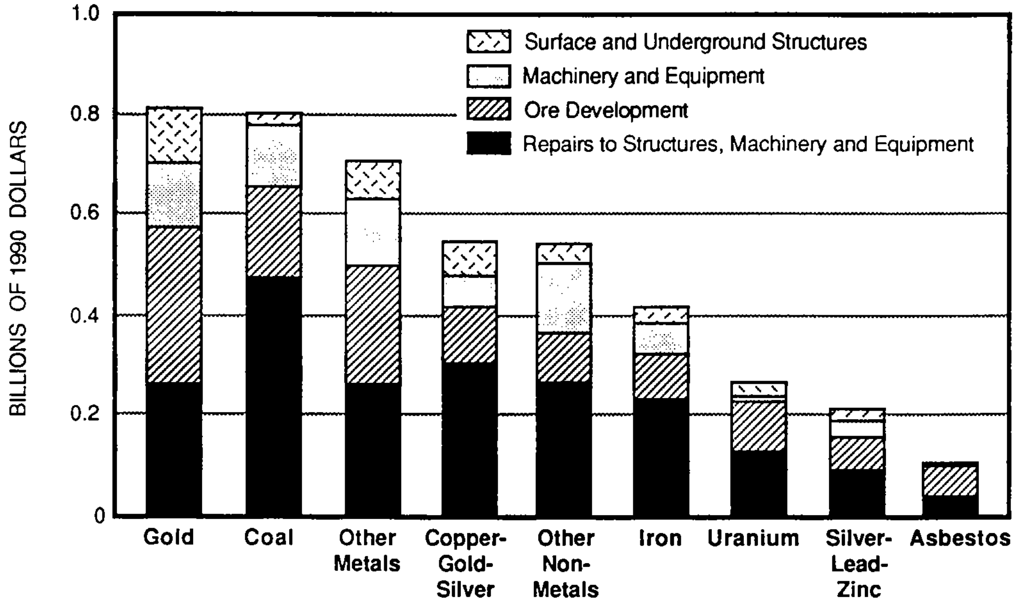
$5.2 BILLION



a Actual.
Source: Energy, Mines and Resources Canada, based on Statistics Canada, Exploration Development and Capital Expenditures for Mining, catalogue 61-216.

Figure 3

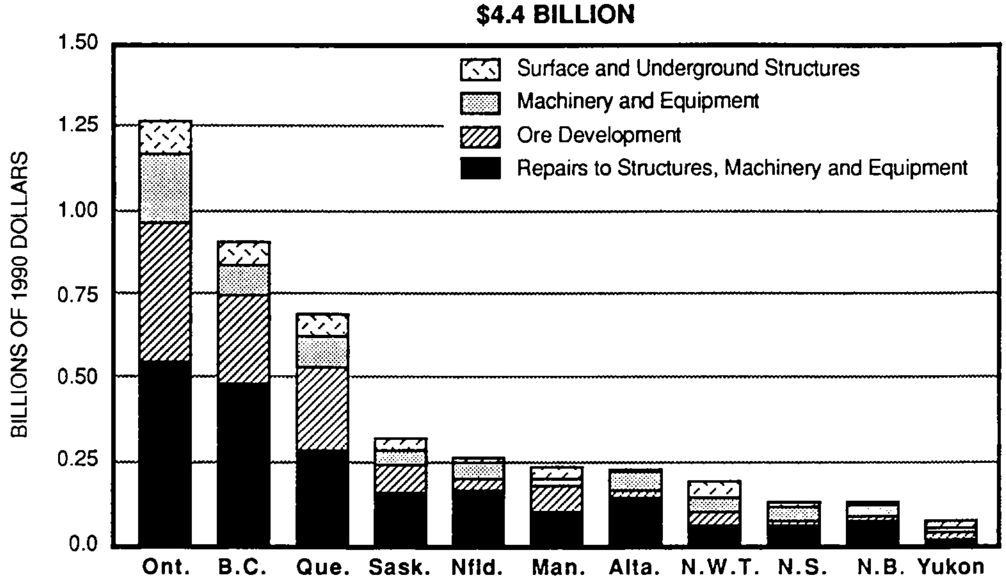
MINE INVESTMENT IN CANADA, 1990[a]
BY INDUSTRY GROUPS
$4.4 BILLION



a Actual.
Source: Energy, Mines and Resources Canada, based on Statistics Canada, Exploration Development and Capital Expenditures for Mining, catalogue 61-216.

Figure 4

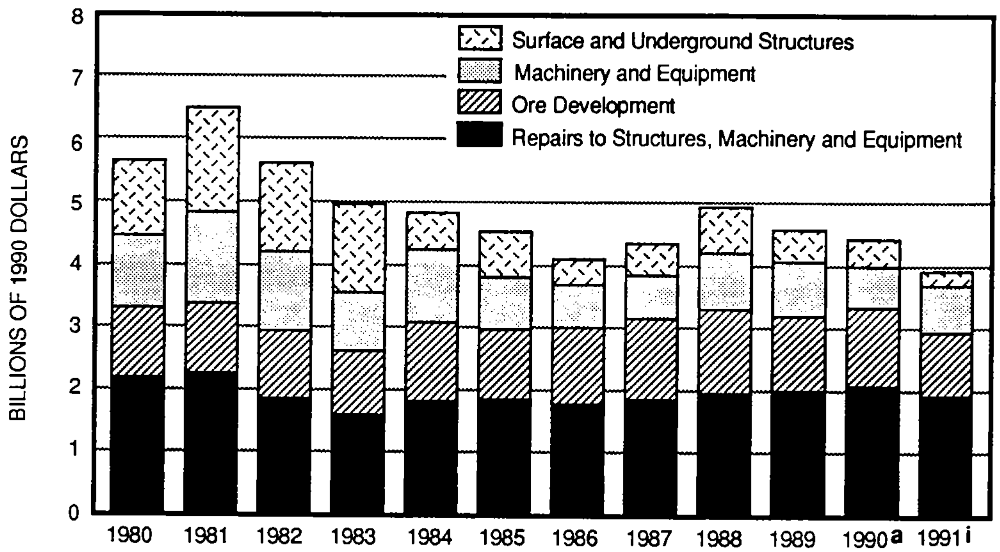
MINE INVESTMENT IN CANADA, 1990[a]
BY PROVINCE AND TERRITORY
$4.4 BILLION



a Actual.
Source: Energy, Mines and Resources Canada, based on Statistics Canada, Exploration Development and Capital Expenditures for Mining, catalogue 61-216.

Figure 5

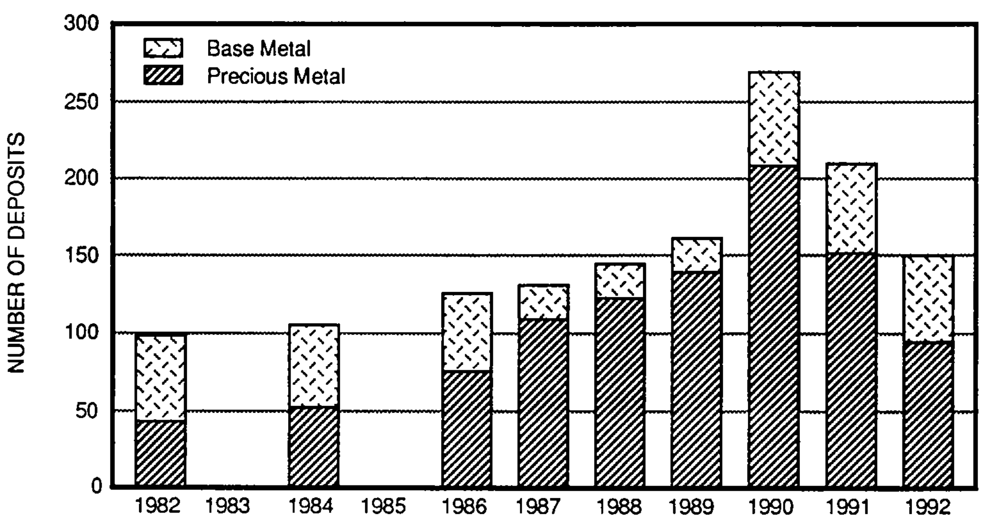
MINE INVESTMENT IN CANADA, 1980-91
BY INVESTMENT CATEGORY



a Actual; i Intentions.
Source: Energy, Mines and Resources Canada, based on Statistics Canada, Exploration Development and Capital Expenditures for Mining, catalogue 61-216.

Figure 6

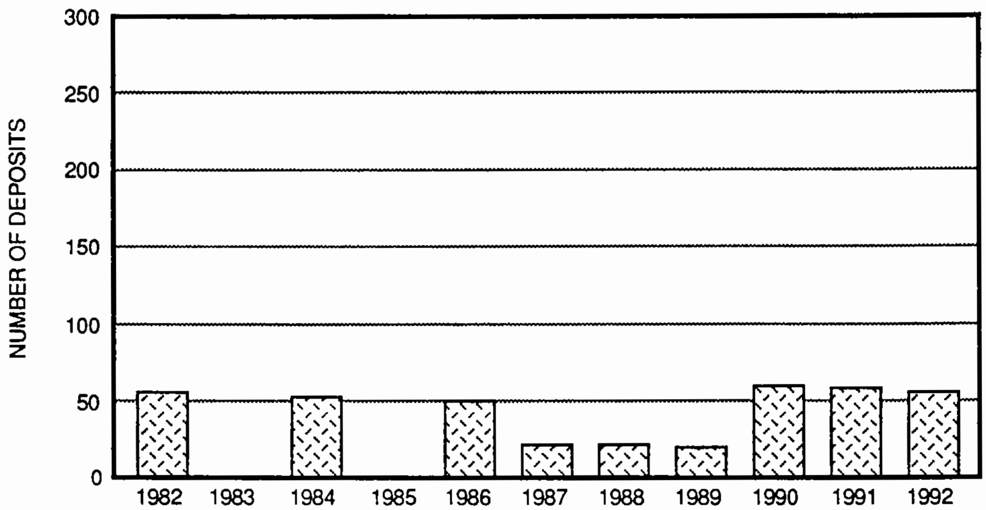
CANADIAN PRECIOUS-METAL AND BASE-METAL DEPOSITS CONSIDERED PROMISING FOR FUTURE PRODUCTION



Note: Data for 1983 and 1985 are not available.
Source: Energy, Mines and Resources Canada, based on company reports.

Figure 7

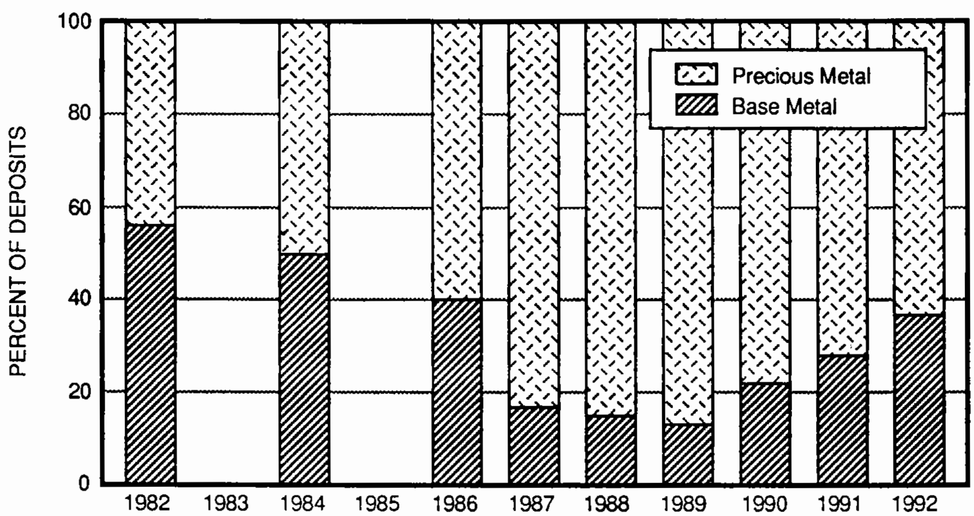
CANADIAN BASE-METAL DEPOSITS CONSIDERED PROMISING FOR FUTURE PRODUCTION



Note: Data for 1983 and 1985 are not available.
Source: Energy, Mines and Resources Canada, based on company reports.

Figure 8

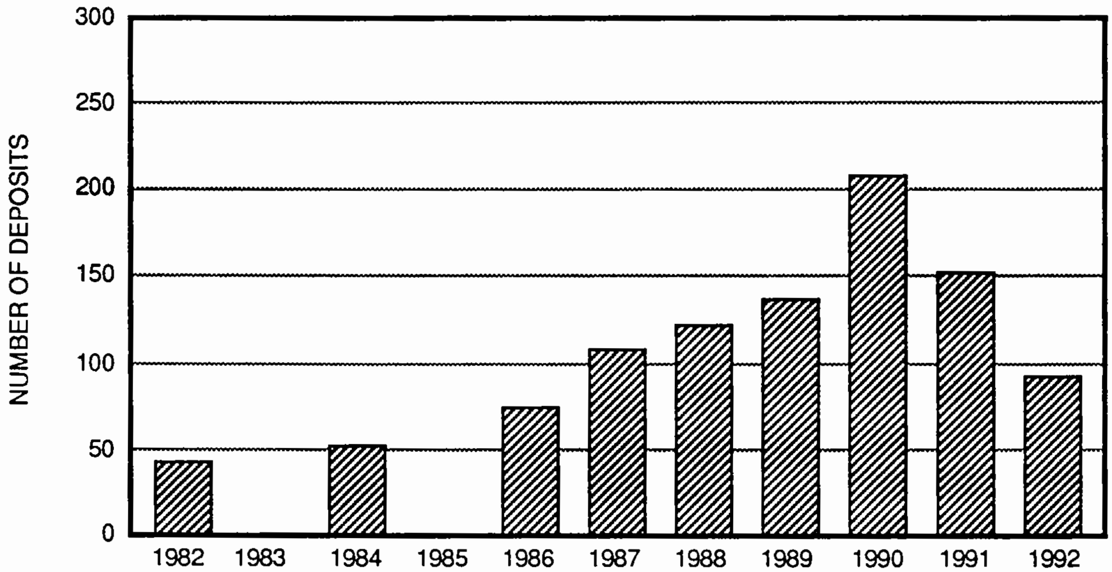
CANADIAN PRECIOUS-METAL AND BASE-METAL DEPOSITS CONSIDERED PROMISING FOR FUTURE PRODUCTION



Note: Data for 1983 and 1985 are not available.
Source: Energy, Mines and Resources Canada, based on company reports.

Figure 9

CANADIAN PRECIOUS-METAL DEPOSITS CONSIDERED PROMISING FOR FUTURE PRODUCTION



Note: Data for 1983 and 1985 are not available.
Source: Energy, Mines and Resources Canada, based on company reports.

TABLE 4

TONNAGE AND GRADE OF ADDITIONAL BASE-METAL AND PRECIOUS-METAL DEPOSITS CONSIDERED, IN JANUARY 1992, PROMISING FOR FUTURE PRODUCTION

- DEPOSITS: Individual deposits have been selected on the basis of public information available during 1991. Deposits committed for production as at January 1, 1992, are not included.
- TONNAGE and GRADE: As reported by companies or, where necessary, from the secondary source that appeared to be the most reliable. Imperial units reported were converted to metric units and rounded. Tonnage and grade descriptions such as "probable and possible" are those reported by companies.
- COMPANIES: Where two or more companies are identified with a deposit, the first is usually the operator.

DEPOSITS	COMPANIES	TONNAGE AND GRADE DESCRIPTION	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
			(tonnes)[1]	(%)	(%)	(%)	(%)	(%)	(g/t)[2]	(g/t)[2]
NEWFOUNDLAND										
Rambler - Ming West	Petromet Resources Limited Newfoundland Exploration Company Limited Teck Corporation	Drill indicated geological	100 000	5.6	–	–	0.37	–	–	2.4
Rambler - tailings	Petromet Resources Limited Newfoundland Exploration Company Limited Teck Corporation	Potential mineable	1 163 671	0.31	–	–	–	–	–	1.7
Rendell-Jackman	Noranda Inc. Major General Resources Ltd.	Geological	390 000	–	–	–	–	–	–	12.
NOVA SCOTIA										
Goldboro	Exploration Orex Inc. Minnova Inc.	Probable	1 043 890	–	–	–	–	–	–	6.2
Mooseland	Acadia Mineral Ventures Limited	Inferred	414 400	–	–	–	–	–	–	16.
NEW BRUNSWICK										
Half-Mile Lake	Noranda Inc. Conwest Exploration Company Limited	Undiluted geological	5 300 000	0.08	–	3.25	10.26	–	29.	–
Murray Brook Copper	NovaGold Resources Inc.	Geological	354 000	4.58	–	–	–	–	45.9	–
Nash Creek	Falconbridge Limited	Potential	2 000 000	–	–	0.9	4.6	–	27.	–
QUEBEC										
Abitibi Copper	Aur Resources Inc. Consolidated Abitibi Resources Limited		1 200 000	0.75	–	–	–	–	–	–
Aldermac	Deak Resources Corporation		1 373 000	1.80	–	–	4.60	–	35.0	0.55
Arntfield	Deak Resources Corporation Noranda Inc. Nova-Cogesco Resources Inc.		633 000	–	–	–	–	–	–	4.83

Casa Berardi - Principal (including Domex claims)	TVX Gold Inc. Golden Knight Resources Inc.	Probable and possible geological	4 236 000	–	–	–	–	–	–	7.41
Connell Corner - E Zone	Aurizon Mines Ltd. Ezekiel Explorations Ltd.		673 000	2.36	–	–	–	–	–	0.7
Courville	Placer Dome Inc. Explorations Cache Inc. Parquet Resources Inc.	Probable	123 000	–	–	–	–	–	–	6.9
Dalquier - Main and Lower zones	Aur Resources Inc. Jonpol Explorations Ltd.	Geological	2 699 000	1.26	–	–	0.9	–	38.4	0.09
Douay Vezza - Central zone	TVX Gold Inc. Société d'Exploration Minière Vior Inc.		505 000	–	–	–	–	–	–	7.9
Douay Vezza - West zone	TVX Gold Inc. Société d'Exploration Minière Vior Inc.	Geological	583 000	–	–	–	–	–	–	9.9
Doyon - Warrenmac zone	LAC Minerals Ltd. Cambior inc.	Mineral inventory	170 000	–	–	–	3.2	–	27.	6.9
Doyon - Westwood zone	LAC Minerals Ltd. Cambior inc.	Mineral inventory	417 000	–	–	–	–	–	–	9.3
Dumont Nickel (Launay-Trecesson)	Timmins Nickel Inc Dumont Nickel Corporation (NPL)		486 000 000	. .	0.39	–	–	–	–	–
Duquesne mine	Radisson Mining Resources Inc.	Probable and possible	678 822	–	–	–	–	–	–	8.56
Duvay Obalski	Sphinx Exploration Inc.		6 039 298	–	–	–	–	–	–	2.
East Amphi (Darius joint venture)	Breakwater Resources Ltd. Bond Gold Canada Inc.	Probable and possible	757 900	–	–	–	–	–	–	8.57
Eastmain	Meston Lake Resources Inc. MSV Resources Inc.	Proven and probable geological	863 979	–	–	–	–	–	–	12.
Fontana	Bay Resources and Services Inc. Jilbey Exploration Ltd.	Probable and possible	878 295	–	–	–	–	–	–	5.66
Goldex - Extension zone	Goldex Mines Limited Ormico Exploration Ltée	Bulk inventory	12 000 000	–	–	–	–	–	–	3.1
Goldstack - new discovery	Sphinx Exploration Inc. Goldstack Resources Ltd.	Probable and possible	659 978	–	–	–	–	–	–	5.97
Goldstack mine - residual tonnage	Sphinx Exploration Inc. Goldstack Resources Ltd.	Possible	454 000	–	–	–	–	–	–	6.5
Grevet "B"	VSM Exploration Inc. Sérem-Québec Inc.	Diluted probable mining reserves	477 000	0.58	–	–	9.67	–	24.00	–
Grevet "M" - zones III, IV and 97	VSM Exploration Inc. Sérem-Québec Inc.	Diluted probable and possible mining reserves	12 264 000	0.49	–	–	8.92	–	36.70	–
Hebecourt	Deak Resources Corporation Noranda Inc.		658 000	2.80	–	–	–	–	–	–
Inmont	Mazarin Mining Exploration Inc. Teck Corporation Dufresnoy, Mining Exploration Inc.		120 000	1.6	–	–	–	–	–	4.6

TABLE 4 (cont'd)

DEPOSITS	COMPANIES	TONNAGE AND GRADE DESCRIPTION	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
			(tonnes)[1]	(%)	(%)	(%)	(%)	(%)	(g/t)[2]	(g/t)[2]
Joubi	Western Quebec Mines Inc. Messeguay Mines Inc.		541 370	–	–	–	–	–	–	5.82
Lac Frotet	Minnova Inc.	Drill indicated geological	21 200 000	0.2	–	–	–	–	–	2.1
Louvicourt	Aur Resources Inc. Louvem Mines Inc.	Mineable	22 860 000	4.01	–	–	1.99	–	30.7	1.2
Magusi	Deak Resources Corporation		3 650 000	1.79	–	–	3.02	–	29.	0.89
Noyon - RJ zone	Northway Explorations Limited TOTAL Energold Corporation	Preliminary	304 580	–	–	–	–	–	–	5.5
Pelletier Lake	Thunderwood Resources Inc. Falconbridge Limited	Drill indicated	880 000	–	–	–	–	–	–	6.86
Philibert	Société québecoise d'exploration minière (SOQUEM) Cambion inc.	Geological	1 250 000	–	–	–	–	–	–	5.23
Poirier - west part	Ressources Minière Forbex Inc. Bonanza Metals Inc.	Mineable	793 602	1.31	–	–	8.69	–	–	–
Raglan	Falconbridge Limited		16 800 000	0.88	3.13	–	–	–	–	–
Scott Lake	Thunderwood Resources Inc. Greenstone Resources Ltd.	Geological	705 000	0.41	–	6.87	–	–	12.	0.3
Taché - Main zone	Teck Corporation Bitech Corporation Greenstone Resources Ltd.	Probable and possible	1 399 000	–	–	–	3.31	–	–	1.9
West MacDonald (Gallen)	Deak Resources Corporation Noranda Inc.		1 052 000	0.20	–	–	7.50	–	32.	1.3
ONTARIO										
Armistice - Kerr and Sheldon zones	GSR Mining Corporation Armistice Resources Ltd.	Drill indicated probable and possible	502 000	–	–	–	–	–	–	5.1
Beatty Hislop	Noranda Inc. Glimmer Resources Inc.	Preliminary	983 977	–	–	–	–	–	–	11.6
Cadieux	Cameco Corporation Breakwater Resources Ltd.	Drill indicated	825 005	–	–	0.96	9.62	–	–	–
Cameron Lake	Nuinsco Resources Limited	Proven, probable and possible	2 866 838	–	–	–	–	–	–	5.76
Cheminis	Northfield Minerals Inc.	Proven, probable and possible	2 396 409	–	–	–	–	–	–	5.83
Chester	Young-Shannon Gold Mines Ltd.	Geological	630 000	–	–	–	–	–	–	11.8
Dixie Lake	Teck Corporation Mutual Resources Ltd.	Geological	454 000	–	–	–	–	–	–	4.5

Duport	Consolidated Professor Mines Limited	Geological	1 800 000	–	–	–	–	–	–	12.
Edwards	Spirit Lake Explorations Limited		251 629	–	–	–	–	–	–	19.
Garrison Twp.	Perrex Resources Inc. LAC Minerals Ltd. GSR Mining Corporation		410 000	–	–	–	–	–	–	4.97
Garrison Twp.	Jonpol Explorations Limited T & H Resources Ltd.	Drill indicated	466 100	–	–	–	–	–	–	9.6
Goldlund	Noranda Inc. Camreco Inc.	Probable mining	300 362	–	–	–	–	–	–	4.01
Hemlo-Interlake	Hemlo Gold Mines Inc. Teck Corporation Franco-Nevada Mining Corporation Limited		8 600 000	–	–	–	–	–	–	6.34
Hislop	Noranda Inc. Glimmer Resources Inc.	Geological	983 699	–	–	–	–	–	–	11.6
Hislop - Creek and Main zones	Stroud Resources Ltd.	Drill proven and drill indicated	1 014 465	–	–	–	–	–	–	6.31
Hislop - Matachewan	Noranda Inc. Alban Explorations Ltd. Matachewan Consolidated Mines, Limited	Geological	181 000	–	–	–	–	–	–	3.1
Horseshoe Island	Noranda Inc. Noront Resources Ltd.		810 578	–	–	–	–	–	–	4.8
Jacobson Twp.	Sprit Lake Explorations Limited		148 000	–	–	–	–	–	–	37.0
Kasagiminnis Lake	Moss-Power Resources Inc.		454 000	–	–	–	–	–	–	5.1
Leckie	Stroud Resources Ltd.		299 000	–	–	–	–	–	–	7.37
Lightning	Noranda Inc. Freewest Resources Inc.		4 300 000	–	–	–	–	–	–	8.3
Lindsley[3]	Falconbridge Limited		6 400 000	1.51	1.58	–	–	–	–	–
Madsen	Madsen Gold Corp.	Mineable	99 750		–	–	–	–	–	7.9
Marathon[4]	Fleck Resources Ltd.	Near surface	37 000 000	0.31	0.04	–	–	–	1.31	0.07
Mattawasaga	American Barrick Resources Corporation		2 000 000	–	–	–	–	–	–	6.2
McCreedy East (new discovery)	Inco Limited	Preliminary	4 200 000	11 00	0.80	–	–	–	..	..
Mishi	Granges Inc. MacMillan Gold Corp.	Undiluted geological	1 194 000	–	–	–	–	–	–	5.69
Moss Lake	Noranda Inc. Central Crude Limited Storimin Exploration Limited Tandem Resources Ltd.	Probable and possible	74 583 172	–	–	–	–	–	–	1.1
Pick Lake	Minnova Inc.		1 600 000	1.1	–	–	17.7	–	–	–

TABLE 4 (cont'd)

DEPOSITS	COMPANIES	TONNAGE AND GRADE DESCRIPTION	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
			(tonnes)[1]	(%)	(%)	(%)	(%)	(%)	(g/t)[2]	(g/t)[2]
Robertson Twp.	Queenston Mining Inc. Strike Minerals Inc.	Preliminary	363 000	1.1	–	–	3.8	–	–	–
Shunsby	Kirkton Resources Corp.	Preliminary	3 700 000	0 59	–	–	2.56	–	–	–
Tyranite	Tyranex Gold Inc.	Mineable	477 000	–	–	–	–	–	–	6.9
Victor (new discovery)	Inco Limited	Preliminary	4 200 000	7.3	2.25	–	–	–	..	..
Victor (1975 discovery)	Inco Limited	Preliminary	6 400 000	0.50	2.17	–	–	–	..	..
MANITOBA										
Big Island Lake	Minnova Inc. Westfield Minerals Limited New Goldbrae Developments Ltd.		130 000	1.	–	–	17.	–	72.	3.8
Bucko Lake	Falconbridge Limited		17 000 000	–	2.32	–	–	–	–	–
Little Stull Lake	Westmin Resources Limited Tanqueray Resources Ltd.	Geological	750 000	–	–	–	–	–	–	10.5
MacBridge Lake	Bellex Mining Inc. Eastmin Resources Inc. Kancana Ventures Ltd.		1 800 000	0.35	–	–	8.77	–	..	..
Minago	Black Hawk Mining Inc.	Probable and possible geological	11 861 000	–	1.25	–	–	–	–	–
Monument Bay - Seeber zone	Bellex Mining Corp. Noranda Inc.	Drill inferred	649 000	–	–	–	–	–	–	9.87
San Antonio	Rea Gold Corporation	Diluted proven, probable and possible	1 361 000	–	–	–		–	–	7.41
Snow Lake (tailings)	Sikaman Gold Resources Ltd.		274 000	–	–	–	–	–	–	12.
SASKATCHEWAN										
Athona	RJK Mineral Corp. Greater Lenora Resources Corp. Cominco Ltd.	Probable, possible and potential	5 000 000	–	–	–	–	–	–	2.2
Box Mine	RJK Mineral Corp. Greater Lenora Resources Corp. Cominco Ltd.	Probable, possible and potential	14 900 000	–	–	–	–	–	–	2.0
Contact Lake - Bakos zone	Cameco Corporation Uranerz Exploration and Mining Limited Westward Explorations Ltd.	Mineable	964 000	–	–	–	–	–	–	9.5

Contact Lake - Pap zone	Cameco Corporation Uranerz Exploration and Mining Limited Westward Explorations Ltd.	Geological	400 000	–	–	–	–	–	–	12.1
Hanson Lake	Cameco Corporation Billiton Resources Canada Inc.	Probable mineable	13 200 000	0.83	–	–	4.66	–	..	..
Komis (Waddy Lake)	Waddy Lake Resources Inc.	Probable drill indicated geological	510 000	–	–	–	–	–	–	14.8
Niko (Kaslo)	Golden Rule Resources Ltd.		85 700	–	–	–	–	–	–	6.2
Tower East (Tower Lake)	Golden Rule Resources Ltd. International Mahogany Corp.	Probable geological	921 900	–	–	–	–	–	–	6.9
Weedy Lake - B zone	Tyler Resources Inc. Golden Rule Resources Ltd. Cameco Corporation	Geological	314 000	–	–	–	–	–	–	4.8
Weedy Lake - Golden Heart	Tyler Resources Inc. Golden Rule Resources Ltd. Cameco Corporation	Geological	666 200	–	–	–	–	–	–	7.9
BRITISH COLUMBIA										
Chu Chua[5]	Minnova Inc. Pacific Cassiar Limited International Vestor Resources Ltd. Quinterra Resources Inc.		1 043 000	2.98	–	–	0.3	–	10.	0.55
Copper Canyon	Consolidated Rhodes Resources Ltd. Canamax Resources Inc.	Preliminary geological	32 400 000	0.75	–	–	–	–	17.	1.2
Debbie and Yellow	Westmin Resources Limited	Probable and possible geological	471 956	–	–	–	–	–	–	6.27[6]
Discovery (Samatosum)	Rea Gold Corporation	Drill proven	145 000	1.06	–	3.72	4.99	–	120.	8.47
Dolly Varden - North Star	Dolly Varden Minerals Inc.	Proven and probable geological	128 436	–	–	–	5.	–	401.5	–
Eskay Creek	Prime Resources Group Inc. Stikine Resources Ltd.	Indicated probable geological	1 807 000	–	–	–	–	–	1913.	50.4
Expo - Hushamu zone	Moraga Resources Ltd. BHP-Utah Mines Ltd.	Probable and possible mineable	97 000 000	0.28	–	–	–	0.01	–	0.34
Fish Lake	Taseko Mines Ltd. Cominco Ltd.		544 000 000	0.32	–	–	–	–	–	0.549
Frasergold	ASARCO Incorporated Eureka Resources, Inc.	Drill indicated geological	11 000 000	–	–	–	–	–	–	2.
Goldwedge	Waterford Resources Inc. Exponential Holdings Ltd.	Proven, drill indicated and inferred	337 768	–	–	–	–	–	36.65	25.79
Harrison - Jenner Stock	Bema Gold Corporation Abo Resource Corp.	Drill indicated	2 204 000	–	–	–	–	–	–	4.1
J&L - Main and Yellowjacket	Cheni Gold Mines Inc. Equinox Resources Ltd. Pan American Minerals Corp.	Probable and possible	5 677 000	–	–	2.7	4.8	–	69.	6.0

TABLE 4 (cont'd)

DEPOSITS	COMPANIES	TONNAGE AND GRADE DESCRIPTION	TONNAGE	GRADE						
				Cu	Ni	Pb	Zn	Mo	Ag	Au
			(tonnes)[1]	(%)	(%)	(%)	(%)	(%)	(g/t)[2]	(g/t)[2]
Kerr	Placer Dome Inc.		125 700 000	0.62	–	–	–	–	2.4[e]	0.3
Kutcho Creek	American Reserve Mining Corporation Homestake Mining (Canada) Ltd.	Mineable	14 300 000	1.76	–	–	2.54	–	35.	0.37
Mascot Fraction	Golden North Resource Corporation		756 296	–	–	–	–	–	–	4.5
Midway	Regional Resources Ltd.	Probable and possible mineable	1 377 000	–	–	5.8	8.3	–	317.	–
Millie Mack	Greenstone Resources Ltd. Dragoon Resources Ltd.	Open pit	1 500 000	–	–	–	–	–	206.	5.73
Mt. Milligan	Placer Dome Inc.	Mineable	290 000 000	0.2	–	–	–	–	–	0.5
Mt. Polley (S-19)	Imperial Metals Corporation	Mineable	49 000 000	0.383	–	–	–	–	–	0.556
Polaris Taku	Suntac Minerals Corporation Rembrandt Gold Mines Ltd.	Geological	1 451 000	–	–	–	–	–	–	15.
Porcher Island - AT zone	Cathedral Gold Corporation	Drill indicated and inferred	1 361 000	–	–	–	–	–	–	6.86
QR (Quesnel River)	Rea Gold Corporation	Mineable	1 200 000	–	–	–	–	–	–	5.22
Red Dog Hill	Crew Natural Resources Ltd. Moraga Resources Ltd.	Preliminary pit layout	41 050 000	0.26	–	–	–	0.006	–	0.3
Red Mountain	Bond International Gold, Inc.	Geological	846 000	–	–	–	–	–	–	13.
Seneca (Agassiz-Weaver)	Minnova Inc. International Curator Resources Ltd.		1 506 400	0.65	–	–	3.57	–	41.	0.82
Similco Mine - Alabama	Princeton Mining Corporation	Possible	9 000 000	0.32	–	–	–	–	–	n.a.
Siwash North (Elk)	Fairfield Minerals Ltd.	Drill indicated	308 000	–	–	–	–	–	25.	22.2
Ski (Eskay Creek)	Adrian Resources Ltd.		238 000	–	–	–	–	–	987.	22.
South Kemess	St. Phillips Resources Inc. El Condor Resources Ltd.	Geological	127 000 000	0.23	–	–	–	–	–	0.58
Spectrum	Columbia Gold Mines nc. Eurus Resource Corp.	Bulk tonnage	8 375 000	0.18	–	–	–	–	–	1.3
Stronsay (Cirque)	Curragh Resources Inc. Asturiana de Zinc S.A.	Possible	52 200 000	–	–	2.	8.	–	..	–
Takla Rainbow	Eastfield Resources Ltd. Cathedral Gold Corporation	Drill indicated, inferred and potential geological	290 000	–	–	–	–	–	–	8.6
Tam - Boundary	Varitech Resources Ltd. Major General Resources Ltd.		6 500 000	0.55	–	–	–	–	–	n.a.

Taseko	Asarco Exploration of Canada Westpine Metals Ltd.	Mineable open pit	10 050 000	0.61	–	–	–	–	2.[e]	0.79
Tillicum Mtn.	Columbia Gold Mines Ltd.		460 000	–	–	–	–	–	–	11.
Tulsequah Chief	Cominco Ltd. Redfern Resources Ltd.	Geological	7 000 000	1.55	–	1.22	6.81	–	109.	3.
Vault	Inco Limited Seven Mile High Group Inc.	Drill indicated	152 000	–	–	–	–	–	–	14.
Vine	Kokanee Explorations Ltd. Cominco Ltd.	Proven, probable and possible	1 361 000	0.1[e]	–	4.7[e]	2.4[e]	–	52.[e]	2.[e]
Windy Craggy[6]	Geddes Resources Limited Northgate Exploration Limited	0.50% Cu cutoff grade	297 439 000	1.38	–	–	..	–	..	..
NORTHWEST TERRITORIES										
Bugow - Andrew	Aber Resources Ltd.		64 000	–	–	–	–	–	–	5.5
Bugow - Cabin Creek	Aber Resources Ltd.	Drill indicated	91 000	–	–	–	–	–	–	10.
Butterfly	Cominco Ltd. Cogema Canada Limited Aber Resources Ltd.		91 000	–	–	–	–	–	–	21.
Cache (Southwin)	Placer Dome Inc. Noble Peak Resources Ltd.	Possible	363 000	–	–	–	–	–	–	8.9
Con Mine - tailings	NERCO, Inc.		5 173 000	–	–	–	–	–	0.29	1.4[e]
Izok Lake	Falconbridge Limited		11 000 000	2.99	–	1.46	14.47	–	77.5	–
Nicholas Lake	Athabasca Gold Resources Ltd. Chevron Minerals Ltd.	Probable and possible	858 000	–	–	–	–	–	–	16.
Ren	Westview Resources Inc. Cominco Ltd.	Potential	2 000 000	–	–	–	–	–	–	9.9
YUKON TERRITORY										
Blende	Billiton Metals Canada Inc. NDU Resources Ltd.	Open pittable geological	19 500 000	–	–	2.81	3.04	–	55.9	–
Brewery Creek	Loki Gold Corporation Hemlo Gold Mines Inc.	Geological	15 000 000	–	–	–	–	–	–	1.9
DY (underground)	Curragh Resources Inc.	Diluted probable	11 300 000	–	–	5.82	6.34	–	83.	0.94
Marg	NDU Resources Ltd. Cameco Corporation	Drill indicated diluted	2 860 000	1.62	–	2.25	4.17	–	55.9	0.89
Mt. Nansen	B.Y.G. Natural Resources Inc.	Proven, probable and possible	953 383	–	–	–	–	–	190.	9.39

TABLE 4 (cont'd)

DEPOSITS	COMPANIES	TONNAGE AND GRADE DESCRIPTION	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
			(tonnes)[1]	(%)	(%)	(%)	(%)	(%)	(g/t)[2]	(g/t)[2]
Mt. Skukum	Wheaton River Minerals Ltd.		522 627	–	–	–	–	–	24.9	9.57
Williams Creek (oxide)	Thermal Exploration Company Western Copper Holdings Limited Archer, Cathro and Associates		13 200 000	1.06	–	–	–	–	–	..

– Nil; .. Not available; • Author's estimate.
[1] One tonne = 1.1023113 short tons. [2] One gram per tonne (g/t) = 0.02916668 troy ounces per short ton. [3] The Lindsley deposit also contains gold, silver, platinum, palladium and cobalt.
[4] The Marathon deposit also contains platinum, palladium and rhodium. [5] The Chu Chua deposit also contains cobalt, talc and magnetite. [6] The Windy Craggy deposit also contains cobalt.

Canadian Mineral Exploration

Ginette Bouchard and Donald Cranstone

The authors are with the Mineral Policy Sector, EMR Canada. Telephone: (613) 992-4665 and (613) 992-4666, respectively.

THE FEDERAL-PROVINCIAL EXPLORATION SURVEY

The year 1990 is the second year for which Energy, Mines and Resources Canada (EMR) has coordinated the collection of all statistics for expenditures on general exploration, while Statistics Canada has coordinated the collection of statistics for on-property (mine-site) exploration, which that agency needs for the preparation of Canada's National Accounts. Both federal agencies cooperate with the provinces in assembling and publishing the comprehensive national exploration statistics presented in this chapter.

ACTIVITY

Exploration Expenditures - 1990

In 1990, Canadian exploration expenditures, exclusive of those incurred in the search for oil and gas, totalled $775 million, down from the $828 million spent in 1989. Senior companies spent $534 million of the $775 million, and junior companies spent $241 million. A total of $662 million was spent on general exploration. The remaining $113 million was directed to on-property (mine-site) exploration, defined as the search for new mines on the properties of existing mines.

Flow-Through Shares as a Source of Financing

In 1990, funds raised through the issue of flow-through shares (Table 1) financed about 32% of Canadian exploration expenditures. In 1991 the funds financed an estimated 7% of such outlays. EMR estimates that companies listed on Canadian stock exchanges sold $250 million of flow-through shares in 1990 but only about $40 million in 1991.

Claim Staking

In 1991, the 5 398 340 hectares (ha) of claims staked in Canada (Table 2, Figure 1b), was up by 8% from the area staked in 1990 and was the largest since 1988. The increase was chiefly the result of a major increase in staking in the Northwest Territories, where the area of 2 213 337 ha staked was six times the area staked in 1990. This reflects a major interest in diamond exploration. Relative to 1990, staking was up by 48% in Saskatchewan and also up slightly in New Brunswick, Quebec and Manitoba. Staking in Alberta, which had amounted to 808 000 ha in 1990 (largely because of diamond exploration), dropped to only 4400 ha in 1991. Staking was down significantly (by 22%-34%, depending on the province) in Newfoundland, Nova Scotia, British Columbia, Ontario and the Yukon.

Exploration Drilling

In 1990, 3 191 936 metres (m) of surface exploration drilling (Table 3, Figure 1c) were drilled in Canada, about the same as the 3 165 438 m drilled in 1989. Diamond drilling (2 953 626 m) constituted 93% of this amount. In 1990, spending on diamond drilling accounted for 45% of Canadian field exploration expenditures and for 38% of total exploration expenditures. Underground exploration drilling (diamond drilling plus other drilling) totalled 751 600 m, an amount significantly lower than the 1 071 156 m of underground exploration drilling in 1989.

Exploration Expenditures by Province and Territory - 1990

The most active exploration areas in 1990 (Tables 7 and 14, Figure 2) were British Columbia ($226.5 million), Quebec ($196.4 million), and Ontario ($152.6 million). Although total exploration expenditures in British Columbia exceeded those in Quebec by $30 million, field exploration expenditures in British Columbia were only $2 million higher than those in Quebec.

In 1990, exploration expenditures (Table 3) were up somewhat in New Brunswick at $16.5 million, compared to $13.6 million in 1989; in Manitoba at $41.2 million ($37.0 million in 1989); and in the Yukon at $18.4 million ($15.1 million in 1989). The figure for exploration expenditures in Alberta, $10.7 million ($6.3 million in 1989), was the highest since 1985. The difference in Alberta resulted from a considerable part of 1990 expenditures being directed towards the search for diamonds, whereas exploration prior to 1989 had been directed overwhelmingly at coal.

In 1990, exploration expenditures were down significantly in Newfoundland ($23.3 million compared to $36.2 million in 1989), in Nova Scotia ($11.0 million compared to $21.4 million in 1989), in Saskatchewan ($42.2 million compared to $63.3 million in 1989), and in the Northwest Territories ($36.0 million compared to $45.7 million in 1989).

Expenditures by Commodity Sought - 1990

Precious metals and base metals were the main exploration targets in 1990 (Tables 4 and 5, Figure 3). Some $457 million (59%) of exploration expenditures was directed to precious metals, chiefly gold; exploration expenditures for platinum group metals amounted to $5.3 million, down from $8.3 million in 1989 and an estimated $19.5 million in 1988. The $236.3 million in expenditures for base metals accounted for 31% of Canadian exploration expenditures in 1990.

Exploration expenditures on precious metals were down by 17% from the amount spent in 1989. They were up by 28% for base metals and 7% for coal, but were down by 28% for uranium. More than $8 million was spent on exploration for diamonds in 1990, an increase from the $5.1 million spent in 1989.

Regional Expenditures by Commodity Sought - 1990

Precious metals (almost entirely gold) were the principal exploration target in most provinces and territories (Table 9, Figure 4). In New Brunswick and Manitoba, base metals were the principal metals sought, while in Saskatchewan the search continued to be mainly directed at uranium. In Alberta, coal was the principal target.

Regional Expenditures by Type of Company - 1990

As in 1989, producing companies and their affiliates dominated exploration spending in all provinces and territories except Nova Scotia and British Columbia (Table 13, Figure 5). Junior companies accounted for 74% of exploration spending in Nova Scotia and for 45% in British Columbia, where they slightly exceeded the spending by producers and affiliates. In Quebec, for the second consecutive year, producers and their affiliates spent close to twice the amount spent by juniors. This is in contrast to the years between 1985 and 1988 when junior companies were the dominant exploration spenders in Quebec.

Expenditures by Type of Company and Commodity - 1990

Junior companies (Table 10, Figure 6) directed 77% of their exploration expenditures at gold and 17% at base metals in 1990 (up from 11% in 1989). Producing companies and their affiliates directed 51% of their exploration spending at precious metals in 1990 (down from 60% in 1989) and 40% at base metals (up from 30% in 1989).

In 1990, foreign companies directed 41% of their exploration expenditures at precious metals, 31% at uranium, 16% at base metals, and 13% at nonmetallic minerals.

Type of Company Engaged in Exploration - 1990

Table 6 gives 1990 exploration expenditures and percentages of Canadian exploration expenditures according to company type.

The proportion of total exploration expenditures accounted for by junior companies rose during the 1980s, especially after changes to the income tax regulations for flow-through shares in 1983. Expenditures by junior companies began to decline in 1988 (Figure 7), a decline that continued in 1990 and 1991.

Oil companies, which in the 1970s accounted for more than one quarter (28% in 1977) of total exploration expenditures on the search for non-petroleum minerals, provided only slightly more than 1% of Canadian exploration expenditures for such minerals in 1990, down from 3% in 1989.

Exploration Expenditures, Preliminary 1991 and Intentions 1992

This year, the results of the Preliminary 1991/Intentions 1992 exploration survey, together with 1990 "final" totals by province/territory and type of company, appear in Tables 14 and 6. The "final" figures for 1990 are included for comparison purposes. The results of this survey suggest that exploration expenditures, which totalled $774.7 million in 1990, declined to about $600 million in 1991 and are expected to further decline to some $500 million in 1992.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. FUNDS RAISED BY COMPANIES LISTED ON CANADIAN STOCK EXCHANGES THROUGH THE ISSUE OF FLOW-THROUGH SHARES, 1983-91

Year	Value of Funds Raised	
	(current $ millions)	(1991 $ millions)
1983	34	45
1984	139	177
1985	275	342
1986	673	818
1987	1 183	1 372
1988	850	941
1989	350	370
1990	250[e]	257[e]
1991	40[e]	40[e]

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada, from Montreal, Toronto and Vancouver Stock Exchange records.
[e] Estimated.

TABLE 2. AREA[1] OF NEW MINERAL CLAIMS STAKED IN CANADA, 1985-91

	1985		1986		1987		1988		1989		1990		1991	
	(hectares)	(%)	(hectares)	(%)	(hectares)	(%)	(hectares)	(%)	(hectares)	(%)	(hectares)	(%)	(hectares)	(%)
Newfoundland	262 653	5.9	258 605	4.3	376 362	5.4	419 184	6.7	275 040	5.4	163 568	3.3	127 748	2.4
Nova Scotia	449 907	10.1	577 260	9.6	624 508	8.9	423 019	6.7	174 456	3.4	176 609	3.5	126 833	2.3
New Brunswick	81 860	1.8	44 872	1.0	72 748	1.0	110 976	1.8	139 776	2.8	69 776	1.4	73 136	1.4
Quebec	641 995	14.5	1 165 262	19.4	890 977	12.7	537 217	8.6	823 452	16.3	483 289	9.7	494 210	9.2
Ontario	464 431	10.5	983 386	16.4	949 231	13.5	598 632	9.6	390 619	7.7	419 259	8.4	317 568	5.9
Manitoba	136 736	3.1	301 974	5.0	212 139	3.0	162 264	2.6	209 483	4.1	127 342	2.5	127 935	2.4
Saskatchewan	630 972	14.2	467 051	7.8	700 459	10.0	741 944	11.8	418 832	8.3	184 939	3.7	274 242	5.1
Alberta	1 472	0.03	48 664	0.8	9 408	0.1	20 757	0.3	50 240	1.0	807 910	16.2	4 400	0.1
British Columbia	1 326 525	29.9	1 613 775	26.9	2 269 925	32.4	2 212 125[a]	35.3	1 946 000[a]	38.4	2 014 250	40.3	1 510 850[b]	28.0
Yukon	147 406	3.3	176 962	2.9	357 576	5.1	301 713	4.8	178 683	3.5	195 202	3.9	128 081	2.4
Northwest Territories	294 887	6.6	360 361	6.0	552 385	7.9	739 928	11.8	456 987	9.0	355 346	7.1	2 213 337	41.0
Total	4 438 844	100.0	5 998 172	100.0	7 015 718	100.0	6 267 755	100.0	5 063 568	100.0	4 997 490	100.0	5 398 340	100.0

[a] Excludes placer leases. [b] Not strictly comparable to 1990 and earlier years because the 1991 total is the area of claims recorded in 1991 not the area of claims staked during 1991.
[1] Excludes coal.
Note: Numbers may not add to totals due to rounding.

TABLE 3. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, 1989-90, AND DRILLING ACTIVITIES BY PROVINCE AND TERRITORY, 1990

Province/Territory	1990 Field Expenditures	1990 Overhead[2] Expenditures	1990 Total Expenditures	1989 Total Expenditures	1990 as % of 1989 Total Expenditures	1990 Surface Drilling Diamond Drilling	1990 Surface Drilling Other Drilling	1990 Surface Drilling Total
	($ millions)				(%)	(metres)		
Newfoundland	19.2	4.0	23.3	36.2	64.1	82 048	279	82 327
Nova Scotia	8.2	2.8	11.0	21.4	51.4	18 053	400	18 453
New Brunswick	14.1	2.4	16.5	13.6	121.3	94 447	1 665	96 112
Quebec	185.0	11.4	196.4	185.0	106.2	928 665	10 162	938 827
Ontario	122.8	29.8	152.6	217.8	70.0	636 276	12 998	649 274
Manitoba	36.6	4.5	41.2	37.0	111.4	150 653	12 012	162 665
Saskatchewan	34.5	7.8	42.2	63.3	66.7	112 680	12 962	125 642
Alberta	7.1	3.5	10.7	6.3	169.8	4 375	128 787	133 162
British Columbia	187.2	39.3	226.5	186.6	121.4	715 149	42 086	757 235
Northwest Territories	31.5	4.5	36.0	45.7	78.8	183 690	–	183 690
Yukon Territory	13.9	4.5	18.4	15.1	121.9	27 590	16 959	44 549
Total	660.3	114.4	774.7	827.9	93.6	2 953 626	238 310	3 191 936

Source: Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 4. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, INCLUDING OVERHEAD,[2] BY COMMODITY SOUGHT, 1990

Commodity Groups	Expenditures	Percentage of Canadian Total	1990 as % of 1989 Expenditures
	($ millions)	(%)	(%)
Base metals (Cu, Ni, Pb, Zn)	236.3	30.5	128.2
Precious metals (Ag, Au, Pt group)	456.7	59.0	82.7
Iron ore	0.4	0.1	66.7
Uranium	24.1	3.1	71.7
Other metals	9.1	1.2	108.3
Nonmetals	23.8	3.0	87.2
Coal	11.9	1.5	107.2
Unspecified commodities	12.5	1.6	119.1
Total	774.7	100.0	

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
1 Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. 2 Overhead expenditures include land costs, field administration costs and exploration-related head office expenses (from data in Table 9b).
Note: Numbers may not add to totals due to rounding.

TABLE 5. PERCENTAGE OF GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES DIRECTED AT THE SEARCH FOR BASE METALS AND PRECIOUS METALS, 1975-90

Year	Base Metals[2]	Precious Metals[3]
	(percent)[4]	
1975	63	7
1977	42	7
1979	35	12
1981	34	25
1983	42	29
1985	20	65
1986	14	76
1987	11	83
1988	13	82
1989	23	67
1990	31	60

Sources: 1975-83 compiled by Energy, Mines and Resources Canada (EMR) from individual company responses to Statistics Canada exploration questionnaires; 1985-90 compiled by EMR from the Survey of Federal-Provincial Mining and Exploration Companies.
1 Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. 2 Nickel, copper, zinc and lead. 3 Gold, silver and platinum group metals. In recent years, gold exploration has accounted for 95% of exploration expenditures on precious metals. 4 Includes a portion of expenditures from unspecified commodities.

TABLE 6. GENERAL EXPLORATION PLUS MINESITE EXPLORATION,[1] INCLUDING OVERHEAD,[2] BY TYPE OF COMPANY, 1989-92

Type of Company	1989 Exploration Expenditures		1990 Exploration Expenditures		1991pe Exploration Expenditures		1992f Exploration Expenditures	
	($ millions)	(% of Canadian total)	($ millions)	(% of Canadian total)	($ millions)	(% of Canadian total)	($ millions)	(% of Canadian total)
1. Producing companies (those with a producing mine in Canada and their affiliates)	462.4	55.9	459.7	59.3	399.9	67.1	294.1	59.7
2. Oil companies (excluding group 1 above)	23.9	2.9	8.7	1.1	13.5	2.3	10.3	2.1
3. Foreign companies (excluding groups 1 and 2 above)	46.9	5.7	43.3	5.6	40.7	6.9	49.3	10.1
4. Junior companies and prospectors	272.6	32.9	241.0	31.1	127.5	21.4	130.8	25.5
5. Other companies	22.3	2.7	22.0	2.8	13.3	2.3	13.0	2.7
Total	827.9	100	774.7	100	594.9	100	497.5	100

Sources: Energy, Mines and Resources Canada (EMR) and Statistics Canada, from Federal-Provincial Survey of Mining and Exploration Companies.
pe Preliminary estimate 1991 (survey carried out December 1991 through March 1992); f Forecast 1992 (survey carried out December 1991 through March 1992).
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding. Statistics Canada totals for minesite exploration have been revised by EMR.

TABLE 7. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] ACTIVITIES BY PROVINCE AND TERRITORY, BY TYPE OF WORK, 1990

Province/Territory	Drilling (Surface and Underground) Diamond Metres	Diamond Cost	Other Metres	Other Cost	Surveys - Other Exploration Work Geochemical	Geology	Geophysical Ground	Geophysical Airborne	Rock Work	Other Field Costs	Total Field Expenditures	Total, Including Overhead[2]
	(000)	($000)	(000)	($000)	($000)							
Newfoundland	83	6 882	–	11	2 230	5 070	1 598	320	1 062	2 061	19 234	23 275
Nova Scotia	23	1 863	–	12	275	1 133	513	35	3 512	896	8 240	11 025
New Brunswick	97	6 721	2	12	1 054	2 689	1 346	152	517	1 636	14 128	16 506
Quebec	1 208	74 825	11	1 187	5 646	20 730	11 094	1 351	23 657	46 471	184 961	196 356
Ontario	815	61 984	13	974	5 077	20 161	7 617	952	11 367	14 697	122 829	152 603
Manitoba	201	18 969	12	659	754	3 047	3 453	1 127	6 717	1 916	36 642	41 167
Saskatchewan	143	12 528	13	3 848	1 612	3 839	2 973	421	1 077	8 166	34 466	42 218
Alberta	4	374	129	3 009	147	971	232	792	76	1 533	7 134	10 667
British Columbia	911	76 315	44	1 914	10 290	28 683	7 685	3 435	24 990	33 935	187 247	226 534
Northwest Territories	187	17 406	–	–	631	6 326	1 786	210	305	4 827	31 491	35 994
Yukon Territory	30	4 115	17	948	574	1 578	1 040	134	4 134	1 388	13 912	18 374
Total Canada	3 702	281 982	241	12 575	28 291	94 227	39 339	8 928	77 414	117 527	660 284	774 719

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 8. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] ACTIVITIES BY TYPE OF COMPANY, 1990

Type of Company	Drilling (Surface and Underground)				Surveys - Other Exploration Work						Total Field Expenditures	Total, Including Overhead[2]
	Diamond		Other				Geophysical					
	Metres	Cost	Metres	Cost	Geochemical	Geology	Ground	Airborne	Rock Work	Other Field Costs		
	(000)	($000)	(000)	($000)	($000)							
1. Companies with a producing mine in Canada	2 106	145 575	173	8 953	8 488	35 939	15 425	2 173	34 743	55 446	306 742	348 220
2. Affiliates of group 1	519	41 502	49	2 873	6 001	16 876	7 148	2 346	4 858	9 607	91 209	111 493
3. Oil companies	18	1 464	1	16	174	1 411	602	198	279	2 284	6 428	8 673
4. Foreign companies (excluding group 3)	142	10 930	–	9	1 583	6 860	2 466	802	812	7 157	30 620	43 344
5. Junior companies and prospectors	825	73 625	17	725	11 700	29 688	11 245	2 917	35 974	39 850	205 724	241 021
6. Other companies	92	8 887	–	–	345	3 454	2 453	492	748	3 183	19 562	21 968

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 9a. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, NOT INCLUDING OVERHEAD,[2] BY PROVINCE AND TERRITORY, BY COMMODITY SOUGHT, 1990

Province/Territory	Metals					Nonmetals	Coal	Commodity Not Specified	Total Field Expenditures
	Base	Precious	Iron	Uranium	Other				
					($000)				
Newfoundland	8 066	9 196	5	–	544	1 424	–	–	19 234
Nova Scotia	1 195	6 023	42	–	167	472	291	49	8 240
New Brunswick	8 192	5 031	–	–	63	119	399	324	14 128
Quebec	66 981	107 089	39	–	6 077	4 775	–	–	184 961
Ontario	39 297	79 261	–	–	18	2 229	–	2 024	122 829
Manitoba	26 712	8 910	–	–	427	193	–	400	36 642
Saskatchewan	3 836	10 241	–	14 752	–	4 873	347	417	34 466
Alberta	45	84	–	630	–	1 359	4 929	87	7 134
British Columbia	48 257	128 115	7	–	1 260	1 775	2 192	5 640	187 247
Northwest Territories	4 057	23 333	–	2 597	107	804	–	594	31 491
Yukon Territory	5 570	7 672	–	–	22	–	–	647	13 912
Total Canada	212 207	384 955	93	17 978	8 685	18 024	8 159	10 182	660 284

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 9b. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, INCLUDING OVERHEAD,[2] BY PROVINCE AND TERRITORY, BY COMMODITY SOUGHT, 1990

Province/Territory	Metals					Nonmetals	Coal	Commodity Not Specified	Total, Including Overhead
	Base	Precious	Iron	Uranium	Other				
	($000)								
Newfoundland	9 157	11 722	5	52	602	1 734	–	2	23 275
Nova Scotia	1 531	8 333	58	–	211	516	305	71	11 025
New Brunswick	9 502	5 911	–	–	77	183	430	402	16 506
Quebec	69 897	114 266	39	–	6 161	5 994	–	–	196 356
Ontario	43 978	100 890	230	1	31	4 512	–	2 960	152 603
Manitoba	29 185	10 505	–	–	454	312	–	711	41 167
Saskatchewan	4 257	11 683	–	19 491	–	5 498	650	640	42 218
Alberta	45	100	–	964	–	2 062	7 377	119	10 667
British Columbia	57 348	156 431	11	–	1 394	2 047	3 186	6 117	226 534
Northwest Territories	4 145	26 558	12	3 569	119	879	–	714	35 994
Yukon Territory	7 242	10 345	–	–	34	35	–	718	18 374
Total Canada	236 288	456 744	354	24 076	9 083	23 772	11 948	12 454	774 719

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
1 Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. 2 Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 10a. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, NOT INCLUDING OVERHEAD,[2] BY TYPE OF COMPANY AND BY COMMODITY SOUGHT, 1990

Type of Company	Metals: Base	Metals: Precious	Metals: Iron	Metals: Uranium	Metals: Other	Nonmetals	Coal	Commodity Not Specified	Total Field Expenditures
					($000)				
1. Companies with a producing mine in Canada	134 367	138 464	–	7 016	2 694	8 343	7 513	8 345	306 742
2. Affiliates of group 1	30 466	59 258	–	465	331	13	406	271	91 209
3. Oil companies	688	4 676	–	–	448	616	–	–	6 428
4. Foreign companies (excluding group 3)	5 085	13 332	–	9 519	10	2 670	–	5	30 620
5. Junior companies and prospectors	36 275	155 855	93	979	5 201	5 520	241	1 561	205 724
6. Other companies	5 327	13 371	–	–	1	863	–	–	19 562

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production.
[2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 10b. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, INCLUDING OVERHEAD,[2] BY TYPE OF COMPANY AND BY COMMODITY SOUGHT, 1990

Type of Company	Metals: Base	Metals: Precious	Metals: Iron	Metals: Uranium	Metals: Other	Nonmetals	Coal	Commodity Not Specified	Total, Including Overhead
					($000)				
1. Companies with a producing mine in Canada	147 614	158 587	226	9 058	2 739	9 814	10 172	10 010	348 220
2. Affiliates of group 1	34 610	74 756	3	601	384	170	648	321	111 493
3. Oil companies	828	5 942	–	–	448	645	777	32	8 673
4. Foreign companies (excluding group 3)	6 880	17 670	12	13 270	21	5 487	–	6	43 344
5. Junior companies and prospectors	40 499	184 678	113	1 148	5 481	6 776	319	2 007	241 021
6. Other companies	5 857	15 112	–	–	9	880	32	78	21 968

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production.
[2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 11. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] OF SURFACE AND UNDERGROUND DRILLING, BY PROVINCE AND TERRITORY, BY COMMODITY SOUGHT, 1990

Province/Territory	Metals					Nonmetals	Coal	Total
	Base	Precious	Iron	Uranium	Other			
	(000 metres)							
Newfoundland	39	40	–	–	1	3	–	83
Nova Scotia	6	9	–	–	1	7	–	23
New Brunswick	52	25	–	–	–	2	20	99
Quebec	434	725	–	–	26	34	–	1 219
Ontario	258	568	–	–	–	3	–	828
Manitoba	151	60	–	–	2	1	–	213
Saskatchewan	17	55	–	70	–	11	2	156
Alberta	–	–	–	4	–	1	129	133
British Columbia	316	589	–	–	10	4	35	955
Northwest Territories	30	149	–	7	–	1	–	187
Yukon Territory	16	31	–	–	–	–	–	47
Total Canada	1 318	2 250	–	81	41	66	186	3 944

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production.
Note: Numbers may not add to totals due to rounding.

TABLE 12. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] OF SURFACE AND UNDERGROUND DRILLING BY TYPE OF COMPANY AND BY COMMODITY SOUGHT, 1990

Type of Company	Metals					Nonmetals	Coal	Total
	Base	Precious	Iron	Uranium	Other			
	(000 metres)							
1. Companies with a producing mine in Canada	892	1 124	–	44	16	34	168	2 279
2. Affiliates of group 1	181	369	–	1	–	–	17	568
3. Oil companies	2	15	–	–	2	1	–	19
4. Foreign companies (excluding group 3)	47	64	–	31	–	1	–	142
5. Junior companies and prospectors	176	613	–	4	23	24	1	842
6. Other companies	21	65	–	–	–	6	–	92

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production.
Note: Numbers may not add to totals due to rounding.

TABLE 13a. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, NOT INCLUDING OVERHEAD,[2] BY PROVINCE AND TERRITORY, BY TYPE OF COMPANY, 1990

Province/Territory	(1) Companies With a Producing Mine in Canada	(2) Affiliates of (1)	(3) Oil Companies	(4) Foreign Companies Excluding (3)	(5) Junior Companies and Prospectors	(6) Other Companies	Total Field Expenditures
				($000)			
Newfoundland	5 587	8 468	107	181	4 884	8	19 234
Nova Scotia	1 398	1 077	4	–	5 735	26	8 240
New Brunswick	4 673	6 439	–	–	2 873	142	14 128
Quebec	86 870	16 564	2 040	5 836	64 275	9 376	184 961
Ontario	68 596	31 488	556	5 429	15 795	965	122 829
Manitoba	22 456	11 046	–	134	3 007	–	36 642
Saskatchewan	21 472	1 740	88	7 695	3 471	–	34 466
Alberta	5 274	574	–	1 211	75	–	7 134
British Columbia	66 772	9 139	2 732	6 020	99 089	3 495	187 247
Northwest Territories	16 069	2 383	699	3 517	3 317	5 506	31 491
Yukon Territory	7 576	2 291	203	597	3 202	43	13 912
Total Canada	306 742	91 209	6 428	30 620	205 724	19 562	660 284

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

TABLE 13b. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, INCLUDING OVERHEAD,[2] BY PROVINCE AND TERRITORY, BY TYPE OF COMPANY, 1990

Province/Territory	(1) Companies With a Producing Mine in Canada	(2) Affiliates of (1)	(3) Oil Companies	(4) Foreign Companies Excluding (3)	(5) Junior Companies and Prospectors	(6) Other Companies	Total, Including Overhead
				($000)			
Newfoundland	6 644	9 957	200	210	6 254	8	23 275
Nova Scotia	1 589	1 796	4	–	7 607	29	11 025
New Brunswick	4 974	7 647	–	–	3 497	388	16 506
Quebec	90 904	17 828	2 745	7 471	68 018	9 391	196 356
Ontario	79 823	41 809	628	8 751	20 433	1 158	152 603
Manitoba	25 280	12 249	–	238	3 400	–	41 167
Saskatchewan	25 252	2 163	113	11 021	3 670	–	42 218
Alberta	7 752	834	60	1 881	139	–	10 667
British Columbia	78 888	11 369	3 859	7 943	120 266	4 210	226 534
Northwest Territories	17 278	2 726	789	4 582	3 905	6 714	35 994
Yukon Territory	9 836	3 116	275	1 247	3 831	70	18 374
Total Canada	348 220	111 493	8 673	43 344	241 021	21 968	774 719

Source: Energy, Mines and Resources Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
– Nil.
[1] Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. [2] Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

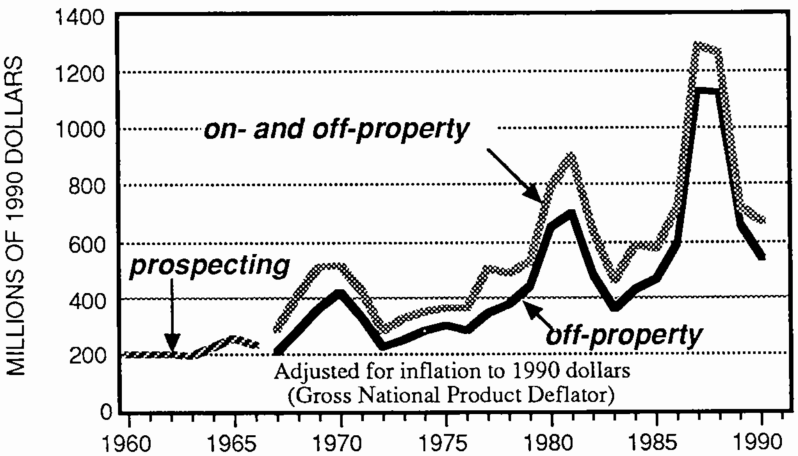
TABLE 14. GENERAL EXPLORATION PLUS MINESITE EXPLORATION[1] EXPENDITURES, INCLUDING OVERHEAD,[2] BY PROVINCE AND TERRITORY, 1989-92

Province/Territory	1989 ($ millions)	1989 (%)	1990 ($ millions)	1990 (%)	1991pe ($ millions)	1991pe (%)	1992f ($ millions)	1992f (%)
Newfoundland	36.2	4.4	23.2	3.0	12.2	2.0	11.1	2.3
Nova Scotia	21.4	2.6	11.0	1.4	4.7	0.8	2.4	0.5
New Brunswick	13.6	1.6	16.5	2.1	18.9	3.2	17.0	3.5
Quebec	185.0	22.3	196.4	25.4	156.2	26.5	123.3	25.2
Ontario	217.8	26.3	152.6	19.7	107.6	18.3	98.0	18.9
Manitoba	37.0	4.5	41.2	5.3	30.9	5.2	26.2	5.4
Saskatchewan	63.3	7.6	42.2	5.4	50.0	8.5	53.5	10.9
Alberta	6.3	0.8	10.7	1.4	6.8	1.1	6.0	1.2
British Columbia	186.6	22.5	226.5	29.2	158.5	25.9	113.2	22.5
Northwest Territories	45.7	5.5	36.0	4.6	33.7	5.7	36.0	7.4
Yukon Territory	15.0	1.8	18.4	2.4	15.3	2.6	10.8	2.2
Total	828.0	100	774.7	100	594.9	100	497.5	100
General exploration	712.6	86.1	662.3	85.5	514.5	86.3	426.3	85.4
Minesite exploration	115.4	14.0	112.4	14.5	80.4	13.7	71.2	14.6

Sources: Energy, Mines and Resources Canada and Statistics Canada, from the Federal-Provincial Survey of Mining and Exploration Companies.
f Forecast 1992 (survey carried out December 1991 through March 1992); pe Preliminary estimate 1991 (survey carried out December 1991 through March 1992).
1 Exploration activity includes only the search for new mines; it does not include exploration for extensions to deposits already being mined or committed to production. 2 Overhead expenditures include land costs, field administration costs and exploration-related head office expenses.
Note: Numbers may not add to totals due to rounding.

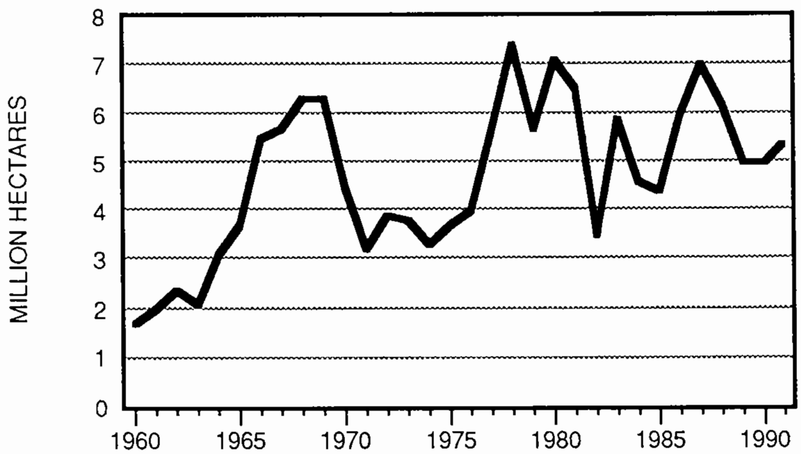
Figure 1

SELECTED MEASURES OF EXPLORATION ACTIVITY



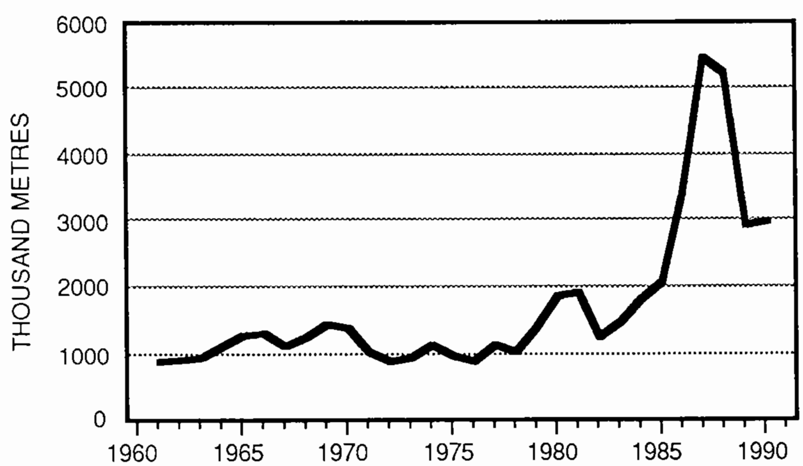
(a)
FIELD EXPENDITURES ON MINERAL EXPLORATION (All minerals except oil and gas)

Sources: 1960-66, Dominion Bureau of Statistics, General Review of the Mineral Industries, Mines, Quarries and Oil Wells (Catalogue 26-201), and Energy, Mines and Resources Canada; 1967-89, Statistics Canada, Exploration, Development and Capital Expenditures for Mining and Petroleum and Natural Gas Wells, Intentions (Catalogue 61-216, formerly Catalogue 61-007), and Federal-Provincial Survey of Mining and Exploration Companies.



(b)
AREA OF MINING CLAIMS AND CLAIM BLOCKS RECORDED

Sources: Gathered by Energy, Mines and Resources Canada from Provincial and Territorial Mining Recorders.



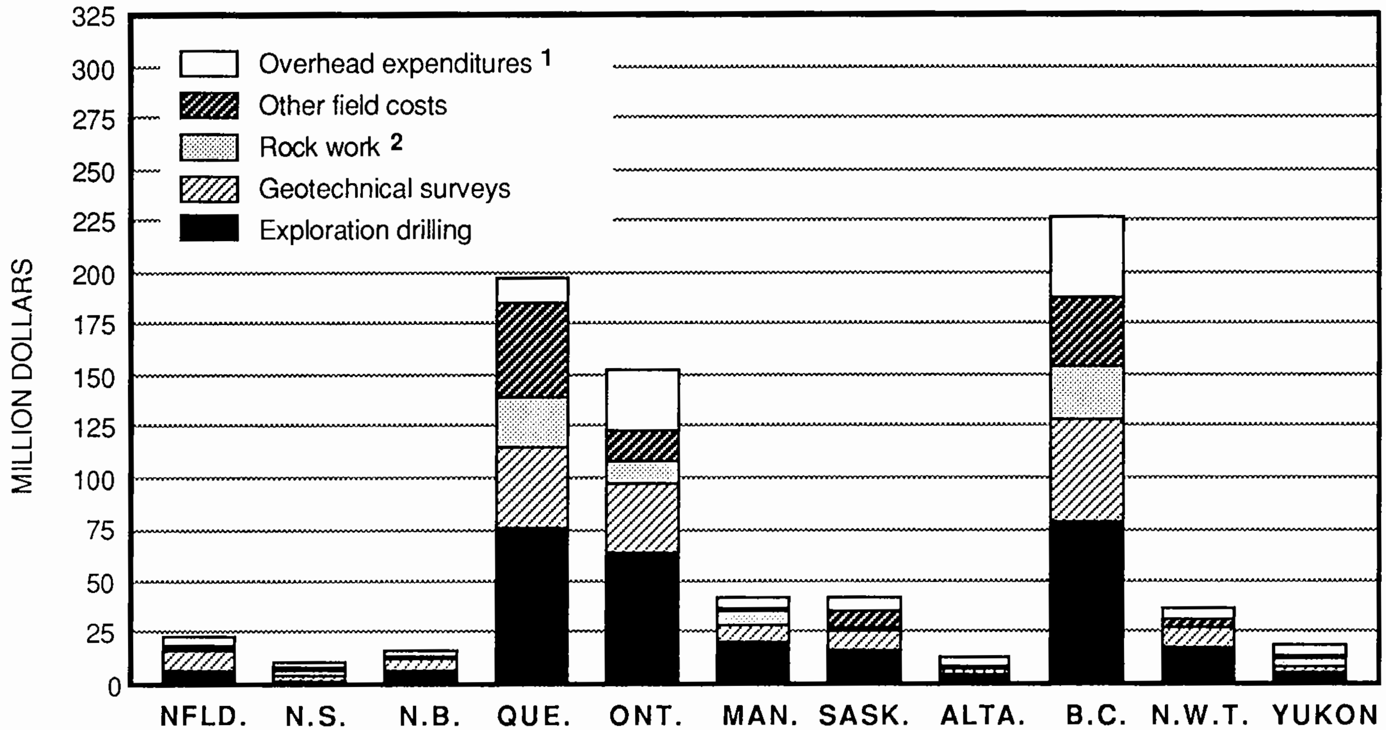
(c)
SURFACE DIAMOND DRILLING (All minerals except oil and gas)

Sources: Dominion Bureau of Statistics, General Review of the Mineral Industries, Mines, Quarries and Oil Wells (Catalogue 26-201), and Federal-Provincial Exploration Survey.

Figure 2

FIELD EXPLORATION EXPENDITURES BY PROVINCE AND TERRITORY, 1990

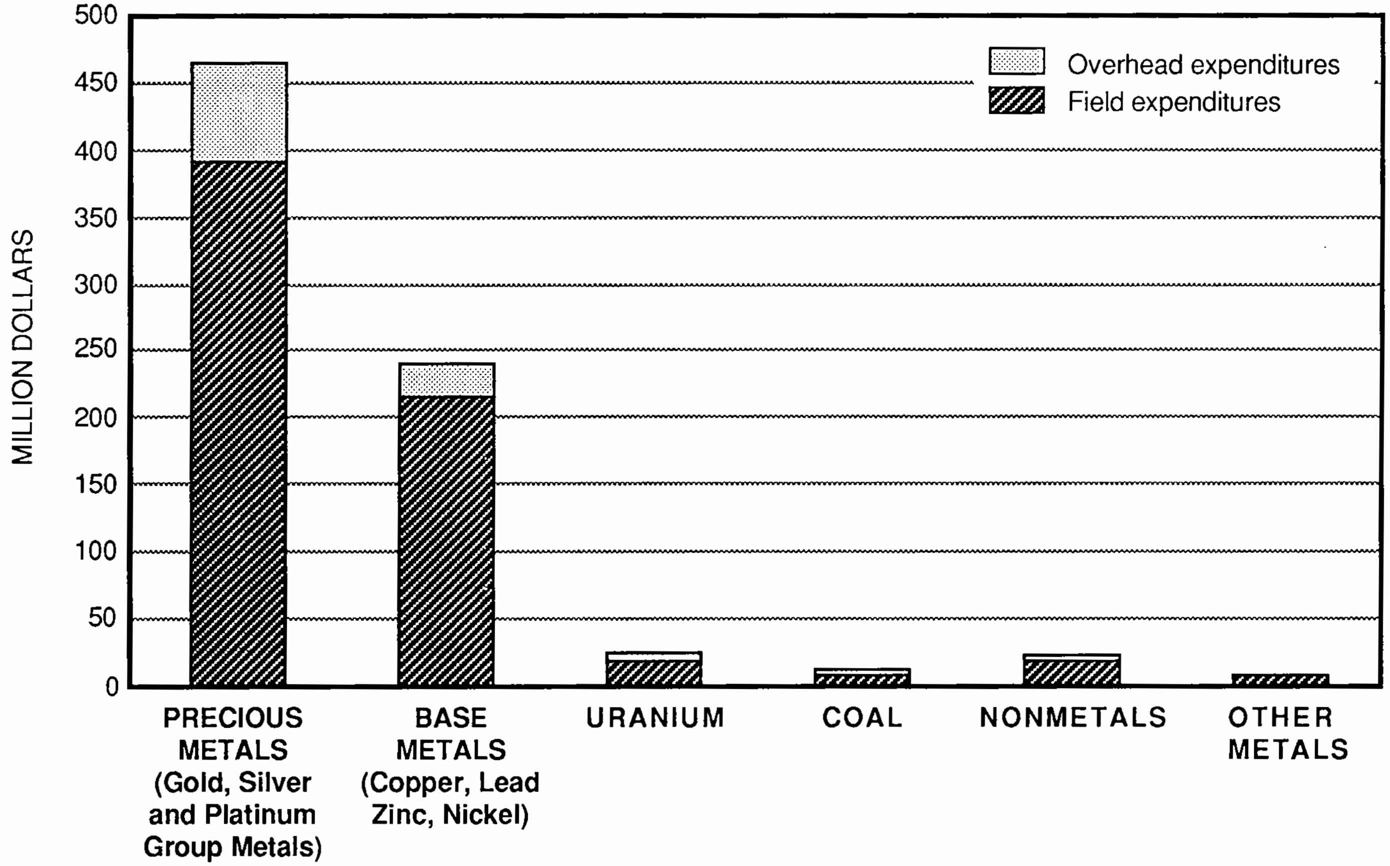
PHYSICAL WORK AND SURVEYS



1 Such as field supervision and line cutting.
2 Such as stripping, trenching, shaft-sinking and underground work.
Source: Federal-Provincial Survey of Mining and Exploration Companies.

Figure 3

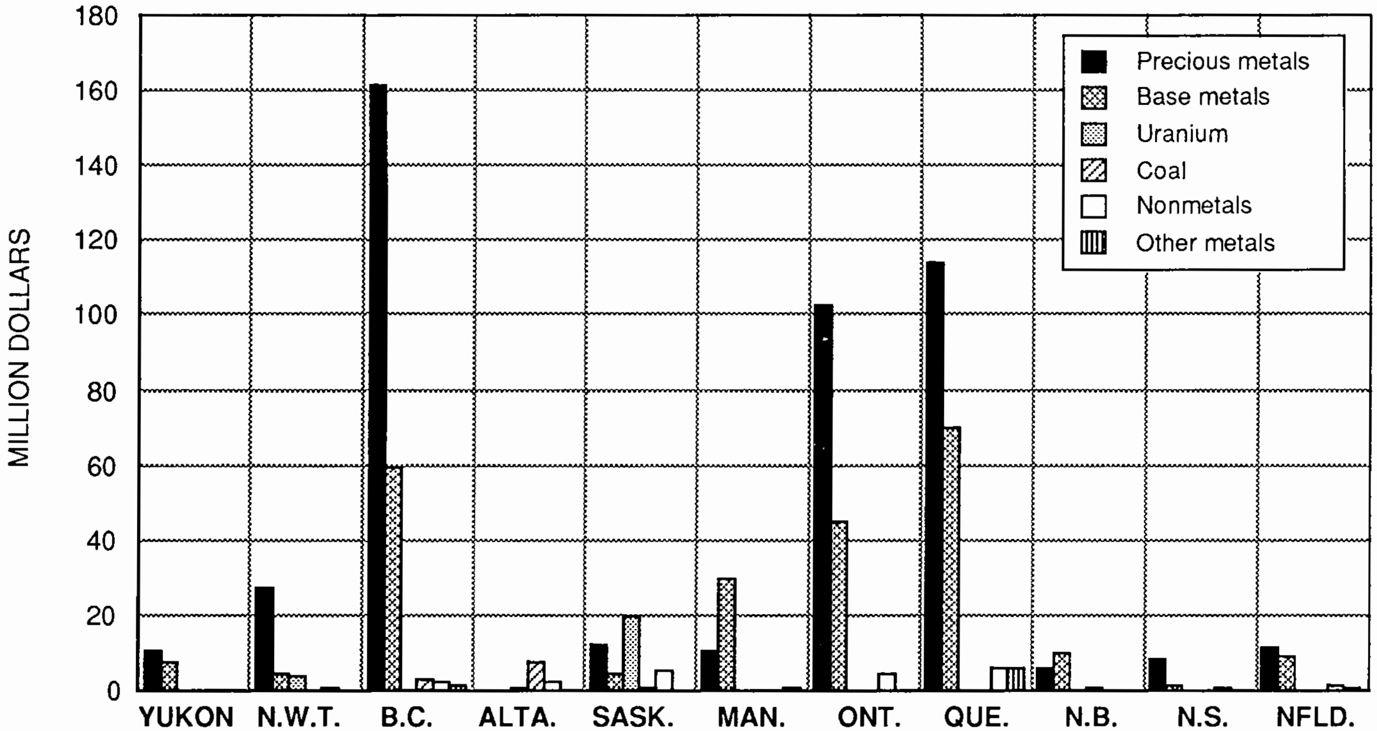
EXPLORATION EXPENDITURES BY COMMODITY SOUGHT, 1990[1]



1 Some $12.5 million of exploration expenditures were for unspecified commodities. This amount has been pro-rated among the six commodity groups shown here.
Source: Federal-Provincial Survey of Mining and Exploration Companies.

Figure 4

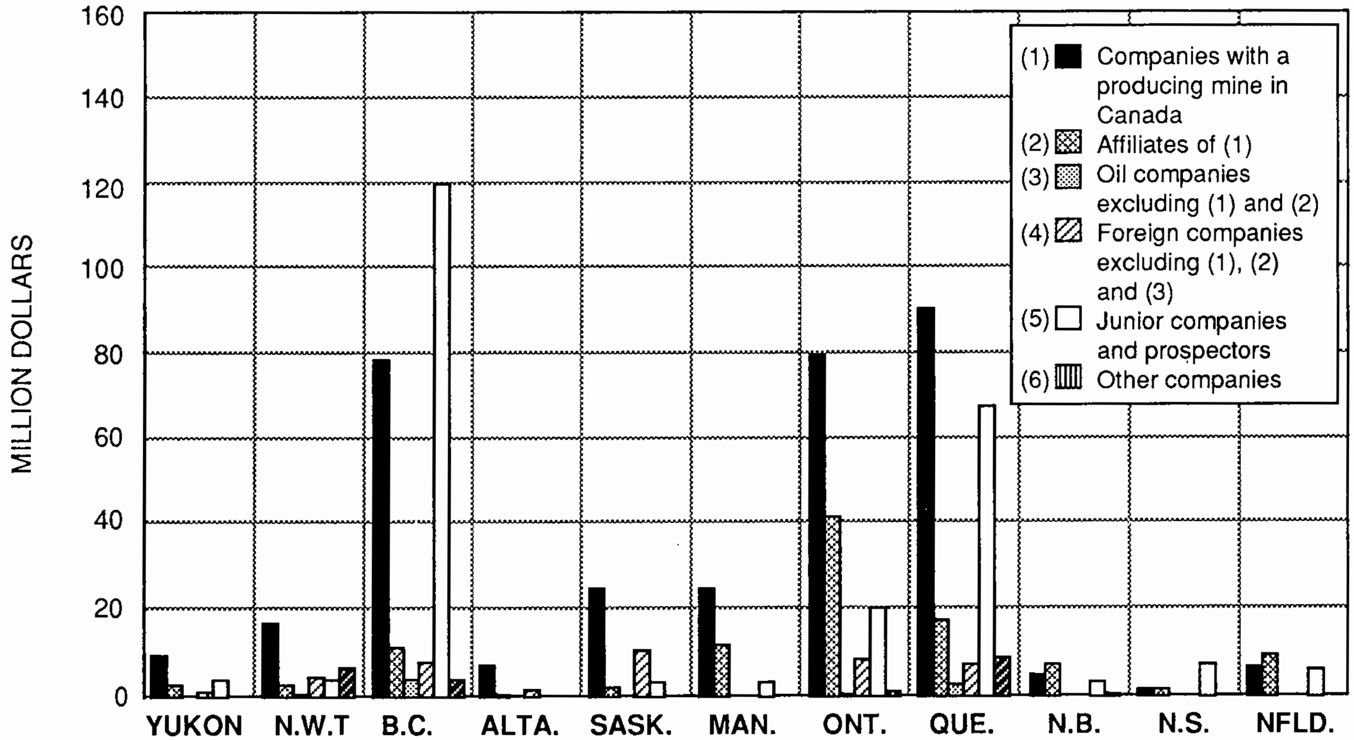
REGIONAL EXPLORATION EXPENDITURES BY COMMODITY SOUGHT, 1990[1]



1 Some $12.5 million of exploration expenditures were for unspecified commodities. This amount was pro-rated among the six commodity groups shown here.
Source: Federal-Provincial Survey of Mining and Exploration Companies.

Figure 5

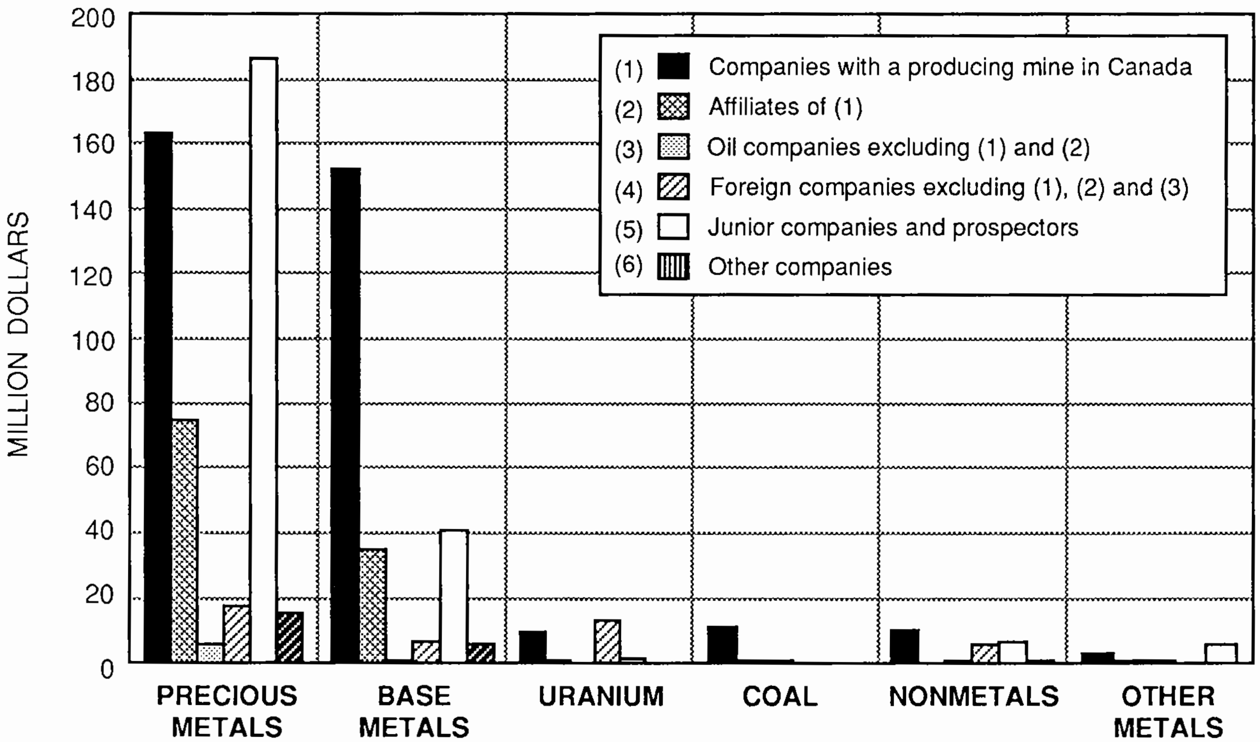
REGIONAL EXPLORATION EXPENDITURES BY TYPE OF COMPANY, 1990



Source: Federal-Provincial Survey of Mining and Exploration Companies.

Figure 6

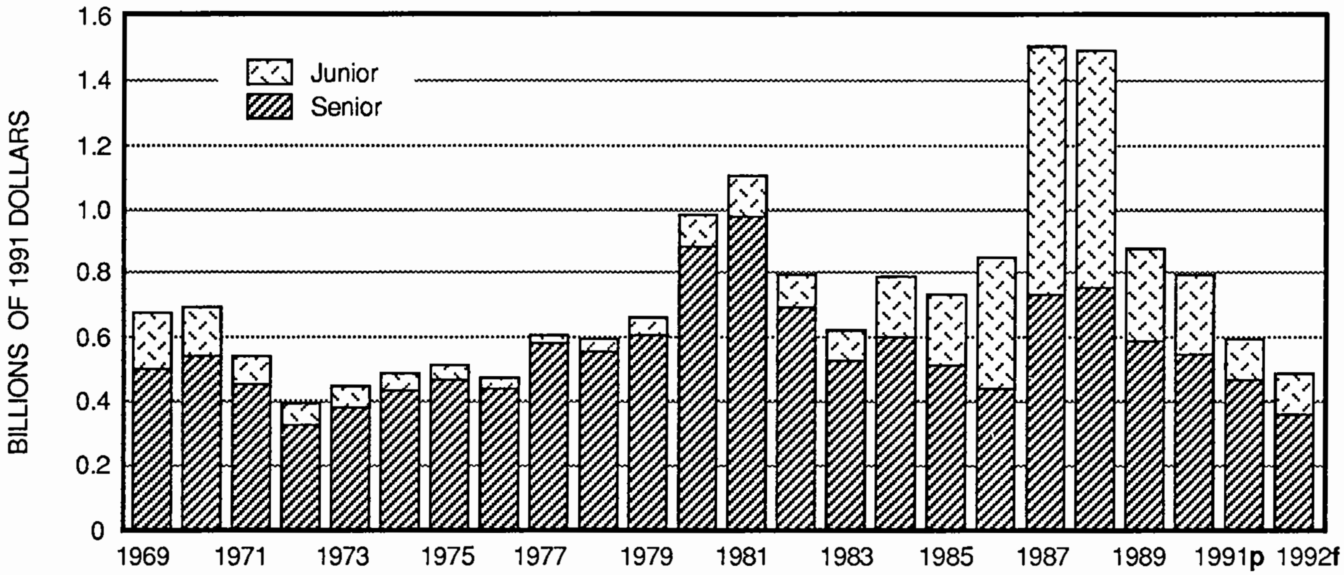
EXPLORATION EXPENDITURES BY TYPE OF COMPANY AND COMMODITY, 1990[1]



1 Some $12.5 million of exploration expenditures were for unspecified commodities. This amount was pro-rated among the six commodity groups shown here.
Source: Federal-Provincial Survey of Mining and Exploration Companies.

Figure 7

TOTAL EXPLORATION EXPENDITURES BY JUNIOR AND SENIOR COMPANIES 1969-92



The total exploration expenditures depicted here for 1975 to 1981 are overstated by an average of about 17% relative to earlier and later years because of different methodologies used by Statistics Canada for those years. Expenditures include overhead and were adjusted using the GDP Implicit Price Index.
f Forecast; **p** Preliminary.
Sources: Energy, Mines and Resources Canada; Statistics Canada.

Canadian Mine Openings, Re-Openings, Expansions, Suspensions and Closures

Lo-Sun Jen

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-0658

The year 1991 was turbulent for the Canadian mining industry. As Table 1 indicates, 18 mining operations came into production during the year, including 3 re-opened and 9 new gold mines, 1 re-opened and 4 new base-metal mines, and 1 new coal mine. In the same period, 33 mines suspended operations or closed, including 14 gold, 8 base-metal, 3 copper-gold, 1 silver-lead-zinc, 1 uranium, 2 asbestos, 3 sodium sulphate, and 1 natural graphite operation.

While the majority of the mine closures (including suspensions) occurred in Newfoundland, northwestern Quebec, northern Ontario, Saskatchewan and British Columbia, most new and re-opened mines opened in similar regions in Quebec, Ontario and British Columbia, thereby offsetting somewhat the impact of the closures in the affected regions.

Among the new mines that opened in 1991 are the Westray coal mine in Nova Scotia, the Lower Coleman nickel-copper mine in Ontario, the Snip and SB gold mines in British Columbia, and the Sa Dena Hes (formerly Mt. Hundere) zinc-lead-silver mine in the Yukon. Production resumed at the Francoeur gold mine in Quebec and the Goldstream copper-zinc mine in British Columbia was reactivated.

While 14 mines closed because of depletion of ore reserves, most 1991 closures appear to have resulted from economic problems caused by depressed metal prices and market conditions. This was especially the case for gold mines, which were affected by the lower gold prices that prevailed from the beginning of 1990; it was also the case for sodium sulphate operations, whose market conditions had been deteriorating for some time.

Overall, the number of mine openings (including re-openings) in 1991, as in 1990, was exceeded by the number of mine closures and suspensions. While new and re-opened Canadian mines added over 13 000 tonnes (t) of daily production capacity and 1300 jobs in 1991, mine suspensions and closures reduced this Canadian ore production capacity by 58 000 tonnes per day and eliminated some 3300 jobs, resulting in an overall net loss of 45 000 t of daily capacity and 2000 jobs, respectively.

Several expansions were carried out in 1991, including at the Kerr gold operation (formerly known as the Kerr Addison mine) in Ontario, and the Joe Mann and Bousquet No. 2 gold mines in Quebec. Despite lower demand for nickel, mine expansion continued at Inco Limited's Birchtree nickel mine in Manitoba. Because of depressed coal prices, the planned production increase at the Quinsam mine in British Columbia did not materialize in 1991, although Consolidated Brinco Limited still plans to double coal production to 500 000 t at that location in 1992.

OUTLOOK

Among the mine openings expected in 1992 are two important base-metal mines. Noranda Minerals Inc. plans to bring its E-29 copper deposit at Gaspé, Quebec, on stream in March. In addition, Curragh Resources Inc. is preparing its Grum, Yukon, zinc-lead deposit for possible production sometime during 1992; however, depressed zinc prices and the company's current financial problems may force it to postpone completion of this project. Falconbridge Gold Corporation, which closed its Kidd Creek gold mill in December, re-opened its newly acquired Bell Creek mill on January 13, 1992, to custom mill ore from its Hoyle Pond gold mine.

Planned mine closures in 1992 include: the East Kemptville mine (tin) near Yarmouth, Nova Scotia; the Mcleod mine (iron ore) at Wawa and the Denison mine (uranium) at Elliot Lake, both in Ontario; the Mobrun mine (zinc-copper-silver) near Rouyn-Noranda and the Lac Shortt mine (gold) near Desmaraisville, Quebec; the Spruce Point mine (copper-zinc) in the Snow Lake area of Manitoba; the Equity Silver mine (silver-copper) near Houston, the Bell Copper mine (copper) at Babine Lake, the Cassiar (McDame) mine (asbestos) near Cassiar, and the Samatosum mine (silver-copper-zinc-lead-gold) near Adams Lake, British Columbia; and the Faro open-pit and underground mines (zinc-lead) at Faro, Yukon.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. CANADIAN MINE OPENINGS, RE-OPENINGS, EXPANSIONS, SUSPENSIONS, AND CLOSURES IN 1991

Project	Location	Province	Capacity (tonnes/day)	Employment[1]	Status	Date	Mine Type	Main Commodities	Companies	Remarks[2]
NEW OPERATIONS										
Precious Metals										
Snip	Stewart	B.C.	300	140	New mine	January	UG	Gold, copper	Cominco Ltd. and Prime Resources Group Inc.	Gold production is expected to be about 90 000 oz annually. Snip is a "fly-in, fly-out" operation.
Norlartic	Val-d'Or	Que.	550	65	New mine	May	UG	Gold	Aur Resources Inc. and Nova-Cogesco Resources Inc.	Produced about 9700 oz of gold in 1991. Plans to produce 29 000 oz in 1992 and 26 000 oz in 1993. Ore is custom milled at AurBel (Ferderber) mill. The mine originally opened 30 years ago. The ore is now obtained from new ore zones.
SB	Stewart	B.C.	1 500	100	New mine	May 20	OP	Gold	Westmin Resources Limited and Tenajon Resources Corp.	Ore production from the 35 zone, a small orebody, began in May 1991. Custom milling began at the Premier Gold mine in July 1991. The mine closed in November of the same year (see closures below).
Golden Bear	Telegraph Creek	B.C.	315	83	New mine	July	OP	Gold	North American Metals Corp.	The underground mining operation was closed in March 1991 (see closures below).
Mouska	Rouyn-Noranda	Que.	400	67	New mine	July	UG	Gold	Cambior inc.	Ore is milled at the Yvan Vezina mill. Production is expected to be about 25 000 oz of gold per year over the next eight years.
Cheminis	Virginiatown	Ont.	350	20	New mine	July	UG	Gold	Northfield Minerals Inc.	Ore is custom milled at the nearby Kerr mill.
Duvay-Obalski	Amos	Que.	800	60	New mine	August	OP	Gold	Société Minière Sphinx Inc. and Goldstack Resources Ltd.	Heap-leached 36 000 t sample in 1990. Plans to treat 200 000-400 000 t of ore annually.
Dome Mountain	Smithers	B.C.	320	25	New mine	October	UG	Gold	Timmins Nickel Inc. and Habsburg Resources Limited	Ore is currently custom milled at both the Premier mill and the Equity Silver mill. Eventually, only one of the two mills will be used. Production is expected to be 35 000 oz of gold annually. About half of the workers are on contract.
Seabee	La Ronge	Sask.	400	100	New mine	November	UG	Gold	Claude Resources Inc. and Mantle Investments Limited	Planned mine life is about five years. Annual production is expected to be 52 000 oz of gold. Seabee is a "fly-in, fly-out" operation.

TABLE 1 (cont'd)

Project	Location	Province	Capacity	Employment[1]	Status	Date	Mine Type	Main Commodities	Companies	Remarks[2]
			(tonnes/day)							
Base Metals										
Lower Coleman	Sudbury	Ont.	1 500[e]	100	New mine	April	UG	Nickel, copper	Inco Limited	Based on current ore reserves, mine life is expected to be about 10 years.
Sa Dena Hes (formerly Mt. Hundere)	Watson Lake	Y.T.	1 500	100	New mine	July 20	OP, UG	Zinc, lead, silver	Curragh Resources Inc. and Hillsborough Resources Limited	Based on current reserves, mine life is expected to exceed 10 years.
CNE	Newcastle	N.B.	250	25	New mine	August 19	OP	Zinc, lead, silver	Stratabound Minerals Corp.	Ore is custom milled at the Heath Steele mill. Mining is being carried out through contract mining in batch mode.
Samatosum	Adams Lake	B.C.	270	16	New mine	September	UG	Silver, lead, zinc, copper	Minnova Inc. and Rea Gold Corp.	Underground ore reserves are expected to be depleted by October 1992. Ore reserves at the open pit will be exhausted in April.
Others										
Westray	New Glasgow	N.S.	3 000	210	New mine	August 1	UG	Coal	Curragh Resources Inc.	Planned annual production is about one million tonnes of coal. The mine has been for sale since late 1991.
RE-OPENINGS & EXPANSIONS										
Precious Metals										
Simkar	Val-d'Or	Que.	300	50	Re-opening	May 1	UG	Gold	Ronrico Explorations Limited and Louvicourt Gold Mines Inc.	Ore is custom milled at the nearby Ferderber mill. Production is expected to be about 18 000 oz of gold annually. The mine last produced in July 1949.
New Privateer	Zeballos	B.C.	90	5	Re-opening	July	UG	Gold	New Privateer Mine Ltd.	Between 1937 and 1948 the mine produced 168 000 oz of gold.
Francoeur	Rouyn-Noranda	Que.	400	59	Re-opening	October 1	UG	Gold	LAC Minerals Ltd. and Richmont Mines Inc.	Ore is custom milled at the nearby Kerr mill. The mine began production in July 1988. Mining was suspended in June 1990 because of high operating costs. The mine produced some 19 000 oz of gold in 1991 and is expected to produce 22 000 oz of gold in 1992.
Kerr (formerly Kerr Addison)	Virginiatown	Ont.	2 000	166	Mill expansion	1991-92	UG	Gold	Deak Resources Corporation and GSR Mining Limited	Increased one of the three 1360 t/d gold circuits from 1800 t/d in 1990 to 2000 t/d in 1991. Company plans to further increase this capacity to 2700 t/d by July 1992. As well, the company plans to convert another 1360 t/d circuit to treat base-metal or further gold ore.

Joe Mann	Chibougamau	Que.	1 630	241	Expansion	1989-92	UG	Gold	Campbell Resources Inc.	Increased production capacity from 1270 t/d to 1630 t/d in 1991. Gold production increased from about 67 000 oz in 1990 to 75 000 oz in 1991. It is planned to increase output to 100 000 oz in 1992. Milling is done at the Camchib mill.
Bousquet No. 2	Malartic	Que.	1 360	235	Expansion	1991-92	UG	Gold, copper	LAC Minerals Ltd.	Commercial production began in October 1990. Gold production increased from 67 163 oz in 1990 to the 169 500-oz level in 1991, and is planned to further increase to 200 000 in 1992. Ore is milled at Est-Malartic mill which, in September 1991, began a capacity expansion program (scheduled for completion in the third quarter of 1992) to accommodate increased ore production from Bousquet No. 2 mine.

Base Metals

Goldstream	Revelstoke	B.C.	1 100	110	Re-opening	May	UG	Copper, zinc	Bethlehem Resources Corporation and Goldnev Resources Inc.	Concentrate shipments to smelters in Japan began on June 30, 1991. Based on 1991 ore reserves, mine life is expected to be about five years. The mine was first brought into production by Noranda Minerals Inc. in 1983, but closed in 1984 due to low prices for metals and low zinc recovery.
Birchtree	Thompson	Man.	3 000e	85e	Expansion	1991-97	UG	Nickel, copper	Inco Limited	Work started on expansion to double production to 34 million lb of nickel annually by 1997.

SUSPENSIONS AND CLOSURES

Precious Metals

Blackdome	Clinton	B.C.	180	134	Closure	January 19	UG	Gold	MinVen Gold Corporation	Mine was originally scheduled to close in December 1990; now closed due to depletion of ore reserves.
Beaverdell	Beaverdell	B.C.	100	36	Closure	February 28	UG	Silver, lead, zinc	Teck Corporation	Mine closed due to low metal prices.
Buffonta	Virginiatown	Ont.	270	12	Suspension	March	OP	Gold	GSR Mining Corporation	Mining suspended due to a lack of funds.
Golden Bear	Telegraph Creek	B.C.	315	118	Closure	March 4	UG	Gold	North American Metals Corp.	Underground operation suspended indefinitely for economic reasons. Company began open-pit mining which can still access the underground ore. About 83 employees were kept on for the open-pit operation.

TABLE 1 (cont'd)

Project	Location	Province	Capacity (tonnes/day)	Employment[1]	Status	Date	Mine Type	Main Commodities	Companies	Remarks[2]
Precious Metals (cont'd)										
Hope Brook	Chetwynd	Nfld.	3 150	340	Suspension	May 23	OP	Gold	BP Canada Inc.	Mining suspended due to environmental problem. 270 workers were laid off. Royal Oak Mines Inc. of Vancouver is in the process of acquiring the mine for re-opening, possibly in 1992.
Jolu	La Ronge	Sask.	400	56	Closure	May	UG	Gold	International Mahogany Corp. and International Corona Corporation	Operations ceased due to exhaustion of ore reserves. Mining ended September 1990; milling stopped in May 1991.
Sleeping Giant	Amos	Que.	900	190	Closure	May 20	UG	Gold	Aurizon Mines Ltd.	Mine closed due to exhaustion of known ore reserves. A joint exploration program is now under way with Cambior inc. to explore other orebodies nearby. Initial drilling results have been encouraging.
Colomac	Indin Lake	N.W.T.	9 000	300	Suspension	July	OP	Gold	Northwest Gold Corp.	Operation suspended due to financial problems.
Shasta	Smithers	B.C.	180	40	Closure	August 1	UG	Gold	International Shasta Resources Ltd.	Until the mine's closure, ore was custom milled at Sable Resources Ltd.'s Baker mill. The mine closed due to depletion of ore reserves.
Hislop East	Timmins	Ont.	400	25	Suspension	September	UG	Gold	Goldpost Resources Inc. and St. Andrew Goldfields Ltd.	Mining suspended due to economic reasons, such as low gold price and high winter trucking costs. Plans to re-open in 1992 provided gold price warrants.
Renabie	Wawa	Ont.	635	170	Closure	September	UG	Gold	International Corona Corporation and American Barrick Resources Corporation	Mine closed permanently due to increased costs, decreasing dimensions of orebody at depth, and lower ore grades.
Jasper	La Ronge	Sask.	200	31	Closure	December 10	UG	Gold	Cameco Corporation and Shore Gold Fund Inc.	Mining ceased May 25. Milling continued until closure. The mine closed due to exhaustion of ore reserves. 14 employees were laid off; the rest were relocated to the company's other operations.

Bell Creek	Timmins	Ont.	400	99	Suspension	December	UG	Gold	Falconbridge Gold Corporation	Operations were suspended by former owner, Canamax Resources Inc., in early December 1991, to facilitate sale of the mine and mill to Falconbridge Gold Corporation. All employees of Canamax at the mine and mill were laid off. The sale was completed on December 17, 1991. The new owner, Falconbridge Gold, re-opened the Bell Creek mill on January 13, 1992, to process ore from its Hoyle Pond mine. Any re-opening of the Bell Creek mine will depend on a higher gold price.
SB	Stewart	B.C.	1 500	100	Closure	November 14	OP	Gold	Westmin Resources Limited and Tenajon Resources Corp.	The mine closed due to depletion of ore reserves. Production lasted only six months from May 20 to November 14, 1991.
Eastmaque Gold tailings operation	Kirkland Lake	Ont.	2 270	45	Suspension	December 20	Surface	Gold	Eastmaque Gold Mines Limited	Operation suspended due to low gold price.
Base Metals									Base	
Normetmar	La Sarre	Que.	450	42	Suspension	January 1	UG	Zinc, silver	Normetal Mining Exploration Inc.	Ore was custom milled at the Mattagami Lake mill until the end of 1990. The mine closed because of economic reasons.
Gays River	Gays River	N.S.	1 350	150	Suspension	May	UG	Zinc, lead	Westminer Canada Limited	The mine was first brough into production by Esso Minerals Canada in 1979, but closed in 1982. It was re-opened in early 1990. The operation was suspended due to an underground water problem which has since been resolved. Re-opening of the mine now depends on metal prices, which have fallen since the closure. 120 employees were laid off; 30 are being kept on site for care-and-maintenance work.
Lyon Lake mine & Mattabi mill	Ignace	Ont.	2 800	240	Closure	May	UG	Copper, lead, zinc	Noranda Minerals Inc.	Operations ceased due to high costs, lower metal prices and the exhaustion of ore reserves.
Estrades	Joutel	Que.	700	36	Suspension	June	UG	Zinc, copper, gold	Breakwater Resources Ltd. and Brookline Minerals Inc.	Mining was suspended due to weak metal prices, increasing operating costs and excess dilution.
Perry	Chapais	Que.	1360	250	Closure	End of June	UG	Copper, gold	Minnova Inc.	Mine closed due to exhaustion of ore reserves.
Springer	Chapais	Que.	1360	Included with Perry	Closure	End of June	UG	Copper, gold	Minnova Inc.	Mine closed due to exhaustion of ore reserves.
Afton/Ajax	Kamloops	B.C.	9 000	216	Suspension	August 23	OP	Copper, gold	Teck Corporation and Metall Mining Corporation	Operation suspended due to depressed metal prices and lower grades. About 15 employees were kept on for care-and-maintenance work.

TABLE 1 (cont'd)

Project	Location	Province	Capacity (tonnes/day)	Employment[1]	Status	Date	Mine Type	Main Commodities	Companies	Remarks[2]
Base Metals (cont'd)										
Rod	Snow Lake	Man.	360	34	Closure	October	UG	Copper, zinc	Hudson Bay Mining and Smelting Co., Limited	Mine closed due to depletion of ore reserves.
Falconbridge crown pillar	Sudbury	Ont.	700	50	Closure	October	UG	Nickel, copper	Falconbridge Limited	Mine closed due to depletion of ore reserves. Employees were relocated to company's other operations in the Sudbury area.
Creighton No. 3	Sudbury	Ont.	700[e]	80[e]	Suspension	December	UG	Nickel, copper	Inco Limited	Mining suspended due to low metal prices. Most jobs were eliminated through attrition or transfer to company's other projects. The larger Creighton No. 9 mine continues to produce.
Whistle	Sudbury	Ont.	2 000[e]	35[e]	Suspension	December	OP	Nickel, copper	Inco Limited	Mining suspended due to low metal prices. All jobs at the mine site were eliminated.
Other Minerals										
Baie Verte	Baie Verte	Nfld.	8 500	380	Closure	February 4	OP	Asbestos	Baie Verte Mines Inc. and Cliff Resources Corporation	Closed due to exhaustion of open-pit ore reserves.
Alsask	Alsask	Sask.	45	12	Closure	May 4	Surface	Sodium sulphate	Francana Minerals Inc.	Operation ceased due to market conditions and the financial situation of the parent company, Agassiz Resources Ltd., which had been placed in receivership.
Cabri	Cabri	Sask.	60	25	Closure	May 4	Surface	Sodium sulphate	Francana Minerals Inc.	(Same reasons as for Alsask mine above.)
Metiskow	Provost	Alta.	55	19	Closure	May	Surface	Sodium sulphate	Francana Minerals Inc.	(Same reasons as for Alsask mine above.)
Baie Verte wet process operation	Baie Verte	Nfld.	6 000	72	Suspension	December	Surface	Asbestos	Princeton Mining Corporation	Mine tailings derived from the Baie Verte open-pit asbestos mine, accumulated since 1963, were processed by Baie Verte Mines Reprocessing Inc. between August 1990 and February 1991, using a so-called "wet" process method. Teranov Mining Corporation, a wholly owned subsidiary of Princeton Mining Corporation, restarted the operation in July 1991, but low fibre recovery, caused by frozen tailings, forced the operation to be suspended in December. All 72 employees were laid off. The company is optimistic that the operation will be re-opened in 1992 with an increased workforce.

Collins Bay B-Zone	Rabbit Lake	Sask.	2 000	..3	Closure	February 7	OP	Uranium	Cameco Corporation	Mine closed due to exhaustion of ore reserves. Employees were transferred to other Cameco operations.
Diotte	Lac-des-Îles	Que.	850	60	Suspension	November	OP	Graphite	Graphicor Resources Inc.	Mining suspended due to economic reasons. Company plans to continue testing stockpiled materials for possible future operations.

Source: Energy, Mines and Resources Canada.
OP Open-pit; UG Underground.
. . Not available; e Estimated.
1 Employment refers to workers on the company's payroll and to contract workers at an operation, or at an operation prior to its closure. 2 t = metric tonnes. 3 Total number of employees for the entire Rabbit Lake operation is about 199; no separate figure is available for employment at the Collins Bay B-Zone mine.

Aluminum

Patrick Chevalier

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4401

The international aluminum industry faced one of its most difficult years in 1991. Although Western World demand for aluminum increased slightly, this was more than offset by high production combined with increased exports from the former U.S.S.R. The overall result was an increase in inventories while prices on the London Metal Exchange (LME) tumbled to their lowest levels since 1982.

Aluminum inventories on the LME continued to rise later in the year despite several major production cuts which totalled about 800 000 tonnes (t). Inventories in LME warehouses reached record high levels of close to 1 million tonnes (Mt) by year-end.

Canadian aluminum smelter capacity increased 200 000 t to 1.835 Mt in 1991. With the completion of two new smelters at Sept Îles and Deschambault, Canadian production capacity is expected to reach 2.265 Mt in 1992.

CANADIAN DEVELOPMENTS

Canadian production of primary aluminum in 1991 was 1.822 Mt compared to 1.567 Mt in 1990. Canadian exports of primary smelter products during the first nine months of 1991 were 1.12 Mt, compared with 944 400 t for the same period in 1990. Exports to the United States in the first nine months totalled 723 900 t compared to 660 500 t for the same period last year.

Starting in November, Alcan Aluminium Limited temporarily reduced primary aluminum production at three of its older, higher-cost smelters in Quebec. The company reduced production at Shawinigan by 21 000 t/y, at Isle Maligne by 24 500 t/y, and at Arvida by 22 000 t/y. Alcan considered the temporary closures necessary due to the weak international price of aluminum, combined with water shortages in the Saguenay-Lac-St-Jean region. Reduced reservoir capacity required Alcan to purchase higher-cost supplementary power from Hydro-Québec.

In May, Alcan completed the final installations at its Laterrière smelter. Built at a cost of close to $800 million, the plant has now reached its full production capacity of 200 000 t/y. Production started at the plant in July 1990. The Laterrière smelter incorporates pollution control technology that captures more than 99% of the dust particles and fluorides in process gases. The start-up of the new smelter and the permanent closure of an equal amount of old Söderberg capacity at Jonquière will result in a reduction of emissions of polycyclic aromatic hydrocarbons by 60%, and of fluorides by 50%.

Construction at Alcan's Kemano Completion Project near Kitimat, British Columbia, was suspended pending the outcome of an appeal by Alcan to a Court ruling calling for an independent environmental review. The $1 billion project is the second phase of Alcan's hydro-electric development of the Nechako River system, which had been expected to add 540 megawatts (MW) to Alcan's Kemano hydro-electric generating station by 1994. Construction started in 1989 following extensive environmental reviews and modifications to meet federal and provincial regulations. The Kemano station currently supplies power to Alcan's 268 000-t/y aluminum smelter at

Kitimat. To the end of the year, Alcan's expenditures and spending commitments on the expansion exceeded $675 million. Alcan's appeal hearings, which lasted from December 16 to 20, 1991, adjourned until April 8, 1992.

Two smelter expansion projects in Quebec were completed in 1991 ahead of schedule. In March, Aluminerie de Bécancour Inc. (ABI) completed the $500 million expansion of its smelter at Bécancour, Quebec. The addition of a third potline increased the plant's total capacity to 360 000 t/y. The company began production in April 1986. The smelter is owned by a consortium of companies comprising Pechiney Québec Inc., Canadian Reynolds Metals Company Limited, Alumax Inc., and Albecour Inc.

In April, Canadian Reynolds completed a $500 million expansion at its smelter at Baie Comeau, Quebec. The addition of a fifth potline raised production capacity to 400 000 t/y from 280 000 t/y, making it North America's largest aluminum smelter. In September, Reynolds Cable announced a delay in the start-up of its new rod mill at Bécancour, Quebec. The $49 million plant, scheduled to begin operation in November, will not begin operation until April 1992. The delay was in response to weak demand for electrical cable.

The new Aluminerie Lauralco Inc. smelter at Deschambault, Quebec, was nearing completion by the end of 1991. The $1 billion plant is wholly owned by Alumax Inc. of the United States. It is scheduled to begin operations in February 1992 and should reach its full production capacity of 215 000 t/y by the fall of 1992.

Production is set to begin in June 1992 at the new Aluminerie Alouette Inc. project at Sept-Îles, Quebec. The $1.4 billion smelter will have a production capacity of 215 000 t/y. The company expects to reach full production capacity by the end of the year. Aluminerie Alouette Inc. is a consortium of five companies comprising Germany's Vereinigte Aluminium-Werke AG (VAW), Austria Metall Aktiengesellschaft, Hoogovens Groep BV of the Netherlands, Société générale de financement du Québec (SGF), and Japan's Kobe Steel Ltd. and Marubeni Corp.

A Venezuelan company, Cabelum, signed a preliminary agreement to purchase 40 000 t/y of aluminum from two of the six partners in the Alouette consortium. The aluminum will go to a new rod plant that Cabelum plans to build near Sept-Îles. SGF and Hoogovens Groep will provide 20 000 t/y each of aluminum from their share of production. Construction of the rod plant is still subject to the company raising the necessary financing.

In June, Kaiser Aluminum and Chemical Corporation announced that it is moving its extrusion plant from Scarborough to London, Ontario. The new $21 million plant is scheduled for completion by 1993. Some equipment and most of the employees will be relocated to the new facility. The plans also include a modern scrap recycling-remelt facility.

Alcan International Limited, Alcan Aluminium Limited's technology, research and development division, announced job cuts at its Canadian laboratories. Thirty-four positions were cut at the Kingston Research and Development Centre in Ontario and another twenty-eight positions were cut at the Arvida Research and Development Centre in Quebec. Some cuts were made through early retirement, relocation and non-renewal of short-term contracts. Alcan will focus its research and development activities with its related businesses and intensify the orientation of its laboratories toward customers and markets.

WORLD DEVELOPMENTS

Despite aluminum's weak market conditions, several new greenfield projects and plant expansions were announced, while some previously announced projects, particularly in Venezuela and Iceland, were put on hold until market conditions improve. Some scheduled closures, particularly at older, high-cost European smelters, were made sooner than planned.

World demand for aluminum increased in 1991, but not ahead of supply. Demand was particularly strong in Germany, Japan and some other Asian-Pacific nations.

United States

Despite falling world prices, most of the 23 U.S. smelters continued to operate at or above capacity. Total name-plate capacity in the United States is 4.087 Mt/y. Two exceptions were Ormet Corporation's Ravenswood smelter in West Virginia and the Reynolds Metals Company's Troutdale smelter in Oregon. The 200 000-t/y Ravenswood smelter operated at about 85% of capacity due to a labour dispute. At year-end, no solution had been reached in the dispute that has affected the smelter since 1990. In August, Reynolds Metals Company temporarily closed three of its five potlines at its Troutdale smelter in Oregon because of weak demand caused by the recession and a world oversupply of aluminum. By December, all of Troutdale's 120 000-t/y capacity had been idled. Total U.S. production was 4.121 Mt of aluminum in 1991, compared to 4.048 Mt in 1990.

The Aluminum Company of America (Alcoa) and Japan's Kobe Steel, Ltd. agreed to form two joint-venture companies to service the transportation industry. One will be located in the United States and the other in Japan. The initial emphasis of the new companies will be to expand the use of aluminum in passenger cars and light trucks. In another joint venture with Kobe Steel, Alcoa will form a 50:50 joint-venture company called Alcoa-Kobe Specialties Ltd. The company will manufacture and market aluminum photoreceptor tubes for the North American market from a plant in North Carolina. The tubes are used in copy machines, word processors, and personal computer and facsimile laser printers.

Alcan officially opened its new US$20 million cable plant in Roseburg, Oregon, in May. The plant produces aluminum transmission-and-distribution conductor cable and aluminum building wire for the American market. Alcan's Kitimat smelter and Vancouver rod mill, both in British Columbia, will supply the feedstock for the plant.

Jamaica

Jamaica and Trinidad and Tobago signed an agreement to proceed with a preliminary study for a new 200 000-t/y aluminum smelter to be built in Trinidad. The two governments are seeking private investors to provide most of the equity and financing for the project. The smelter will take advantage of Trinidad's abundant natural gas to produce electricity.

The Jamaica Bauxite Institute announced net earnings for 1991 at US$240 million, down from $270 million in 1990. Earnings were lower despite a 5% increase in bauxite and alumina production.

At year-end, a final draft agreement was reached between the Ukraine's Nikolaev alumina operation and five U.S. investors to re-open the Lydford bauxite mine at an annual rate of between 1.0 and 1.5 Mt of bauxite. Most of the production would be exported to the Ukraine. The Nikolaev plant currently receives two thirds of its supply from mines in Guinea.

South America

In March, a transmission line failure and power outage severely damaged the Aluminio Brasileiro SA smelter at Belem in northern Brazil. The 330 000-t/y Albras smelter was without power for 12 hours. Several potlines froze and full production was not restored until July.

Brazil's Valesul Aluminio SA announced in June the signing of a technology agreement to increase production from 92 000 t/y to 98 000 t/y by 1993. The agreement, signed with Norway's Hydro Aluminium, will modernize the Santa Cruz smelter and reduce its operating costs.

Alcan Aluminio do Brasil SA, a subsidiary of Alcan Aluminium Limited, shut down a 9000-t/y potline at its Ouro Preto smelter. The company permanently closed the line because of weak market conditions and environmental considerations. The 60 000-t/y Ouro Preto smelter started production in 1945 and is Alcan's oldest smelter in Brazil. Alcan announced that it would acquire a 10% equity interest in the Alumar consortium's new 1 Mt/y alumina refinery. The consortium now comprises Alcoa Aluminio SA (54%), Billiton Metais SA (36%), and Alcan Aluminio do Brasil (10%). Alcan has indicated that it does not intend to acquire any rights in the Alumar consortium's 350 000-t/y Soa Luis smelter.

In November, Noranda Aluminum, Inc. and Projectos de Aysen SA announced plans outlining a joint-venture agreement for the construction of a 240 000-t/y aluminum smelter in southern Chile. The $1.5 billion Alumysa project includes plans for a 380-MW hydro-electric plant. Construction of the hydro-electric plant is scheduled to begin next year, and completion of the smelter is expected by 1996. Financial arrangements for the project have yet to be completed.

Weak aluminum prices in the latter half of 1991 prompted several companies to review their plans to invest in new megaprojects in Venezuela. The Venezuelan government plans to install 2 Mt of primary aluminum smelting capacity by the year 2000 as part of a major industrial expansion program. Four projects were approved under Venezuela's debt-equity conversion program in the first half of 1991. The three greenfield smelter projects include the 300 000-t/y Alcoven project, the 215 000-t/y Aluyana project, and the 240 000-t/y Orinoco project. A fourth project, Quintametall, is a 215 000-t/y expansion of the Aluminio del Caroni SA (Alcasa) Peurto Ordaz smelter. In December, Alcoa announced that it is suspending its participation in the Alcoven project until market conditions improve. Earlier in the year, Austria Metall withdrew from the Quintametall project. Reynolds Metal Company and Mitsubishi Corporation were working on a feasibility study for the 215 000-t/y Aluyana smelter, and an announcement is expected early in 1992.

In August, Paraguay announced that the Japan International Development Organisation offered to build a 225 000-t/y smelter if Paraguay agreed to supply power at a rate of US1.6¢/kilowatt (kW). The government was reportedly studying the proposal.

Argentina's only primary aluminum smelter reduced production by 9% starting in October. Aluar Aluminio Argentino SAIC's Peurto Madryn smelter has an annual production capacity of 170 000 t/y and produces aluminum mainly for the export market.

Europe

British Alcan Aluminium plc reduced production at two of its smelters in the United Kingdom. The company reduced production at its Lynemouth smelter by half, or 66 000 t/y, and at Lochaber, Scotland, by 10 000 t/y.

Pechiney Aluminum closed the Noguères and Rioupéroux smelters before opening its new 215 000-t/y Dunkirk smelter. Noguères was built in the early 1960s and had a total installed capacity of 114 000 t/y. It had been operating at 38 000 t/y since October 1990. The Rioupéroux smelter had an annual capacity of 25 000 t/y which had been reduced to 14 000 t/y in 1987.

The state-owned Hungarian Aluminium Corporation (Hungalu) decided to close all three of its primary aluminum smelters. The 17 000-t/y Tatabanya smelter closed at the end of 1991. The two remaining primary smelters, Ajka (22 000 t/y) and Inota (36 000 t/y), will close in 1992. The company continues to operate its three alumina plants and several semi-fabricating facilities in Hungary.

The Swiss aluminum company, Alusuisse-Lonza Holding Limited, announced that it would be setting up a new joint-venture company in Czechoslovakia. The company, called Aluminium Decin, will operate the Kovohute Decin extrusion plant in northern Bohemia. In June, Alusuisse-Lonza announced the closure of its Rheinfelden aluminum smelter in Germany. Citing weak economic conditions, rising operating costs and environmental considerations, the company stated that the plant was no longer profitable.

Also in Germany, Alcoa announced plans to build a plant that will produce aluminum space-frame components and sub-assemblies for the German auto industry. Alcoa also announced that it had signed an agreement to supply aluminum space-frame components to the German automobile manufacturer Audi AG. The $70 million plant will be completed in 1993 and will produce components for more than 100 000 cars annually.

In the Netherlands, Hoogovens Groep BV announced that it was cutting production by an average of 10% (18 000 t/y) at its two aluminum smelters. The company operates one smelter in the Netherlands (Delfzijl) and one in Germany (Voerde). Pechiney Nederland, a subsidiary of the French aluminum producer Pechiney, cut primary production by 12.5%. The Vlissingen smelter produced 174 000 t of aluminum in 1990.

High electricity costs were cited as the main reason for the decision by Austria Metall to close its 83 000-t/y Ranshofen aluminum smelter in Austria by the end of 1991.

In Italy, Alumix SpA announced that it had reached an agreement with its unions and the Italian government to close production at two smelters. Aluminum production at the 30 000-t/y Porto Marghera plant stopped in September. Production is scheduled to cease at the 30 000-t/y Fusina plant by 1993.

The civil war in Yugoslavia interrupted primary aluminum production at Croatia's 75 000-t/y Sibenik smelter. Reports suggested that the plant's transformers were damaged in September and the potlines froze. The nearby fabricating facilities and port were also affected. The country's three other primary aluminum smelters were reportedly operating at full capacity.

Hydro Aluminium AS, the Norwegian subsidiary of Norsk Hydro AS, announced production cuts at its four Norwegian smelters. The company plans to cut production by 7.5% (45 000 t) before the end of 1991. Elsewhere in Scandinavia, Sweden's Granges AB announced that it would cut primary aluminum production by 20% (about 20 000 t/y).

Plans to build a new 210 000-t/y aluminum smelter in Iceland have been delayed for at least two years. Atlantal Aluminium, a consortium of companies comprising Hoogovens Groep BV, Alumax Inc., and Granges Aluminium AB, announced that it will wait until market conditions improve before proceeding with the project. Plans by the Icelandic government to expand a hydro-electric plant that will supply power to the new smelter have also been put on hold.

U.S.S.R.

Exports from the former U.S.S.R. were reportedly between 800 000 t and 1 Mt, compared to 300 000 t in 1990. Approximately 600 000 t of Soviet aluminum were delivered to the LME warehouse in Rotterdam. Material that was not deliverable to the LME was reportedly sold to European fabricators at discounts of up to US$200/t. Despite the political uncertainties, several Western countries announced the formation of joint-venture companies within the former U.S.S.R.

Under the new political arrangement, Russia will retain about 85% of the former Soviet aluminum industry. Of the 15 producing aluminum smelters in the former U.S.S.R., 11 smelters, with a total production capacity of 3 315 000 t/y, are in Russia. Ukraine has one 120 000-t/y smelter at Dnieper. The 520 000-t/y Regar prebake smelter in Tadzhikistan is considered to be the most modern of the former Soviet aluminum smelters. The Republic of Kazakhstan has one smelter, Pavlodar, with an annual capacity of 200 000 t/y. The 60 000-t/y Sumgait smelter is located near Baku in Azerbaijan. The 100 000-t/y Kanaker smelter at Yerevan in Armenia is thought to be closed.

Reynolds International, along with Italian and Russian joint-venture partners, is building a new foil plant at Sayanogorsk in southern Siberia. Construction of the Sayanal plant has already begun; the US$160 million financing was arranged through a consortium of European banks. The plant is scheduled to be operational by 1993 and initial production capacity is rated at 47 000 t/y. The ownership will be shared 13.5% by Reynolds, 13.5% by Fata European Group of Italy, 3% by the San Paolo Bank of Italy, and 70% by a Russian consortium comprising five agencies. Reynolds will receive 25% of the output for marketing in Europe and act as the plant operator and manager.

In April, Tokyo Maruichi Shoji Company Limited announced the formation of a joint-venture company to produce Teflon-coated pans at the Bratsk aluminum smelter in eastern Siberia. The joint-venture company, called BM International, will produce 300 000 to 400 000 utensils annually for the Russian market when fully operational. Ownership in the company will be shared between Bratsk Aluminium (67%) and Tokyo Maruichi (33%). The plans also include improvements to the plant's flat-rolling capability and ingot manufacturing. In the longer term, Tokyo Maruichi hopes to supply Japanese cars, consumer goods and electrical appliances under a barter deal for aluminum ingot. The Bratsk smelter is the world's largest aluminum smelter with a production capacity of 1 Mt/y.

The South Korean aluminum-fabricating company, Samsun Industry, reportedly signed a joint-venture deal with the Soviet enterprise KMT for the production of aluminum wheels. Samsun will supply US$6 million worth of aluminum wheel production, casting, heat treatment and painting equipment.

The Finnish plant-making firm, Kumera Corporation, is currently involved in a plan to retrofit the 70 000-t/y Nadvoytsy smelter and the 70 000-t/y Kandalaksha smelter in Russia's Kola Peninsula region. The three-year program is scheduled to begin by the end of 1992 and will convert the Söderberg plants to prebake technology. Both smelters are sources of pollution for the region and neighbouring Finland.

A Japan-Russia joint venture in Khabarousk will produce secondary aluminum from local scrap material. Production will be sold in Russia and Japan. The joint-venture company will be held 60% by Bostokmetal and 40% by a consortium of Japanese companies comprising Daigen Co., Eiwa Trading Co., and Nakataya Co. The plant will have a remelt capacity of 30 000 t/y.

Asia

Iran announced in November that it had signed the main construction contract with Almahdi Aluminium Corporation for a new 220 000-t/y aluminum smelter. The $1.5 billion smelter will be built at Bandar Abbas near the Strait of Hormuz. The project is a 60:40 joint venture between the Iranian government and the International Development Corporation Ltd. based in Dubai. Earlier this year, Czechoslovakia's Technoexport signed an agreement with the Iranian government for a $330 million mining project to develop 22 Mt of bauxite reserves near Jajroum. Technoexport is also likely to participate in a 2 Mt/y alumina plant near Shiraz. Dubai Aluminium Company Limited will supply technology and training for the new aluminum smelter that is scheduled to start operations in the second half of 1994. The project includes plans for a possible expansion to 330 000 t/y.

Expansion projects at Iran's only producing aluminum smelter, Arak, were reportedly proceeding on schedule. The fourth potline was completed in October and a fifth will increase the smelter's capacity from the current 75 000 t/y to 120 000 t/y by the end of 1992.

Aluminium Bahrain BSC (Alba) continued work on a $1.45 billion expansion project at its Knuff smelter. Work was reportedly ahead of schedule. Once commissioned, the new potline will increase the smelter's capacity to 460 000 t/y by 1994. A retrofit of the existing 210 000-t/y smelter is expected to be completed in 1993 and will add 20 000 t/y of capacity as a result of increased efficiency. Elsewhere in the Gulf region, the Dubai Aluminium Company Limited (Dubal) completed the expansion of its Jebel Ali smelter in January. The addition of the new potline raises the smelter's total capacity to 240 000 t/y.

Work started earlier this year on the first phase of the Pingguo Aluminium Factory in China's Guangxi Autonomous Region. The plant is designed to produce 300 000 t/y of alumina and 100 000 t/y of aluminum, and is scheduled for completion by the end of 1994. The project also includes a power station with an installed capacity of 250 000 kW. Construction on the second phase of the Qinghai aluminum smelter continued in northwest China. When completed in 1993, its production capacity will double to 200 000 t/y.

National Aluminium Company Limited (Nalco) announced plans for a $1.2 billion expansion program for its operations in India. Nalco plans to increase alumina refining capacity by 25% and to double bauxite mining capacity to 4.8 Mt. The plans also include the expansion of its Angul smelter's capacity by 50% to 330 000 t/y. Elsewhere in India, Hindalco Industries Limited announced expansion plans for its Renukoot smelter. The company plans to double capacity to 300 000 t/y and will expand its power plant capacity by 360 MW.

Severe drought conditions in Indonesia affected production at PT Indonesia Asahan Aluminium's (Inalum) plant at Asahan. Power supplies from the Asahan River have dropped from 450 MW to 360 MW. Aluminum production at the Kuala Tanjung smelter fell to 160 000 t/y in 1991. The smelter needs 425 MW to operate and has been operating at 77% of its full capacity of 225 000 t/y since October 1990.

Africa

Alusaf (PTY) Limited announced plans to build a greenfield smelter in South Africa. A technology agreement has already been signed with Pechiney for the proposed 466 000-t/y smelter. A 25-year variable rate electricity contract has also been signed with the state utility, Eskom. The contract will apply to Alusaf's existing smelter once the new smelter is built, sometime in 1994.

Reynolds Metals Company acquired a 10% equity share in a new 180 000-t/y aluminum smelter to be built in southern Nigeria. The Aluminium Smelter Company of Nigeria is expected to begin operating by late 1993 or early 1994. Reynolds will provide technical and managerial skills and market 70% of the smelter's production.

Britain's Commonwealth Development Corporation approved a £3.1 million loan to Ghana to upgrade the port of Takadori. The improvements to the port and other facilities will help to increase Ghana's bauxite exports from the current 400 000 t/y to about 500 000 t/y by 1993.

The Compagnie des Bauxites de Guinée (CBG) began shipments to Alcan's Vaudreuil alumina plant in Quebec from its newly opened Bidi-Koom bauxite mine in Guinea. Alcan holds a 14% share in CBG.

Australia

The Australian government approved an A$600 million expansion of the Tomago aluminum smelter at Newcastle, New South Wales. The addition of a third potline will increase the smelter's production capacity by 140 000 t/y to 360 000 t/y. Production from the new expansion is scheduled to begin by the first quarter of 1993. The contract to build the project was awarded to an engineering joint venture led by the Montreal-based SNC Inc.

The Government of Victoria announced its intention to sell its 35% equity interest in the Aluvic smelter. Alcoa of Australia Limited is the majority shareholder in the 320 000-t/y smelter.

Australia announced in December that it is leaving the International Bauxite Association. Formed in 1974, the association provided bauxite-producing countries with information about the industry. Australia, the largest ore-producing member, contributes about 30% to the association's budget. Australia will leave the association in October 1992. The remaining members will be Ghana, Guinea, Guyana, India, Indonesia, Jamaica, Sierra Leone, Surinam and Yugoslavia.

RECYCLING

Secondary aluminum production is increasing worldwide. Western World production of secondary aluminum in 1991, excluding the direct use of scrap, was estimated at 5.5 Mt. The increase in secondary production can be attributed to continuing improvements in scrap collection systems and increased recycling. The automotive industry is the largest consumer of secondary aluminum, consuming between 70% and 75% of secondary production either through direct sales or to casters supplying the automotive industry. As requirements for lighter vehicles increase, it is likely that the demand for secondary aluminum will increase significantly.

Recycling aluminum requires less than 5% of the energy used to make the original metal. As a result, energy represents only 2% of a secondary aluminum smelter's operating cost, compared to about 26% for a primary smelter. The cost of raw materials (scrap) represents about 80% of a secondary smelter's operating costs, compared to 25% (alumina) for a primary smelter.

In 1990, the largest secondary producers were the United States at 1.8 Mt, Japan at 1.5 Mt, and Germany at 0.5 Mt. Canada produced 67 700 t of secondary aluminum in 1990. Scrap recovery is well established in the United States. In 1990, 41% of total U.S. aluminum consumption was accounted for by secondary aluminum. Secondary aluminum accounted for 19% of total consumption in Japan and 24% of the total in Europe in 1990. Canada consumed 141 600 t of secondary aluminum in 1990 compared to 107 600 t in 1989 (excluding the direct use of scrap).

The most important sources of aluminum scrap in the United States are from the packaging (principally from used beverage containers) and transportation sectors. In 1990, some 55 billion cans were recycled in the United States, representing a recycling rate of about 64%. In Canada, 1.6 billion cans were recycled.

New programs are now under way in the United States and Canada to promote recycling of other types of aluminum household products. New advertising campaigns promoting aluminum foil and other aluminum forms were started by Reynolds Metals and Alcoa in the United States. Alcan's Arvida Research and Development Centre is working on a pilot program in the Lac-St-Jean region of Quebec. The project is designed to develop new technologies for recycling a variety of aluminum household products. Barriers to wider recycling of aluminum foil products include lack of public awareness, municipal curb-side recycling programs that do not accept such products, and aluminum producers who do not handle foil or other household sources of aluminum.

The recycling of used beverage containers in Europe increased significantly in November with the commissioning of British Alcan Aluminium's new recycling plant at Warrington. The plant will produce 50 000 t/y of aluminum from recycled beverage containers. In addition to the used beverage containers plant, British Alcan operates two secondary smelters. The United Kingdom is currently Europe's largest consumer of aluminum beverage cans, but with a recycling rate of only 5.5% in 1990. A target for 50% recycling has been set for the mid-1990s. Recycling rates for beverage containers in Europe increased to about 23% in 1991, compared to 18% in 1990. Pechiney plans to open a 20 000-t recycling plant in France in 1992.

CONSUMPTION AND USES

Western World consumption of primary aluminum is estimated at 15.0 Mt in 1991, compared to 14.9 Mt in 1990. Canada consumed an estimated 415 000 t of primary aluminum in 1991 compared to 464 000 t in 1990. Total Western World consumption of both primary and secondary aluminum decreased 1% to about 19.6 Mt. Total Canadian consumption in 1990, including secondary waste and scrap, was 606 000 t.

Aluminum is the third most abundant element and the most abundant metal in the earth's crust. Unlike most of the other major metals, aluminum is never found in its native state in nature; it occurs mainly as an oxide. When combined with water and other impurities, it produces the main ore of aluminum known as bauxite. Pure aluminum is a bluish silver-white, malleable, ductile metal with one third the density of steel. Aluminum's dull lustre results from a thin coating of oxygen that forms when it is exposed to air. It is this characteristic that accounts for aluminum's resistance to corrosion. Aluminum is also an excellent conductor of electricity. Gram for gram, aluminum has twice the electrical conductance of copper. It is also a good conductor of heat and reflector of light and radiant heat.

Combining aluminum with other metals to produce alloys enhances its characteristics and increases its versatility. The most common metals used in combination with aluminum are copper, magnesium, manganese, silicon and zinc. Aluminum's tensile strength, hardness, corrosion resistance and heat-treatment properties improve when alloyed with one or more of these metals. Some copper-aluminum alloys, for example, can exceed the tensile strength of mild steel by as much as 50%.

In both its pure and alloyed forms, aluminum is used to make a variety of products for the consumer and capital goods markets. The largest markets for aluminum are transportation (25%), building and construction (21%), packaging (21%), electrical (10%), consumer durables (7%), and machinery and equipment (9%). Geographically, North America is the largest consuming region, accounting for 36% of total Western World production, followed by Europe at 30% and Asia at 25%.

The transportation sector is the largest single consumer of primary and secondary aluminum production. The enforcement of stricter fuel efficiency and emissions standards is encouraging many auto-makers to reduce their vehicles' weight. Increased consumer demand for cars with added luxury items is also driving manufacturers to find ways to reduce their automobiles' curb-weight. New applications for aluminum sheet and extrusion go beyond the traditional casting applications used in auto parts.

The average North American automobile built today contains about 80 kg (5% by weight) of aluminum. This is expected to increase to about 90 kg before the end of the decade. By comparison, Japanese automobiles expect to contain about 100 kg of aluminum by 1995. Several joint ventures were announced in 1991 between Japanese steel and aluminum producers to conduct research and to develop new automotive applications for aluminum. In Europe, the French auto-maker Renault announced a joint-venture project with Norsk-Hydro AS to build a prototype aluminum and composite frame for passenger cars. A decision to use the new materials is expected in 1993 and they could appear in Renault's smaller production cars by 1997.

In addition to the automotive industry, aluminum enjoys several applications in other areas of the transportation sector. Aluminum's light weight and strength are used in all types of aircraft, trucks, trains, subway cars and ships.

Aluminum faces increasing competition in the aircraft industry from composites, polymers, ceramics and titanium. Weight-saving carbon-fibre composites now account for between 10% and 15% of the structural weight of most new airliners. Several aluminum producers are meeting the challenge by introducing aluminum-based composites.

Aluminum also enjoys a variety of applications in the building and construction sector. Uses include siding, roofing, eavestroughs, windows, doors, frames, screens, awnings and canopies. In recent years, aluminum has faced intense competition from vinyl in the residential siding market and from wood in framing applications.

The packaging sector is one of the fastest growing markets for the aluminum industry after the transportation sector. Within this sector, which includes foil, flexible packaging and food containers, the beverage can market is forecast to grow by 5% to 15% of total aluminum consumption by the year 2000. In the United States, aluminum beverage cans comprise 95% of the total beverage can market. Despite its higher costs compared to other materials, aluminum has gained wide consumer acceptance based on its light weight, convenience, and recycling potential.

Some of the most promising new applications for aluminum are based on a family of new metal matrices. Alcan's "Duralcan" is an aluminum reinforced with silicone carbide ceramic particles. While out-performing traditional aluminum alloys, it is fabricated using the same techniques. In addition, Duralcan has greater specific strength, is lighter than steel, and is less expensive than titanium. Initial markets for this material are expected in sporting goods, cast products, and small engine components. Potential applications are also expected in the automotive and aerospace industries.

Another promising new use for aluminum is in the new aluminum air-cell battery developed by Alcan. The main advantages of the battery are long shelf-life, low weight before activation, and constant power output. One of the many potential uses for the battery is in electric vehicles. When used in combination with a conventional lead-acid battery, the range of an electric vehicle increases from approximately 75 km to over 300 km.

Alcan and the Ontario Ministry of Energy agreed to fund a $2.5 million demonstration project using aluminum-based heat exchangers. The project is designed to generate electricity from waste heat recaptured from water used in cooling processes at electric generating stations. Aluminum's resistance to corrosion and its efficient heat conductivity are seen as ideal for this type of application. The technology, if installed at appropriate sites in Canada, could recover more than 3000 MW of electricity, or enough to supply one million homes. If successful, Alcan expects to be able to commercialize the technology by 1993.

TARIFFS AND TRADE

The European Community's (EC) 6% import tariff on aluminum ingot continues to be an irritant for aluminum exporters in North America, South America and Australia. While the Uruguay Round of General Agreement on Tariffs and Trade (GATT) negotiations has offered hope of at least a partial resolution of this problem, no progress had been achieved by the end of 1991.

HEALTH, SAFETY AND ENVIRONMENT

In Europe, the European Aluminium Association, in alliance with Eurometaux, protested against a proposed EC energy/ carbon dioxide (CO_2) tax. The tax, to be implemented in several stages starting in 1993, is designed to stabilize greenhouse gas emissions. The effect of the tax on the aluminum industry would be to increase European electricity rates, rendering much of the primary smelting industry uncompetitive internationally. If the taxes are implemented, energy costs for power stations could rise 58% for coal, 45% for heavy fuel oil and 34% for natural gas. A target date for a final decision is set for May 1992.

A report in a U.S. business newsletter cited two gases as having more than 8000 times the global warming potential of carbon dioxide. The two inert, non-toxic gases, tetrafluoromethane and hexafluoroethane, are by-products of aluminum smelting. The quantities of the gases released by the industry were estimated at 30 000 t for 1988, compared to about 5.9 billion tonnes of CO_2 released annually. However, the gases are thought to remain in the atmosphere for more than 10 000 years before decaying. Their molecular structure is said to be exceptionally efficient at trapping heat. At current concentrations, about 0.070 parts per billion (ppb), the researchers emphasized that the gases do not, at present, have an impact on the earth's climate. For any impact to occur, concentrations would have to reach about 1.0 ppb which, at current rates of emission, will require several centuries. The aluminum industry is conducting research to find ways to eliminate gas emissions to avoid long-term problems.

A Quebec Ministry of Environment study reported increased levels of polycyclic aromatic hydrocarbons in waterways near four of the five aluminum smelters still using Söderberg technology in Quebec. These hydrocarbons are produced by the incomplete burning of organic materials such as coal, oil, gas or wood. They are suspected carcinogens. Stream sediment samples taken downstream from the smelters contained concentrations from 8 to 100 times greater than samples taken upstream. The study pointed out that polycyclic aromatic hydrocarbons do not accumulate in fish and cannot be transmitted to humans, but studies are continuing to determine their environmental impact on aquatic life.

Over the past 10 years, Canadian Reynolds has spent over $200 million to install environmental control equipment. The gas purification system at the Baie Comeau smelter not only captures fluorides, but it also recycles them in the process. In addition, polycyclic aromatic hydrocarbon emissions have been reduced from 0.7 kg/t of aluminum produced in 1975 to less than 0.2 kg/t in 1989. The completion of Alcan's Laterrière smelter in 1991 replaced most of the company's Söderberg potlines at Jonquière. The Laterrière plant is the second new smelter in Alcan's commitment to replace its Söderberg smelters with cleaner, more efficient prebake technology.

In the United States, the Environmental Protection Agency (EPA) delisted the final residue of spent potliner processed by Reynolds Metals' rotary kiln treatment technology. Spent potliners were listed as a hazardous waste by the EPA in 1988. The new process incinerates the potliners at high temperatures and burns off cyanide and neutralizes the flourides. The residue can then be disposed of in a regular landfill instead of in a hazardous waste landfill.

Alzheimer's disease is a degenerative disease that affects the brain. As the disease progresses, sufferers lose their memory, judgement and communication skills, eventually rendering them incapable of caring for themselves. The condition was first described by the German physician Alois Alzheimer in 1907. Preliminary research in the 1960s found evidence of higher-than-normal concentrations of aluminum in the brain tissues of Alzheimer sufferers. In June, the Aluminum Association, based in Washington, D.C., announced the signing of a three-year, US$1.35 million contract with the National Institute on Aging to conduct a basic study of Alzheimer's disease. There is still no proof that aluminum causes the disease.

PRICES AND STOCKS

Prices on the London Metal Exchange (LME) averaged US59¢/lb in 1991, compared to US74¢/lb in 1990. By mid-December, reduced demand, high production and increasing inventories on the LME pushed the daily spot prices on the LME to below US49¢/lb.

Stocks on the LME reached record levels by year-end partially due to increased exports from the U.S.S.R. Total aluminum stocks increased to over 900 000 t from about 300 000 t at the beginning of 1991. The Rotterdam warehouse alone accounted for over 600 000 t. In November, the LME announced that it would allow warehouses to store aluminum in the open under tarpaulins. The move by the LME was seen as pre-emptive before further stock increases.

The International Primary Aluminum Institute (IPAI) reported that total Western World aluminum inventories in December 1991 were 3.346 Mt, compared to 3.138 Mt in December 1990. The IPAI also reported that inventories of unwrought aluminum were 1.751 Mt in December 1991, compared to 1.527 Mt in December 1990.

The announcement by the LME that a secondary aluminum contract was under consideration met with stiff opposition by secondary aluminum producers, particularly in Japan. By year-end, the introduction of a secondary aluminum contract was still under consideration by the LME.

Spot alumina prices were reported at between US$150 and $160/t by the end of 1991. Prices for spot alumina ranged between US$225 and $250/t in 1990.

OUTLOOK

Several new smelters and smelter expansions are expected to come on stream by the end of 1992, including two in Canada. Western World smelter capacity is expected to reach 15.95 Mt by year-end. Canadian capacity is expected to be 2.265 Mt by the end of 1992.

The Russian Republic inherited 85% of the former U.S.S.R.'s primary aluminum production capacity. The recently established Concern Aluminii has announced that Russia intends to maintain exports in 1992 at the same levels as in 1991. Several problems, including bauxite quality and supply, shortages of fuel and energy, the transportation network, and environmental concerns, may hamper Russia's efforts to export aluminum at these levels.

Prices are expected to remain in the US50¢-55¢/lb range for at least the first half of 1992. As the economies in North America and Europe recover from the recession and inventories are reduced, prices are expected to rise to about US65¢/lb by year-end. Continued exports from Russia at 1991 levels, however, could reduce any price recovery. In the longer term, as the demand for aluminum increases, prices are forecast to average between US70¢ and US80¢/lb in constant 1990 dollars.

Strong growth in demand for primary aluminum of between 3% and 4% is forecast for most of the 1990s. The transportation and packaging (in particular, beverage cans) industries are expected to lead the increase in demand for aluminum to the year 2000.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
7601.10	Unwrought aluminum, not alloyed				
7601.10.10	Billets, blocks, ingots, notched bars, pigs, slabs and wire bars	Free	Free	Free	Free
7601.10.91	Granules, cut from ingots, for use in the manufacture of cleaning compounds	1.98¢/kg	Free	Free	Free
7601.10.99	Other	10.3%	6.5%	Free	Free
7601.20	Unwrought aluminum alloys				
7601.20.10	Billets, blocks, ingots, notched bars, pigs, slabs and wire bars	Free	Free	Free	Free
7601.20.91	Granules, cut from ingots, for use in the manufacture of cleaning compounds	1.98¢/kg	Free	Free	Free
7601.20.99	Other	10.3%	6.5%	Free	Free
7602.00	Aluminum waste and scrap	Free	Free	Free	Free
76.03	Aluminum powders and flakes	9.2% to 10.3%	Free to 6.5%	Free	Free
76.04	Aluminum bars, rods and profiles	2.1% to 10.3%	Free to 6.5%	0.4% to 2%	0.6% to 2%
76.05	Aluminum wire	2.1% to 10.3%	Free to 6.5%	Free to 1.6%	Free
76.06	Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm	Free to 10.3%	Free to 6.5%	Free to 6.1%	Free to 4.5%
76.07	Aluminum foil not exceeding 0.2 mm	Free to 12.2%	Free to 8%	Free to 7.3%	2.1% to 4%
76.08	Aluminum tubes and pipes	8.1%	Free	1.6%	2.2%
76.09	Aluminum tube or pipe fittings	10.3%	6.5%	Free	Free
76.10	Aluminum structures (excluding prefabricated buildings of heading No. 94.06) and parts of structures, aluminum plates, rods, profiles, tubes and the like, prepared for use in structures	10.3%	6.5%	6.1%	3.9%
7611.00	Aluminum reservoirs, tanks, vats and similar containers	Free to 10.3%	Free to 6.5%	Free to 6.1%	1.8%
76.12	Aluminum casks, drums, cans, boxes and similar containers	10.3%	6.5%	6.1%	1.6% to 3.9%
7613.00	Aluminum containers for compressed or liquefied gas	10.3%	6.5%	6.1%	3.5%
76.14	Stranded wire, cables, plaited bands and the like, of aluminum, not electrically insulated	10.2%	6.5%	6.1%	3.4% to 3.9%
76.15	Table, kitchen or other household articles and parts thereof, of aluminum	10.2% to 11.4%	Free to 6.5%	6.1% to 6.8%	2.6% to 3.9%
76.16	Other articles of aluminum	Free to 10.3%	Free to 6.5%	Free to 6.1%	3.2% to 4.4%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, ALUMINUM PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION		1 567 395	..	1 821 642	..
IMPORTS				(Jan.-Sept.)	
2606.00.00	Aluminum ores and concentrates				
	Brazil	1 583 555	52 481	1 044 191	35 475
	Guinea	268 852	13 879	252 190	11 401
	Sierra Leone	98 144	4 408	207 525	9 041
	Australia	272 984	11 888	207 098	6 890
	United States	31 376	5 743	24 642	5 109
	People's Republic of China	25 598	1 666	57 805	2 986
	Other countries	98 728	4 953	110 835	5 045
	Total	2 379 237	95 018	1 904 286	75 947
2620.40.00	Ash and residues containing mainly aluminum	1 750	709	1 288	871
2818.20.00	Aluminum oxide (excluding artificial corundum)				
	United States	702 988	214 825	680 947	189 882
	Australia	683 713	173 605	591 341	142 220
	Jamaica	503 019	136 820	430 817	104 317
	Japan	81 049	21 574	79 070	22 624
	Ireland	–	–	18 074	3 858
	France	1 317	1 703	1 329	1 677
	Germany[1]	372	1 205	470	806
	Other countries	1 698	1 170	608	478
	Total	1 974 157	550 902	1 802 656	465 862
2818.30.00	Aluminum hydroxide	8 773	6 172	7 810	4 615
7601.10	Unwrought aluminum, not alloyed				
7601.10.10	Billets, blocks, ingots, notched bars, pigs, slabs and wire bars				
	United States	21 091	44 095	14 869	31 006
	France	4 048	13 213	6 167	17 716
	Germany[1]	14	43	305	394
	Switzerland	118	348	79	197
	Other countries	139	463	49	81
	Total	25 409	58 162	21 469	49 394
7601.10.91	Granules, cut from ingots, for use in the manufacture of cleaning compounds	–	–	–	–
7601.10.99	Other	1 911	3 206	874	1 588
7601.20	Unwrought aluminum, alloyed				
7601.20.10	Billets, blocks, ingots, notched bars, pigs, slabs and wire bars				
	United States	52 468	110 377	25 929	49 416
	Switzerland	902	2 766	766	2 113
	United Kingdom	394	1 600	406	1 456
	Brazil	41	81	509	792
	Other countries	1 119	2 931	389	836
	Total	54 924	117 755	27 999	54 613
7601.20.91	Granules, cut from ingots, for use in the manufacture of cleaning compounds	6	15	21	33

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991P	
		(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)					
7601.20.99	Other	2 596	4 921	3 957	6 504
7602.00.00	Aluminum waste and scrap	52 645	73 344	35 228	40 836
76.03	Aluminum powders and flakes	2 156	7 362	1 481	4 858
76.04	Aluminum bars, rods and profiles				
7604.10	Of aluminum, not alloyed				
	United States	4 763	27 662	3 081	16 703
	Other countries	894	3 726	683	2 460
	Total	5 657	31 388	3 764	19 163
7604.21 to 7604.29	Of aluminum alloys				
	United States	10 212	41 791	8 431	36 034
	Other countries	1 287	5 121	1 216	4 114
	Total	11 499	48 912	9 647	40 148
76.05	Aluminum wire	3 123	11 712	2 494	8 799
76.06	Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm	275 786	801 954	195 554	531 703
76.07	Aluminum foil not exceeding 0.2 mm	24 310	100 826	15 624	65 146
76.08	Aluminum tubes and pipes	5 754	25 604	4 084	17 667
76.09	Aluminum tube or pipe fittings	..	9 954	..	7 273
		(number 000)		**(number 000)**	
76.10	Aluminum structures (excluding prefabricated buildings of heading No. 94.06) and parts of structures, aluminum plates, rods, profiles, tubes and the like, prepared for use in structures	..	45 690	..	29 398
76.11	Aluminum reservoirs, tanks, vats and similar containers	...	1 192	...	161
76.12	Aluminum casks, drums, cans, boxes and similar containers	451 439	41 528	291 107	39 253
76.13	Aluminum containers for compressed or liquefied gas	224	4 509	637	3 489
		(tonnes)		**(tonnes)**	
76.14	Stranded wire, cables, plaited bands and the like, of aluminum, not electrically insulated	606	1 845	280	676
76.15	Table, kitchen or other household articles and parts thereof, of aluminum	..	33 205	..	54 509
76.16	Other articles of aluminum	..	117 175	..	71 867
EXPORTS					
2606.00	Aluminum ores and concentrates				
	United States	687	90	1 451	132
	Total	687	90	1 451	132

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991P	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
2620.40	Ash and residues containing mainly aluminum	49 546	6 181	7 040	3 785
7601.10	Unwrought aluminum, not alloyed				
	United States	355 801	685 484	349 675	577 505
	Netherlands	73 638	143 784	88 438	151 260
	Japan	91 111	168 382	50 273	76 680
	South Korea	38 362	75 496	22 640	37 941
	Iran	–	–	7 000	10 602
	Norway	861	1 739	5 632	1 030
	Other countries	104 656	209 939	49 041	98 145
	Total	664 429	1 284 824	572 699	953 163
7601.20	Unwrought aluminum alloys				
	United States	471 794	942 967	374 268	642 211
	Japan	74 279	150 432	79 190	139 678
	South Korea	12 097	25 732	17 705	33 012
	Netherlands	8 786	16 136	18 362	29 783
	Taiwan	4 038	8 940	7 474	14 371
	Turkey	12 511	27 763	7 489	13 912
	Israel	7 582	16 470	6 721	13 389
	France	236	428	5 682	10 083
	Other countries	26 324	55 968	25 856	50 380
	Total	617 647	1 244 836	542 747	946 819
7602.00	Aluminum waste and scrap				
	United States	156 493	232 082	113 442	152 308
	Japan	21 372	34 505	13 546	19 694
	South Korea	1 317	1 995	1 503	1 834
	Taiwan	2 284	2 776	1 371	1 586
	Other countries	6 800	10 089	2 825	3 606
	Total	188 266	281 447	132 687	179 028
76.03	Aluminum powders and flakes	290	623	105	251
76.04	Aluminum bars, rods and profiles	1 909	7 258	1 622	5 536
76.05	Aluminum wire	10 671	27 657	14 782	34 540
76.06	Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm	165 693	422 989	134 651	319 641
76.07	Aluminum foil not exceeding 0.2 mm	7 455	43 500	7 452	35 736
76.08	Aluminum tubes and pipes	1 291	8 532	307	3 804
7609.00	Aluminum tube or pipe fittings	..	2 259	..	1 687
76.10	Aluminum structures (excluding prefabricated buildings of heading No. 94.06) and parts of structures, aluminum plates, rods, profiles, tubes and the like, prepared for use in structures	..	53 038	..	35 262
		(number 000)		(number 000)	
7611.00	Aluminum reservoirs, tanks, vats and similar containers	1	2 015	...	1 188

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(number)	($000)	(number)	($000)
EXPORTS (cont'd)					
76.12	Aluminum casks, drums, cans, boxes and similar containers	204 730	24 144	142 590	22 381
7613.00	Aluminum containers for compressed or liquefied gas	58	4 095	...	3 303
		(tonnes)		**(tonnes)**	
76.14	Stranded wire, cables, plaited bands and the like, of aluminum, not electrically insulated	7 557	21 558	1 395	4 693
76.15	Table, kitchen or other household articles and parts thereof, of aluminum	..	7 998	..	6 284
76.16	Other articles of aluminum	..	58 776	..	53 344

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available or not applicable; ... Amount too small to be expressed; p Preliminary.
1 Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, ALUMINUM SMELTER CAPACITY

Company	As of December 31, 1991
	(tonnes/year)
Alcan Aluminium Limited	
Quebec	
Grande Baie	171 000
Jonquière (Arvida)	232 000
Isle-Maligne	73 000
Shawinigan	84 000
Beauharnois	47 000
Laterrière	200 000
British Columbia	
Kitimat	268 000
Total Alcan capacity	1 075 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie Comeau	400 000
Aluminerie de Bécancour Inc.	
Quebec	
Bécancour	360 000
Total Canadian capacity	1 835 000

Source: Energy, Mines and Resources Canada.

TABLE 3. CANADA, CONSUMPTION[1] OF ALUMINUM METAL AT FIRST PROCESSING STAGE, 1988-90

	1988	1989[a]	1990[a]
		(tonnes)	
CASTINGS			
Sand	2 193r	2 512r	2 433
Permanent mould	23 221r	33 872r	38 837
Die and other	52 217	53 635r	67 316
Total	77 631r	90 019r	108 586
WROUGHT PRODUCTS			
Extrusions, including tubing	147 213	138 656	123 962
Sheet, plate, coil and foil	153 877	152 340	131 625
Other wrought products (including rods, forgings and slugs)	75 637	71 820r	72 063
Total	376 727	362 816r	327 650
OTHER USES			
Destructive uses (deoxidizer), non-aluminum base alloys, powder and paste and other uses	34 113r	50 475r	28 257
Total consumed	488 471r	503 310	464 493
Secondary aluminum[2]	113 131	107 598r	141 583

	Metal Entering Plant			On Hand December 31		
	1988r	1989r	1990	1988	1989r	1990
Primary aluminum ingot and alloys	444 444	445 946	411 897	33 369r	24 495	15 719
Secondary aluminum	56 152	59 780	67 509	4 266r	4 119	4 054
Scrap originating outside plant	136 873	123 560	138 313	10 101r	6 596	7 166
Total	637 469	629 286r	617 719	47 736r	35 210	26 939
Aluminum shipments[3]				26 577	33 277	23 696

r Revised.
a Increase in number of companies being surveyed. Therefore, closing inventory of previous year does not equal opening inventory of current year.
1 Available data as reported by consumers. 2 Aluminum metal used in the production of secondary aluminum is not included in consumption totals. 3 Aluminum metal shipped without change. Does not refer to shipments of goods of own manufacture.

TABLE 4. AVERAGE ALUMINUM PRICES

Year	Month	LME Cash[1]	M.W. U.S. Markets[1]
		(US¢/lb)	
ANNUAL AVERAGES			
1980		80.7	76.1
1981		57.3	59.8
1982		45.0	46.8
1983		65.3	68.3
1984		56.5	61.1
1985		47.9	48.8
1986		52.2	55.9
1987		70.8	72.3
1988		117.3	110.1
1989		88.5	87.8
1990		74.4	75.0
1991		59.1	60.0
MONTHLY AVERAGES			
1990	January	69.3	69.7
	February	66.0	65.5
	March	71.1	70.9
	April	69.2	71.6
	May	69.3	72.3
	June	71.0	73.1
	July	71.3	72.6
	August	80.8	80.3
	September	93.7	88.1
	October	88.3	82.2
	November	73.4	72.5
	December	69.1	69.8
1991	January	68.8	69.4
	February	68.3	68.9
	March	67.9	68.3
	April	63.2	63.9
	May	58.8	59.3
	June	57.9	57.7
	July	58.8	58.9
	August	57.1	57.6
	September	54.9	55.7
	October	52.2	53.2
	November	51.5	52.5
	December	49.8	50.6

Source: "Metals Week."
[1] Highest grade sold.

TABLE 5. WORLD MINE PRODUCTION OF BAUXITE

	1988	1989	1990
		(000 tonnes)	
EUROPE			
France	977.7	719.8	636.0
Greece	2 533.0	2 576.0	2 504.0
Yugoslavia	3 034.0	3 252.0	2 951.0
Other	19.5	11.7	–
Total	6 564.3	6 559.5	6 091.0
AFRICA			
Ghana	284.5	381.2	381.3
Guinea	16 800.0	17 500.0	17 524.0
Mozambique	6.5	5.5	7.2
Sierra Leone	1 403.0	1 562.0	1 445.0
Total	18 494.0	19 448.7	19 357.5
ASIA			
India	3 828.7	4 345.0	4 340.0
Indonesia	513.1	862.3	1 205.7
Malaysia	361.0	355.2	398.2
Pakistan	3.0	2.0	3.0
Turkey	269.0	561.5	779.0
Iran	93.0	100.0	100.0
Total	5 067.8	6 226.0	6 825.9
AMERICAS			
United States	588.0	670.0	496.0
Brazil	7 727.6	7 893.8	9 875.6
Dominican Republic	167.8	164.5	85.2
Guyana	1 773.9	1 340.0	1 424.0
Jamaica	7 408.4	9 394.9	10 936.7
Surinam	3 434.4	3 530.0	3 266.8
Venezuela	550.0	701.8	771.0
Total	21 650.1	23 695.0	26 855.3
AUSTRALASIA			
Australia	36 370.0	38 583.0	41 391.0
EASTERN COUNTRIES			
People's Republic of China	4 600.0	4 800.0	4 200.0
Hungary	2 906.4	2 643.5	2 559.1
Romania	356.0	313.0	204.0
U.S.S.R.	5 900.0	5 750.0	5 350.0
Albania	38.0	35.0	26.0
Total	13 800.4	13 541.5	12 339.1
Total world	101 946.6	108 053.7	112 859.8

Source: Energy, Mines and Resources Canada.
– Nil.

TABLE 6. WORLD PRODUCTION OF ALUMINA (HYDRATE)

	1988	1989	1990
		(000 tonnes)	
EUROPE			
France	737.4	624.0	606.0
Germany, Federal Republic of	1 162.8	1 174.0	1 165.0[a]
Greece	532.1	533.0	585.0
Ireland	879.0	891.0	926.0
Italy	704.6	722.2	752.0
Spain	880.5	949.1	1 002.0
United Kingdom	114.0	116.2	131.0
Yugoslavia	1 174.0	1 240.0	1 086.0
Total	6 148.4	6 249.8	6 253.0
AFRICA			
Guinea	593.0	626.8	642.0
ASIA			
India	1 188.0	1 418.5	1 334.0
Japan	778.0	863.4	890.0
Turkey	181.7	200.6	177.0
Total	2 147.7	2 482.5	2 401.0
AMERICAS			
Brazil	1 417.0	1 624.4	1 653.0
Canada	992.6	1 048.4	1 087.0
Jamaica	1 520.0	2 205.0	2 869.0
Surinam	1 632.0	1 567.1	1 532.0
United States	4 995.0	4 893.6	5 430.0
Venezuela	1 284.0	1 290.2	1 405.0
Total	11 840.8	12 630.7	13 976.0
AUSTRALASIA			
Australia	10 511.0	10 823.0	11 231.0
EASTERN COUNTRIES			
Czechoslovakia	167.0	205.0	209.0
Germany, Democratic Republic of	64.0	63.0	–
Hungary	881.0	891.0	831.0
Romania	620.1	610.8	400.0
U.S.S.R.	4 400.0	4 800.0	4 000.0
China, People's Republic of	1 900.0	1 900.0	1 700.0
Total	8 031.1	8 469.8	7 140.0
Total world	39 309.0	41 282.6	41 643.0

Source: Energy, Mines and Resources Canada.
– Nil.
[a] 1990 data include production from the former German Democratic Republic.

TABLE 7. WORLD PRODUCTION OF ALUMINUM

	1988	1989	1990	1991[e]
		(000 tonnes)		
EUROPE				
France	327.7	334.9	325.9	280.5
Germany, Federal Republic of	744.1	742.0	720.3[a]	690.3[a]
Italy	226.3	219.3	231.9	224.6
Netherlands	270.7	274.1	270.0	253.6
Norway	826.6	859.0	871.1	874.2
United Kingdom	300.2	297.3	289.8	293.5
Yugoslavia	321.9	342.1	350.5	308.9
Other	790.9	850.6	850.2	834.2
Total	3 808.4	3 919.3	3 909.7	3 759.8
AFRICA				
Total	597.0	603.6	601.1	611.9
ASIA				
Bahrain	182.8	186.4	212.0	212.0
Dubai	162.5	168.0	174.3	239.0
India	334.5	423.4	433.2	505.1
Indonesia	185.1	196.9	192.1	173.1
Japan	35.3	35.0	34.2	32.4
Other	114.2	121.0	127.9	136.9
Total	1 014.4	1 105.6	1 179.4	1 298.5
AMERICAS				
Brazil	873.5	887.9	930.6	1 139.6
Canada	1 534.5	1 554.8	1 567.4	1 821.6
United States	3 944.5	4 030.2	4 048.3	4 121.2
Venezuela	443.4	546.0	594.0	609.7
Other	235.5	262.6	164.4	247.3
Total	7 031.4	7 281.5	7 404.7	7 938.8
AUSTRALASIA				
Australia	1 141.3	1 241.3	1 232.7	1 228.6
New Zealand	255.6	257.5	259.7	226.4
Total	1 396.9	1 498.8	1 492.4	1 455.0
EASTERN COUNTRIES				
China, People's Republic of	713.0	744.4	855.0	..
U.S.S.R.	2 440.0	2 500.0	2 200.0	..
Other	517.2	515.3	389.8	..
Total	3 629.6	3 759.7	3 444.8	3 500.0
Total world	17 442.8	18 229.5	18 182.3	18 564.0

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
.. Not available; [e] Estimated.
[a] Data include production in the former German Democratic Republic.

TABLE 8. WORLD CONSUMPTION OF ALUMINUM

	1988	1989	1990	1991[e]
		(000 tonnes)		
EUROPE				
Belgium/Luxembourg	302.3	302.1	317.8	323.0
France	660.6	684.5	720.9	678.0
Germany, Federal Republic of	1 232.6	1 290.0	1 295.4	1 407.0[a]
Italy	581.0	607.0	652.0	684.0
Spain	268.0	273.4	287.1	313.0
United Kingdom	427.4	454.7	453.7	438.0
Yugoslavia	189.0	229.0	168.4	169.0
Other	826.9	880.7	871.9	765.0
Total	4 487.8	4 721.4	4 767.2	4 777.0
AFRICA				
Total	226.5	245.2	222.5	230.0
ASIA				
India	325.0	420.0	420.0	457.0
Japan	2 123.2	2 203.9	2 414.3	2 390.0
Other	1 727.0	1 823.9	1 306.7	1 560.0
Total	3 511.2	3 769.9	4 141.0	4 287.0
AMERICAS				
Canada	437.2	459.1	387.2	415.0
United States	4 598.1	4 325.9	4 229.6	3 794.0
Brazil	393.0	418.3	341.3	356.0
Other	382.6	386.4	400.4	430.0
Total	5 810.9	5 589.7	5 358.5	4 987.0
AUSTRALASIA				
Total	358.4	354.7	314.8	298.0
EASTERN COUNTRIES				
Germany, Democratic Republic of	240.0	217.4	83.1	..
Hungary	207.1	195.2	133.6	148.0
U.S.S.R.	1 800.0	1 750.0	1 700.9	1 400.0
China, People's Republic of	630.0	700.0	650.0	820.0
Other	773.6	585.5	450.8	393.0
Total	3 391.1	3 448.1	3 018.4	2 761.0
Total world	17 813.9	18 129.0	17 822.4	17 345.0

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
.. Not available; [e] Estimated.
[a] Data include consumption in the former German Democratic Republic.

Figure 1

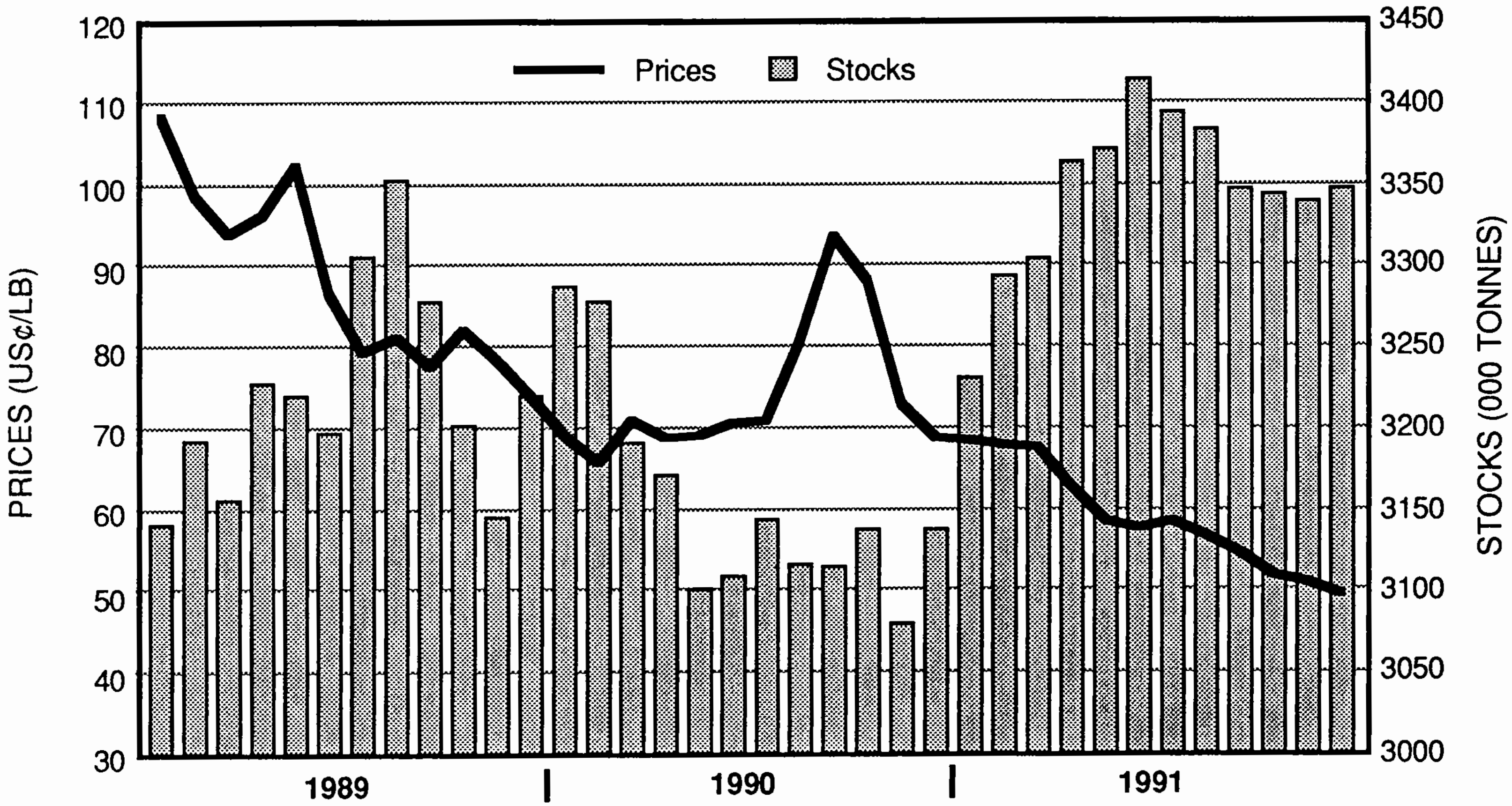
LONDON METAL EXCHANGE ALUMINUM PRICES
1989-91

Source: Energy, Mines and Resources Canada.

Figure 2

ALUMINUM PRICES AND STOCKS

(LME[1] SPOT PRICES AND IPAI[2] STOCKS)



Note: Stocks (all forms) and Average Monthly Prices.
1 London Metal Exchange. 2 International Primary Aluminum Institute.

Arsenic

Elaine Koren

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-8200

(For additional information, telephone Bill McCutcheon at (613) 992-5480.)

Arsenic occurs as a minor constituent of polymetallic sulphides mined primarily for their copper, lead, silver or gold content. Major arsenic-containing minerals are arsenopyrite (FeAsS), realgar (As_4S_4), and orpiment (As_2S_3). The arsenic content of the earth's crust is 1.5-2.0 mg/kg; arsenic ranks twentieth in abundance in relation to other elements. Oxidized forms of arsenic are usually found in sedimentary deposits. The elemental oxidation state, although stable in reducing environments, is rarely found. The table opposite provides some ranges of the arsenic content of crustal materials. High levels of arsenic may also occur in some coals. The average arsenic content of coal in Canada has been estimated at 0.3-320 mg/kg. In some coal mined in Czechoslovakia, the concentration of arsenic has been shown to be as high as 1500 mg/kg.

ARSENIC IN CRUSTAL MATERIALS

Type of Rock	Range of Arsenic Content
	(mg/kg)
IGNEOUS	
Ultrabasic	0.3 – 16
Basalts	0.06 – 113
Andesites	0.5 – 5.8
Granitic	0.2 – 13.8
Silicic, volcanic	0.2 – 12.1
SEDIMENTARY	
Limestones	0.1 – 20
Sandstones	0.6 – 120
Shales and clay	0.3 – 490
Phosphorites	0.4 – 188

CANADIAN DEVELOPMENTS

With the continued decline of the arsenic market and current environmental and health considerations, Royal Oak Resources Ltd.'s Giant Yellowknife Mines, located in the Northwest Territories, continues to stockpile its arsenic trioxide, which is recovered from dust and residues collected during the roasting of gold ores, in permanent underground stope encryptments.

Recovery technology includes the electrostatic precipitation of dust, cooling of the arsenic-containing gases, and collection of arsenic trioxide in the baghouse, which grades 85%-93%. Approximately 40 tonnes (t) of material was shipped to the United States for testing purposes.

With shifting priorities since the Royal Oak takeover, Giant's white arsenic oxide (WAROX) pilot plant project to treat crude arsenic trioxide (currently 85% pure) to produce high-quality industrial product (99% pure) has been placed on hold. This project would involve using sintered metal technology for recovering arsenic pentoxide to be used in the wood preservative industry.

Arsenic

Dickenson Mines' Red Lake Division had been recovering by-product arsenic from dusts and residues associated with the roasting of these ores and collected as impure arsenic trioxide, which was either purified on site or sold directly to a refiner. Given current environmental, health and economic considerations, roasting of the arsenic-rich ores has been discontinued since 1980. Instead, arsenic extraction occurs using bulk sulphide flotation yielding up to 50% recovery of arsenopyrite. The arsenopyrite not recovered through flotation reports to the backfill circuit as flotation tailings. These tailings are cycloned, with coarse fractions being recovered as mine backfill while undersized fractions are stored in underground stopes and tailings ponds, respectively.

The company's future plans will involve a decision on using either the bioleaching/bacterial oxidation (BIOX) process or a pressure oxidation process using an autoclave. It is expected that either choice will push the percentage of gold recovery to 92%. Current gold recovery is in the mid-80s. To date, the expected investment in the pressure oxidation process is approximately $25 million whereas the BIOX investment would be around $6 million.

On July 19, 1991, Placer Dome's Campbell mine brought an autoclave on stream; the roaster was shut down on July 20. The pressure oxidation process (99.9% O_2 completion) converts sulphides to sulphates. The arsenic combines with iron under temperature and pressure to form ferric arsenate, which is relatively environmentally benign. Other metals in solution formerly discharged to tailings are treated with lime form metal hydroxide precipitates. The ferric arsenate and metal sludges are pumped to a designated pond.

It is estimated that Placer Dome's payback will be within two and half years. Additional benefits include increased gold recovery, reduced cyanide and calcine consumption, use of a single-stage leach tank compared with the former multi-stage processing, and reduced metal losses in the tailings (from 0.25%-0.29% oz/t to 0.05%-0.1% oz/t).

Nerco Minerals, based in Vancouver, Washington, has stated that it will treat and stabilize toxic sludges that were produced at its Con mine in Yellowknife, Northwest Territories, between 1948 and 1970 using the pressure oxidation process. Nerco inherited approximately 40 000 t of arsenic-laden sludges when it purchased the mine from Cominco Ltd. in Vancouver in December 1986 for $46 million. Nerco Con Mine Ltd., the Yellowknife-based subsidiary that currently operates the mine, has been extracting arsenic-rich ores since June 1990 and stockpiling the mined materials while waiting for approval from the Northwest Territories Water Board, which reviewed the proposed technology in a plan submitted by the company in February 1991. With approvals given, the company plans to start up in the first week of July 1992.

Canadian arsenic production is produced as arsenic trioxide, a by-product of the treatment of arsenious gold ores. The value of Canadian arsenic trioxide shipments in 1991 is not available given that 40 t were shipped for laboratory testing in the United States, while the remainder of produced materials was either stored in underground stopes or converted to ferric arsenate for storage.

WORLD PRODUCTION

Although arsenic metal production ceased in 1987 following the closure of Boliden International Mining AB's old poly-metallic mine, arsenic trioxide production only stopped in April 1991. In 1990, the arsenic trioxide plant produced only 2000 t/y of its 15 000 t/y capacity from its diminishing stockpile.

According to the U.S. Bureau of Mines, major sources of arsenic trioxide include Peru and the Philippines (from copper ores), Chile (from copper-gold ores), and Canada (from gold ores). Worldwide arsenic metal reserves are estimated at approximately 1 Mt. Furthermore, it is estimated that world resources of copper and lead contain approximately 11 Mt of arsenic.

USES

In 1991, about 70% of arsenic was used in wood preservatives, 22% in agricultural chemicals, 4% in glass manufacturing, 2% in nonferrous alloys and 2% in other uses. The United States remains the world's largest consumer of arsenic, using over 50% of world production.

The wood-preserving chemicals most commonly used are chromated copper arsenate (CCA), ammoniacal copper arsenate (ACA), and fluorochrome arsenate phenol (FCAP). Arsenical wood preservatives are used wherever rot or insect damage may occur, such as in building foundations, fence posts, submerged footings and utility poles.

The agricultural share of arsenic use has dropped from over 80% a decade ago to the current 22%. Monosodium methane-arsenate (MSMA) and disodium methanearsenate (DSMA) are the most common agricultural arsenical chemicals. These compounds are used as herbicides, plant desiccants and defoliants, primarily in the cotton industry where they control grassy and broad-leaved weeds. Arsenicals are considered essential as growth regulators for grapefruit growers and for the control of some grape diseases.

The glass industry uses arsenic trioxide as a decolourizing and refining agent. Due to environmental concerns, the glass industry has been substituting arsenic acid for arsenic trioxide to reduce dust problems associated with handling the trioxide.

Arsenic metal is used as a minor alloying agent (0.01-0.05) in certain copper and lead-based alloys. When added to lead for use in acid storage batteries, arsenic strengthens the lead posts and grids to help withstand sudden jars. Arsenic is also added to lead in many countries, excluding the United States, to make shot for bullets. Arsenic increases the corrosion resistance and tensile strength of copper used in industrial plant piping and auto radiators. Arsenic trioxide can be used in place of arsenic metal in some alloying applications although it is more difficult to use and creates more environmental problems.

High-purity arsenic metal (99.999%) is used in the electronics industry. Gallium arsenide and its alloys are important semiconductors and are used in such products as light-emitting diodes, microwave devices, solar cells and photoemissive surfaces. Gallium arsenides have higher operating frequencies, lower power consumption, lower noise, and higher resistance to nuclear radiation than their silicon counterparts. Integrated circuits using gallium arsenide have extensive military applications.

SUBSTITUTES

Substitutes are increasingly being found for most of arsenic's major end uses, although arsenic may be the preferred material due to its lower cost and superior qualities. The wood preservatives pentachlorophenol and creosote may be substituted for chromated copper arsenate (CCA) and ammoniacal copper arsenate (ACA) where odour and paintability are not problems. Non-wood alternatives such as concrete and steel may be substituted for arsenical pressure-treated wood.

In agricultural uses, synthetic organic compounds, such as parquat, may be substituted for arsenical pesticides, herbicides and desiccants. To date, there are no available alternatives to arsenicals as growth regulators for grapefruit and for the control of some grape diseases.

The use of arsenic in the glass industry is declining. Corning Glass estimates that it uses nearly 900 t of 75% H_3AsO_4 liquid per year in the company's glass operations. Increasingly, cerium and cobalt are used mainly in conjunction with selenium as an oxidation-reduction buffer.

Arsenic use in alloying and brass is diminishing with new regulatory requirements to prevent site-specific usage, e.g., prohibiting the use of arsenic in any substances that may be in totally or partly submerged appliances or equipment.

Wide-ranging substitution of arsenic's major end uses may stem from the fact that arsenic is not widely recycled. For example, the losses at all stages of the manufacturing process for LEDs (light emitting diodes) are quite high. Only a fraction of the gallium arsenide in the original ingot ends up in usable devices. Some of these losses could be recycled. Companies specializing in gallium recovery from electronic scrap have begun to appear in Japan, the United States and Europe. The extent to which arsenic is also recycled is not known; however, given current environmental considerations, it is likely that the arsenic is recovered concurrently.

HEALTH AND SAFETY AND REGULATORY DEVELOPMENTS

Environmental arsenic exposure has received attention primarily because of diseases resulting from the ingestion of water containing inorganic arsenic. These diseases involve chronic arsenic poisoning. Examples include: non-malignant cutaneous changes such as skin cancers; "Blackfoot disease" (a form of arsenic-induced peripheral vascular deficiency leading to gangrene); peripheral neuropathy; and hematopoietic, renal, and hepatic toxicity. Reports have covered the ingestion of water containing less than 1000 µg/L of arsenic over a period of years.

An alternate route of arsenic exposure stems from the inhalation and ingestion of arsenic-containing dusts and fumes mainly emitted from smelters. There is conflicting evidence that such exposure is associated with an increased incidence of lung cancer. For example, a population survey around the former Tacoma smelter operated by ASARCO Incorporated indicated a correlation to lung cancer. At the same time, intensive studies undertaken by Indian and Northern Affairs Canada into the potential health effects of arsenic in Yellowknife, Northwest Territories, and other locations where arsenopyrite is roasted, were inconclusive and showed no such evidence. (Lung cancer has not been associated with the ingestion of arsenic-contaminated water.)

In Canada, arsenic and its compounds have been listed in Group 1 of the federal Priority Substances List. Through Environment Canada and Health and Welfare Canada, arsenic and its compounds have been assessed to determine whether they are toxic according to the definition specified in Section 11 of the *Canadian Environmental Protection Act* (CEPA). A final report with conclusions will be made available in the second quarter of 1992.

In the United States, arsenic and its compounds are regulated by the Occupational Safety and Health Administration (OSHA), which has set an eight-hour time-weighted occupational exposure limit for inorganic arsenic of 10 $\mu g/m^3$. Arsenic also falls under the Environmental Protection Agency's (EPA) Superfund legislation as the EPA is particularly interested in groundwater contamination and arsenic emissions.

In September 1991, the Commission of the European Communities issued council directives relating to restrictions on the marketing and use of arsenic and its compounds. These include prohibition of arsenic compounds for the following: prevention of fouling by micro-organisms, plants, or animals of the hulls of boats; cages, floats, nets and any other appliances or equipment used for fish or shellfish farming; any totally or partly submerged appliances or equipment; and preservation of wood. (The ban does not apply to solutions of inorganic salts of the CCA [copper-chromium-arsenic] type employed in industrial installations using vacuum or pressure to impregnate wood.)

Member States may authorize on their territory the use of preparations of the DFA (dinitrophenol-fluoride-arsenic) type for the retreatment in situ of wooden poles already in place and supporting overhead cables. These preparations must be employed by professionals using vacuum or pressure.

PRICES (US$)

At the beginning of 1991, the Chinese tried and failed to get a grip on the arsenic market. By the end of January, arsenic had traded up to $1.40/lb in frantic trade activity running counter to the general trend in base metals. Hong Kong traders were skeptical of the price increases, which are believed to be the work of a few European traders. Traders in China indicated that arsenic producers are unlikely to bring on stream idled capacity to meet the new demand after last year's experience. (Arsenic prices went from $0.50/lb in late 1989 to over $6.00/lb in early 1990 on similar supply scares.) Many producers that started up after the 1990 price increase shut down again after the price dropped. Given current economic and environmental conditions, these producers are reluctant to restart operations due to an uncertainty about the duration of the latest bull market. Observers speculate that arsenic prices may rise to approximately $2.00/lb. At year-end, the Chinese material was available in the U.S. free market for as little as $0.82-$0.85/lb in a cash market.

OUTLOOK

The outlook for arsenic is somewhat uncertain, although supplies are abundant and demand is expected to remain relatively flat. As arsenic is produced primarily as a by-product, its production is dependent on the demand for, and production of, other metals (copper, gold, lead and zinc). However, environmental concerns have reduced the demand for arsenic. Although substitutes exist for most uses, arsenical compounds are either the preferred or only product for specific uses (i.e., grapefruit orchards and grape vineyards).

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2811.29.10.20	Arsenic trioxide	9.2%	Free	1.8%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, ARSENIC PRODUCTION AND TRADE, 1989-91

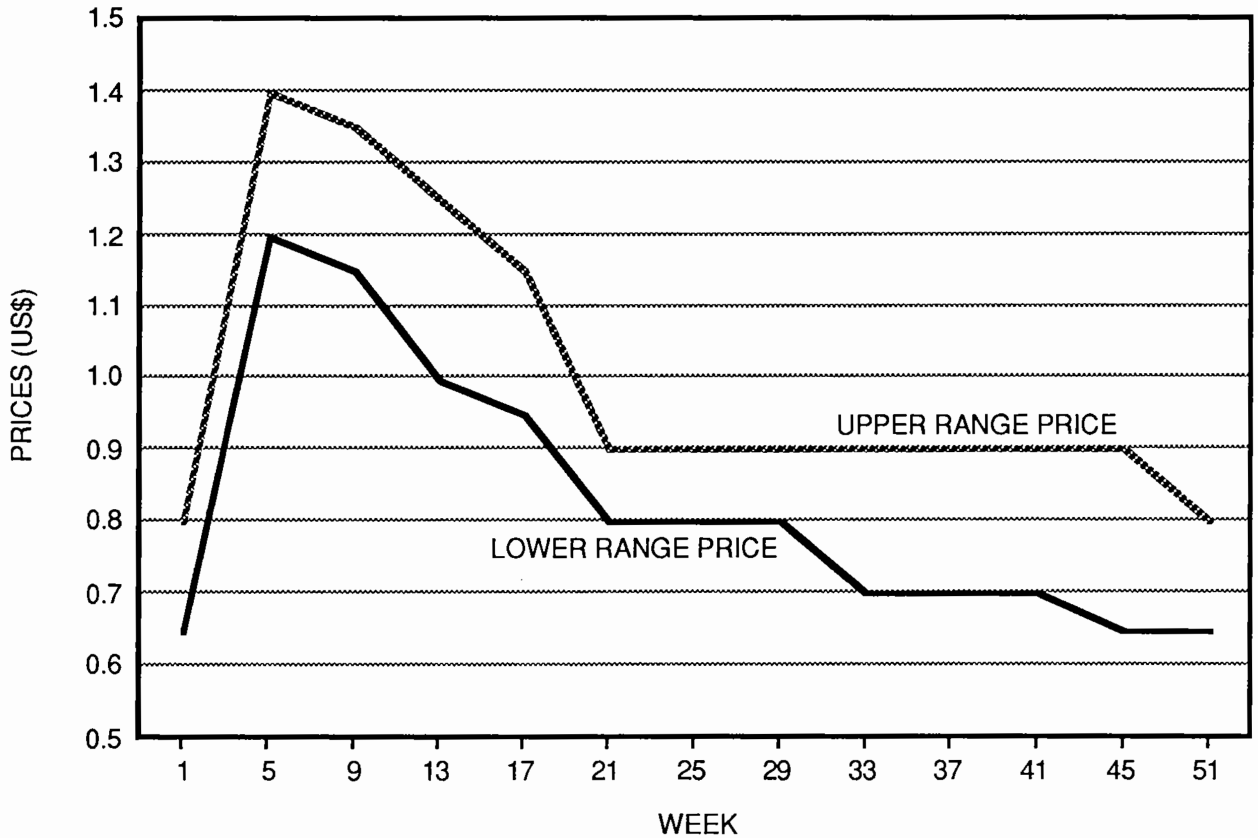
Item No.		1989		1990		1991p	
		(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
PRODUCTION							
	Arsenious trioxide						
	Northwest Territories	x	1 286	x	240	x	247
	Total	x	1 286	x	240	x	247
EXPORTS						**(Jan.-Sept.)**	
2804.80	Arsenic						
	United States	80 609	277	41 577	884	6 293	342
	Germany[1]	118 871	184	207	76	1	8
	Netherlands	–	–	6 000	54	–	–
	France	8 979	78	4	27	–	–
	Total	208 459	539	47 788	1 042	6 294	350
IMPORTS							
2804.80	Arsenic						
	United States	37 827	149	137 916	341	28 694	92
	People's Republic of China	29 304	49	59 381	255	7 117	20
	Japan	–	–	5 744	20	–	–
	Total	67 132	198	203 041	616	35 811	113
2811.29.10.10	Arsenic pentoxide						
	United States	363 765	269	910 324	691	824 572	739
	United Kingdom	184	...	–	–	131	...
	Total	363 949	269	910 324	691	824 703	739
2811.29.10.20	Arsenic trioxide						
	France	163 033	150	83 272	74	92 364	95
	United States	13 037	13	2 127	2	2 077	2
	Total	176 070	163	85 399	77	94 441	97

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; ... Amount too small to be expressed; p Preliminary; x Confidential.
[1] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

Figure 1

ARSENIC PRICES, 1991

(WEEKLY PRICES FROM THE METAL BULLETIN)



Asbestos

Patrick Morel-à-l'Huissier and Wanda M.A. Hoskin

*The authors are with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-3258 and (613) 992-5199, respectively.*

In 1991, Canadian asbestos production decreased 11.3% over 1990, due largely to the closure of the Baie Verte mine in Newfoundland and to problems at Cassiar's new underground McDame mine in British Columbia. Canadian mines operated at various rates: close to 100% of current capacity in Quebec, but at only about 63% in British Columbia. Average prices increased by about 8% to 10%. Total shipments for 1991 are estimated to be 670 368 tonnes (t) valued at $274.5 million, compared to revised figures for 1990 of shipments totalling 685 627 t valued at $272.1 million. The 2.2% decrease in shipments primarily reflected reductions in production due to the mine closure in Newfoundland and problems experienced in British Columbia. The demand for short fibres continued to decline. The U.S. Bureau of Mines estimates imports of Canadian asbestos at 36 822 t for 1991, compared to 40 380 t in 1990, with the decrease continuing to be due to the general negative impact of the U.S. Environmental Protection Agency's (EPA) 1989 final asbestos ban rule.

Canadian export volumes for 1991 are forecast to be about 632 000 t, which represents a decrease of 2.7% from the previous year, although the value of exports is expected to decrease by about 7%. Exports in the January-September 1991 period totalled 474 289 t valued at $289.3 million, compared to 471 493 t valued at $302.4 million for the same period in 1990.

Due to the closure of the Baie Verte mine, employment in asbestos mining/milling decreased by about 11%. In early March 1991, Cassiar experienced a two-week strike at its McDame underground mine.

CANADIAN DEVELOPMENTS

In 1990, Canadian developments involved J M Asbestos Inc., LAB Chrysotile, Inc., Princeton Mining Corporation (Cassiar), Baie Verte Mines Inc., and Teranov Mining Corporation.

As of May 1, 1991, the ownership of J M Asbestos Inc. was transferred from Jeffrey Mine Holding to the Groupe Minier d'Asbestos-Estrie, a holding company of 15 senior managers from the old company. The president of the new company is Bernard Coulombe. In July 1991, a new contract, approved by 85% of the workers, gave the workers 25% of the company as well as three of the nine administrative positions in compensation for monetary concessions. Extensive development work has started at the Jeffrey mine in order to access more ore and, therefore, extend the production of the mine into 1998. The first phase of development is supposed to be completed at the end of 1994. A second phase will start in 1995 and will maintain the production of the mine until 2005. In order to meet its development needs, the company will reduce its annual production capacity by 50 000 t to 250 000 t/y.

In order to avoid closure of the British-Canadian mine owned by Asbestos Corporation Limited and operated by LAB Chrysotile Inc., development work, which began in the summer of 1990, continued through 1991 to ensure its operation until

1997. Some exploration work at the Bell mine will be undertaken in 1992 in order to better define its reserves. LAB Chrysotile expects to increase its annual production by 5%-10% in the next couple of years. Its Black Lake mine currently has 22 years of proven reserves.

On February 4, 1991, Baie Verte Mines Inc. (BVM) closed the open-pit operation one month earlier than anticipated due to equipment problems. This closure happened 27 years after the mine started production and resulted in the permanent layoff of 390 employees. Access rights to one of the open pits for tailings disposal were given to Teranov Mining Corporation, the operator of the wet-milling process.

On the wet-milling process side, the legal battle between Princeton Mining Corporation (which owns 55% of the shares of Baie Verte Mines Reprocessing Inc. (BVMRI), owner of the new wet-process plant and technology) and Cliff Resources Corporation (which owns 45% of BVMRI) continued. The dispute commenced when BVMRI defaulted on a $4 million loan by Princeton Mining Corporation. Coopers & Lybrand were then appointed as receivers by Princeton. Teranov Mining Corporation was the successful bidder for BVMRI and started production in July 1991. There are currently about 72 employees at the wet mill, which had to temporarily shut down in December 1991 due to problems with frozen tailings. It is expected that this wet process will extend asbestos operations in Baie Verte, Newfoundland, by 15-20 years depending on market conditions.

In British Columbia, Cassiar Mining Corporation (Cassiar), owned by Princeton Mining Corporation, experienced technical and financial problems with the new McDame underground mine. It started when the block-caving technique used to extract asbestos produced blocks too big to handle. This problem was solved by installing an underground crusher. As other problems arose, Princeton Mining Corporation was forced to seek Court protection under the *Companies' Creditors Arrangement Act*. Under a Court order, Cassiar was granted 90 days from October 15, 1991, to complete its reorganization, after which it would no longer be under Court protection. Cassiar needs to develop new underground reserves as the current ones will only last until mid-1992. Cassiar is also seeking funds for starting the wet-process operation, which has been on hold since last year. This process will treat the 16 Mt tailings pile from the old open-pit operations grading 3.5% recovery.

INTERNATIONAL AND REGULATORY DEVELOPMENTS

The U.S. Fifth Circuit Court of Appeals of New Orleans finally rendered its judgement on October 18, 1991, on the EPA's final asbestos ban rule issued in July 1989. This judgement followed hearings that took place earlier in the year. Under this rule, the EPA expected to ban and phase out 96% of current asbestos uses in the United States by 1997. In remanding the EPA rule, the Court stated that "...because the EPA failed to muster substantial evidence to support its rule, we [the Court] remand this matter to the EPA for further consideration..." The Court was highly critical of the EPA, most notably for failing to implement the dictates of the *Toxic Substances Control Act* (TSCA) by improperly evaluating and choosing the least burdensome regulatory alternative. The EPA was also criticized for failing to evaluate the toxicity of likely substitute products. The EPA has until February 27, 1992, to use its last option, which is to ask for a review by the U.S. Supreme Court.

A U.S. Democrat for California, Peter Stark, introduced a bill in the House of Representatives on November 22, 1991, in order to impose a $150/t excise tax on the production and import of asbestos into the United States. This bill is seen as an attempt to circumvent the U.S. *Toxic Substances Control Act*, which is the basis for the Court judgement on the EPA asbestos ruling. If successful, this bill could result in a de facto indirect ban on the use of asbestos.

On January 30, 1991, the EPA issued drinking water standards for 33 contaminants, including asbestos. The standard establishes a maximum contaminant level of 7 million fibres (f) per litre of water. The fibres have to be greater than 10 micrometres in length. These new standards become effective in 1992.

In 1991, the Japan Asbestos Association established new, tougher autonomous standard values for the concentration of asbestos dust in occupational environments. Old values determined under the Ministry of Labour "Work Environment Evaluation Standards" were set at 2 f/cm^3 for both chrysotile and amosite. The new standard values for airborne asbestos, as drawn up by the Japan Asbestos Association, are 1 f/cm^3 for chrysotile and 0.5 f/cm^3 for amosite. Standards were established not only for concentration levels in the working environment, but also for occupational exposure levels. The target date for final achievement of these new standards by member companies is May 1992. It is also the opinion of the Japan Asbestos Association that the controlled use of asbestos, as adopted by the International Labour Organization, is possible. Japan is being very progressive in setting standards for occupational fibre/dust which include, but are not limited to, asbestos.

In 1991, asbestos became an issue for the United Nations Conference on Environment and Development to be held in June 1992 in Rio de Janeiro, Brazil. The main goal of this conference is to issue a plan of action on issues related to the environment and economic development for the 21st century; the plan of action is known as "Agenda 21." In Geneva, at the third preparatory meeting for the conference, Venezuela, supported by Colombia, was successful in proposing the inclusion of specific references to asbestos in three paragraphs. Because of the disagreement of countries such as Canada, the paragraphs are subject to further discussions at the fourth preparatory meeting in New York in March 1992. Controlled use remains the most sensible option for protecting workers, the public and the environment.

The European Community (EC) completed a review and amendment of its asbestos workplace directive in December 1990. The limit for concentration of asbestos fibres in the air at the place of work was reduced as follows: for chrysotile (white) asbestos, from 1 f/cm^3 to 0.6 f/cm^3, and for amosite (brown) asbestos, from 0.5 f/cm^3 to 0.3 f/cm^3, with crocidolite (blue) asbestos levels remaining at 0.3 f/cm^3. In addition, the action level was reduced from 0.25 f/cm^3 to 0.20 f/cm^3. These stricter regulations are still achievable by industry and serve to increase worker protection.

The Germans are proceeding with their own legislation in order to ban the importation of asbestos-containing products and building material. It is known as "Asbestverbotsverordnung." If Germany continues its fight against asbestos, the country will be virtually asbestos free by the end of 1994. Germany's motivation is largely economic as it is the largest producer of synthetic fibres in Europe. Italy has also introduced legislation that would ban asbestos use by 1995. However, the EC continues to support the controlled-use approach.

Poland is also proceeding with the introduction of regulations for the use of asbestos. By 1996, asbestos consumption would be reduced to 50% of today's level, and asbestos could be totally eliminated by the year 2000. Working conditions in Poland are in a deteriorated condition and the Montreal-based Asbestos Institute has been holding health and safety seminars there.

In Greece, the only mine in operation in the EC faced major problems, both on the labour side and on the financial side, leading to its shut-down. The Greek government was considering renting it out or privatization. The mine capacity is 100 000 t/y, and production was about 65% of capacity.

In Swaziland, the Havelock mine shut down in January 1991 as the Swazi government refused to further subsidize the mine and the associated infrastructure. As a result, the mine was put on "care and maintenance" while Coopers & Lybrand and Price Waterhouse were appointed to look at the possible privatization of the operation. Later in the year, a new joint venture company, 85% owned by the South African company Consolidated Mining Corporation, and 15% owned by the Swazi government, took over the Havelock mine and immediately renamed it the Bulembu mine. The new mine employs less than half of the 2000 original miners.

In China, where about 45 asbestos mines are in operation, production for 1991 is estimated at 200 000 t, which is a 5% increase over 1990. Exports in 1991 are expected to be about 10 000 t.

SCIENTIFIC DEVELOPMENTS

On a more positive side, on September 25, 1991, the U.S. Health Effects Institute-Asbestos Research (HEI-AR) released the report of its Asbestos Literature Review Panel. This study, which started in 1988, was undertaken at the request of the U.S. Congress and the U.S. EPA. The purpose of the study was to determine the airborne exposure levels prevalent in buildings, to characterize peak exposure and their significance, and to evaluate the effectiveness of asbestos management and abatement strategies in a scientifically meaningful manner. The main conclusion of this report, which represents the most extensive review of the present knowledge concerning asbestos in the air of public and commercial buildings and its potential for adverse health effects, is that asbestos-containing material within buildings in good repair is unlikely to expose office workers and occupants to airborne asbestos fibre concentrations above the levels found in the air outside such buildings. From all data pooled, the mean exposure value observed was 0.00027 f/cm^3; for comparative purposes, in 1989, the World Health Organization recommended a worker exposure level of 1 f/cm^3 for chrysotile asbestos. The report also acknowledges that the removal of asbestos poses the greatest risk of potential exposure and that certain workers in categories with a potential for disturbing asbestos are at a greater risk than others. This report confirms the January 1990 article in the New England Journal of Medicine by Dr. B.T. Mossman (et al).

The article stated that: "...even with damaged asbestos containing materials, the levels of airborne asbestos are magnitudes lower than concentrations in the unregulated workplace in the past and approximately 1/100 of the permissible exposure of 0.2 f/cc in the U.S. workplace." In its recent booklet entitled "Managing Asbestos in Place," the U.S. EPA now relegates removal as a last resort.

Asbestos-containing car friction materials, when used with old systems, are reported to be at the centre of a dispute involving health on one side and auto safety on the other. At issue is whether or not the regulations governing the safety of workers making or repairing brakes are creating a safety risk for motorists. The new non-asbestos brakes are said to be performing differently at various speeds and in different weather conditions, thus reducing considerably the reliability and safety of such brakes. New car brake systems are being designed in order to compensate for the inconsistencies of substitute material such as glass, mineral wool and ceramic fibres, which may also be as much of a health issue as asbestos when more data become available.

The Asbestos Institute sponsored the "International Conference on Asbestos Products" that was held in Kuala Lumpur, Malaysia, November 3-6, 1991. Approximately 230 persons from 34 countries listened to 28 presentations on topics ranging from health facts on asbestos to new product developments. The conference again showed the versatility and cost-effectiveness of asbestos in comparison with its substitutes, and that asbestos-containing products are economic and safe to make and are the products of choice in many countries.

OTHER FIBRES

Non-asbestos fibrous materials, many of which are used as asbestos substitutes, are coming under increasing scrutiny in the workplace. The HEI-AR report expresses concern about the substitutes for asbestos and states that "in view of the growing numbers of different types of man-made fibres that are entering commerce to substitute for asbestos, as a result of the phase-out of asbestos itself, detailed material characterization and biological testing of such fibres should precede their widespread dissemination into the human environment." Investigations on the health and/or environmental effects of substitute fibres are ongoing in many countries and international organizations.

The International Fibre Safety Group (IFSG) was created in June 1991 in Moscow with the mandate to promote the safe use, not only of asbestos, but of all fibres, natural and man-made. The founding members represent 80% of the world's asbestos production and 66% of the world's consumption. The provisional president of IFSG is Michel Gratton, who is also the president of the Asbestos Institute based in Montreal, Quebec. Membership of this new group is growing rapidly and 1992 should be a critical year in determining its future as well as its main focus.

OUTLOOK

The U.S. Court decision, although a positive step for the asbestos industry, will not turn the market around overnight. However, it is expected that world demand for asbestos will remain strong, especially in Asian-Pacific markets and in many developing countries. The new situation in the Commonwealth of Independent States (C.I.S.) is unclear; Russia, which forms most of the C.I.S., was the biggest world producer and actions by some members of the new C.I.S. may have implications on the asbestos world market.

It is anticipated that demand for grades 3 and 4 fibre used in inexpensive asbestos-cement building materials, such as roofing tiles, siding, asbestos sheet and asbestos-cement pipe, will continue to remain strong through the next year due to worldwide housing needs. The demand for shorter fibres is expected to continue to weaken. Asbestos production is expected to remain stable in Quebec and in Newfoundland; however, the future of Cassiar Mining Corporation in British Columbia is uncertain and production could be reduced to zero in the event of its bankruptcy.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2524.00.10	Crude asbestos	Free	Free	Free	Free
2524.00.90	Other asbestos	8%	5%	Free	Free
6811.10	Corrugated sheets of asbestos-cement, of cellulose fibre-cement or the like	8%	5%	1.6%	Free
6811.20	Sheets n.e.s., panels/tiles etc. of asbestos-cement, cellulose fibre-cement, etc.	8%	5%	1.6%	Free
6811.30	Tubes, pipes and tube or pipe fittings of asbestos-cement, of cellulose fibre-cement, etc.	8%	5%	1.6%	0.1¢/kg
6811.90	Articles n.e.s. of asbestos-cement, of cellulose fibre-cement, or the like	8%	5%	1.6%	Free
6812.10	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate	8%	5%	1.6%	Free
6812.20	Asbestos yarn and thread	12.5%	X	2.5%	Free
6812.30	Asbestos cords and string, whether or not plaited	12.5%	X	2.5%	Free
6812.40	Asbestos woven or knitted fabric	8%	5%	5%	Free
6812.50	Asbestos clothing, clothing accessories, footwear and headgear	25%	X	5%	1.2%-5%
6812.60	Asbestos paper, millboard and felt	8%	5%	1.6%	Free
6812.70	Compressed asbestos fibre jointing, in sheets or rolls	8%	5%	1.6%	Free
6812.90.10	Asbestos belting	17.5%	7.5%	3.5%	Free
6812.90.90	Other asbestos fabricated products n.e.s.	8%	5%	1.6%	Free
6813.10.10	Asbestos brake linings and pads for motor vehicles of heading Nos. 87.02, 87.03, 87.04 or 87.05	11.3%	Free	6.7%	Free
6813.10.90	Other asbestos brake linings and pads	8%	5%	4.8%	Free
6813.90.10	Asbestos clutch facings for motor vehicles of heading Nos. 87.02, 87.03, 87.04 or 87.05	11.3%	7.5%	6.7%	Free
6813.90.90	Other asbestos friction material and articles n.e.s.	9.2%	2.5%	5.5%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.
n.e.s. Not elsewhere specified.
Note: The Governor in Council may, on the recommendation of the Minister of Finance, by order, substitute a rate of customs duty for the symbol "X" in the General Preferential Tariff.

Asbestos

TABLE 1. CANADA, ASBESTOS PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION (SHIPMENTS)[1]					
	By type				
	Crude, groups 1, 2 and other milled	–	–	. .	. .
	Group 3, spinning	6 902	5 034	. .	. .
	Group 4, shingle	170 532	94 419	. .	. .
	Group 5, paper	201 613	95 581	. .	. .
	Group 6, stucco	171 886	52 776	. .	. .
	Group 7, refuse	134 694	24 292	. .	. .
	Total	685 627	272 102	670 368	274 535
	By province				
	Quebec	524 466	190 263	593 000	223 150
	British Columbia	88 990	52 834	66 785	47 362
	Newfoundland	72 171	29 005	10 583	4 023
	Total	685 627	272 102	670 368	274 535
EXPORTS				(Jan.-Sept.)	
2524.00.10	Crude asbestos				
	EC countries (12)[1]				
	Japan	1 150	384	1 159	385
	United States	188	164	231	174
	Taiwan	97	148	–	–
	Other countries	34	14	17	7
	Total	1 469	710	1 407	566
2524.00.21	Asbestos milled fibres, group 3 grades				
	EC countries (12)[1]				
	Spain	2 519	3 151	1 865	2 423
	Italy	313	397	646	791
	United Kingdom	1 329	1 800	226	311
	Portugal	160	245	120	184
	Belgium	–	–	107	135
	Germany[2]	302	448	84	99
	France	180	277	40	56
	EC countries subtotal	4 803	6 318	3 088	3 999
	Mexico	445	694	750	1 030
	South Korea	575	801	700	980
	Japan	624	863	509	754
	India	1 095	1 410	485	678
	Turkey	453	588	500	650
	Brazil	525	939	384	557
	People's Republic of China	471	631	288	354
	United States	840	252	226	311
	Venezuela	100	140	100	140
	Sri Lanka	786	633	–	–
	Bulgaria	140	182	–	–
	Other countries	305	426	1 113	745
	Total	11 162	13 877	8 143	10 198
2524.00.22	Asbestos milled fibres, groups 4 and 5 grades				
	EC countries (12)[1]				
	Italy	35 760	29 526	23 272	19 152
	France	28 428	23 070	17 614	14 460
	Spain	12 942	12 771	14 885	13 520
	Belgium	8 926	8 153	6 496	6 315
	Netherlands	4 958	4 924	3 110	3 309
	United Kingdom	7 472	6 838	3 529	3 288
	Germany[2]	7 318	6 453	1 426	1 118
	Other EC countries	8 952	9 060	4 168	4 280
	EC countries subtotal	114 756	100 795	74 500	65 442

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
	Thailand	35 953	26 044	34 372	25 828
	Japan	39 427	31 868	25 854	22 025
	India	30 351	24 595	14 979	11 880
	Malaysia	15 788	12 762	12 099	9 688
	Mexico	9 909	8 420	6 416	5 184
	Indonesia	7 837	5 098	7 336	4 871
	Algeria	11 670	9 858	7 250	4 614
	Colombia	10 649	7 877	5 689	4 611
	Sri Lanka	5 097	4 935	2 597	2 454
	Iran	24 267	24 819	1 940	1 834
	United States	2 168	700	63	26
	Other countries	59 040	51 824	42 098	36 567
	Total	366 912	309 595	235 193	195 024
2524.00.29	Asbestos shorts, groups 6, 7, 8 and 9 grades				
	EC countries (12)[1]				
	Italy	7 802	2 593	9 083	3 043
	Spain	7 367	2 667	5 444	2 097
	France	10 492	3 497	5 726	1 763
	Belgium	6 974	2 417	4 814	1 727
	United Kingdom	5 066	1 937	3 369	1 148
	Germany[2]	4 354	1 299	1 635	400
	Other EC countries	6 111	2 522	4 045	1 695
	EC countries subtotal	48 166	16 932	34 116	11 873
	Japan	54 507	17 852	38 099	13 986
	South Korea	25 442	8 767	36 490	13 321
	Thailand	32 740	13 900	30 851	13 093
	United States	37 224	11 343	26 427	7 788
	Mexico	12 454	4 332	12 062	4 469
	India	10 554	3 483	10 143	4 219
	Indonesia	4 846	1 754	4 540	1 680
	Taiwan	6 971	2 242	3 445	1 026
	Turkey	3 190	1 385	2 068	896
	Algeria	2 683	1 361	1 200	548
	Other countries	31 165	11 324	30 105	10 699
	Total	269 942	94 675	229 546	83 598
Grand total, crude, milled fibres and shorts		649 485	418 857	474 289	289 386
6811.10	Corrugated sheets of asbestos-cement, of cellulose fibre-cement, or the like				
	United States	. .	1 012	. .	255
	Total	. .	1 012	. .	255
6811.20	Sheets, n.e.s., panels/tiles, etc., of asbestos-cement, cellulose fibre-cement, etc.				
	United States	. .	323	. .	1 072
	Total	. .	323	. .	1 072
6811.30	Tubes, pipes and tube or pipe fittings of asbestos-cement, of cellulose fibre-cement, etc.				
	United States	. .	21	. .	1
	Norway	. .	12	–	–
	Total	. .	33	. .	1
6811.90	Articles n.e.s. of asbestos-cement, of cellulose fibre-cement, or the like				
	United States	. .	66	. .	47
	United Kingdom	–	–	. .	15
	Total	. .	66	. .	62

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
6812.10	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate				
	United States	. .	2 512	. .	881
	United Kingdom	–	–	. .	27
	Australia	. .	96	. .	13
	Other countries	–	–	. .	10
	Total	. .	2 608	. .	931
6812.20	Asbestos yarn and thread				
	United Kingdom	–	–	30	180
	United States	86	414	17	152
	Chile	52	191	38	147
	Other countries	36	145	48	170
	Total	174	750	133	649
6812.30	Asbestos cords and string, whether or not plaited				
	United States	. .	6	. .	33
	Other countries	. .	5	–	–
	Total	. .	11	. .	33
6812.40	Asbestos woven or knitted fabric				
	United States	45	442	39	382
	United Kingdom	50	324	25	124
	Other countries	13	73	1	14
	Total	108	839	65	520
6812.50	Asbestos clothing, clothing accessories, footwear and headgear				
	Belgium	. .	237	–	–
	Sweden	. .	176	–	–
	Other countries	. .	77	. .	50
	Total	. .	490	. .	50
6812.60	Asbestos paper, millboard and felt				
	South Korea	. .	65	. .	63
	United States	. .	101	. .	4
	Singapore	. .	91	–	–
	Other countries	. .	114	. .	84
	Total	. .	371	. .	151
6812.70	Compressed asbestos fibre jointing, in sheets or rolls				
	United States	. .	1 068	. .	732
	Other countries	. .	4	. .	4
	Total	. .	1 072	. .	736
6812.90.10	Asbestos building materials				
	South Korea	. .	116	. .	812
	Thailand	. .	232	. .	69
	Indonesia	. .	191	. .	30
	Singapore	. .	303	. .	23
	Other countries	. .	222	. .	60
	Total	. .	1 064	. .	994
6812.90.90	Other asbestos fabricated products n.e.s.				
	Cuba	–	–	. .	109
	United States	. .	55	. .	41
	U.S.S.R.	. .	172	–	–
	United Arab Emirates	. .	71	–	–
	Other countries	. .	100	. .	135
	Total	. .	398	. .	285

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
6813.10	Asbestos brake linings and pads				
	United States	. .	29 114	. .	25 619
	Other countries	. .	244	. .	474
	Total	. .	29 358	. .	26 093
6813.90	Asbestos friction material and articles n.e.s.				
	United States	. .	154	. .	1 239
	Other countries	. .	27	. .	94
	Total	. .	181	. .	1 333
Total exports, asbestos manufactured		. .	38 576	. .	33 165
IMPORTS					
2524.00.10	Crude asbestos	126	189	269	151
2524.00.90	Other asbestos	753	336	290	103
6811.10	Corrugated sheets of asbestos-cement, of cellulose fibre-cement, or the like	. .	55	. .	278
6811.20	Sheets n.e.s., panels/tiles, etc., of asbestos-cement, cellulose-fibre cement, etc.	. .	755	. .	393
6811.30	Tubes, pipes and tube or pipe fittings of asbestos-cement, cellulose fibre-cement, etc.	. .	638	. .	924
6811.90	Articles n.e.s., of asbestos-cement, cellulose fibre-cement or the like	. .	355	. .	87
6812.10	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate	. .	386	. .	341
6812.20	Asbestos yarn and thread	14	58	4	18
6812.30	Asbestos cords and string, whether or not plaited	. .	59	. .	66
6812.40	Asbestos woven or knitted fabric	36	489	37	559
6812.50	Asbestos clothing, clothing accessories, footwear and headgear	. .	239	. .	38
6812.60	Asbestos paper, millboard and felt	. .	471	. .	93
6812.70	Compressed asbestos fibre jointing, in sheets or rolls	75	1 000	68	822
6812.90.10	Asbestos belting	. .	11	–	–
6812.90.90	Other asbestos fabricated products n.e.s.	. .	3 215	. .	2 505
6813.10	Asbestos brake linings and pads	. .	33 475	. .	19 721
6813.90	Asbestos friction material and articles n.e.s.	. .	3 780	. .	4 108

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available or not applicable; n.e.s. Not elsewhere specified; p Preliminary.
1 EC includes Belgium, Denmark, France, West Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and the United Kingdom. 2 Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADIAN ASBESTOS PRODUCERS, 1991

Producers	Mine Location	Normal Mill Capacity Ore/Day	Normal Mill Capacity Fibre/Year	Remarks
		(tonnes)		
Teranov Mining Corp.	Baie Verte, Nfld.	4 000	25 000	Wet-processing of tailings started in July 1991. Open pit closed in February 1991.
LAB Chrysotile, Inc.[1]				Partnership owned 55% by LAQ and 45% by Société nationale de l'amiante (SNA).
- Lac d'Amiante du Québec, Ltée (LAQ)	Black Lake, Que.	9 000	160 000	Open-pit. Since September 1989, LAQ has been owned by Jean Dupéré (President of LAB) and Connell Bros. Company, Ltd. of the United States.
- Asbestos Corporation Limited British Canadian mine	Black Lake, Que.	7 000	70 000	(SNA) Quebec Crown corporation. Open-pit.
- Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2 700	70 000	(SNA) Quebec Crown corporation. Underground. Mine was re-opened January 1989.
J M Asbestos Inc. Jeffrey mine	Asbestos, Que.	15 000	300 000	Open-pit (effective capacity reduced by one half since 1982).
Cassiar Mining Corporation	Cassiar, B.C.	5 000	100 000	Underground McDame orebody came into full production in 1991. Study on wet-milling continues.
Total of four producers at year-end			720 000	

[1] A partnership involving three operating companies.

TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1984-91

	Crude	Milled	Shorts	Total
		(tonnes)		
PRODUCTION[1]				
1984	–	442 503	394 151	836 654
1985	–	397 729	352 461	750 190
1986	–	332 092	330 289	662 381
1987	–	365 144	299 402	664 546
1988	14	399 550	310 793	710 357
1989	–	410 588r	303 448r	714 036r
1990	–	379 047	306 580	685 627
1991p	..	..	..	..
EXPORTS				
1984	45	430 407	366 206	796 658
1985	44	395 158	326 311	721 513
1986	127	375 948	341 609	717 684
1987	1 696	353 321	293 808	648 825
1988	11 288	381 561	292 236	685 085
1989	17 198	379 601	312 915	709 714
1990	1 469	378 074	269 942	649 485
1991[2]	1 407	243 336	229 546	474 289

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; p Preliminary; r Revised.
[1] Producers' shipments. [2] January-September.

Bismuth

Elaine Koren

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-8200

(For additional information, telephone Bill McCutcheon at (613) 992-5480.)

The name bismuth comes from the German word *wismut* (probably white metal or meadow mines), latinized to *bisemutum* by Agricola, the German scientist in the 16th century. The crustal abundance of bismuth is estimated to be 0.0043-1.0 g/t. Although bismuth occurs in nature in its metallic state, the key bismuth-containing minerals are bismite (Bi_2O_3), bismuthinite (Bi_2S_3), bismutite $(BiO)_2CO_3 \cdot H_2O$, and galenobismutite ($PbBi_2S_4$). The major source of bismuth is as a by-product from the treatment of lead and copper ores. Bismuth is also found associated with molybdenum, gold, silver, tin, tungsten and zinc ores. Evidence indicates that bismuth is also associated with the sulphides in coal, which averages less than 0.05 parts per million Bi. Measurement of inputs of bismuth from volcanoes have indicated that volcanic emissions are the predominant source of bismuth in the atmosphere.

CANADIAN DEVELOPMENTS

Cominco Resources International Ltd. (Cominco) produces primary bismuth metal as a by-product of lead-zinc smelting and refining at the Trail complex in British Columbia. Nearly all of Cominco's bismuth production comes from lead concentrates produced at their Sullivan lead-zinc mine. Other sources include Red Dog mine concentrates, which have replaced Pine Point concentrates since 1989, and other domestic shippers. Bismuth is refined to +99.99% purity in batch-processing operations. Production in 1991 was down from previous years due to a declining market for lead and zinc and start-up problems at the Trail smelter.

Lead-bismuth alloys (6% Bi) are produced at Brunswick Mining and Smelting Corporation Limited in Belledune, New Brunswick. Production in 1991 was down due to a strike at the Belledune mine and smelter. Most of the feed comes from the Brunswick No. 12 mine in the form of lead concentrate containing small amounts of bismuth.

Lead-bismuth alloys are also produced at Curragh Resources Inc.'s Faro lead and zinc mine in the Yukon Territory. Production dropped initially as a result of the company's 20% retrenchment announced in February, and then due to the strike at its Faro mine and mill.

NovaGold Resources Inc. acquired the Mount Pleasant tin-tungsten-molybdenum-bismuth mine in New Brunswick from Billiton Metals Canada Inc. and LAC Minerals Ltd. for $12 million. The mine was run as a tin-tungsten operation from 1983 to 1985. The mine has geological reserves of 7 million tonnes (Mt) of ore grading 0.06% bismuth; the bismuth would be recovered as a by-product of the tin-tungsten production.

Canada's total bismuth production in 1991 was approximately 140 t, down by 50 t from 1990. Apparent bismuth consumption in 1991 was approximately 12 t.

WORLD DEVELOPMENTS

Belgium

Société Industrielle d'Études et d'Explorations Chimiques SA (Sidech SA), the major European producer of bismuth, had a 20% decline in production in 1991 due to many factors. First, Sidech lost approximately 60-80 t/y of bismuth from Les Mines de Salsigne, France's largest gold mine, which announced its decision to lay off 60 employees due to worsening financial conditions. Sidech received its last bullion from Salsigne in March when the latter decided to halt production. Secondly, Salsigne had adopted the cyanidation process for gold recovery instead of the former electrolytic process which allowed for the recovery of by-product bismuth. Finally, Sidech lost the output of a North American producer due to labour difficulties; it also lost approximately 50 t/y by discontinuing the treatment of bismuth from spent catalysts. The latter development resulted as a response to low bismuth and molybdenum prices that made it unprofitable to sell spent catalysts to processors like Sidech for treatment.

Japan

The revised estimate of Japan's largest bismuth deposits, formerly thought to be the world's largest, are only one sixth of previous estimates according to the Japanese Ministry of International Trade and Industry's latest analysis. The revised estimate is 8745 t, reducing the world's resources by 30%.

Mexico

In April, the Mexican producer Industrias Peñoles SA de CV (Peñoles) declared that its Met-Mex smelting and refining complex produced approximately 480 t of bismuth in 1989. The Torreon, Mexico lead smelter/refinery of Met-Mex has a capacity of 500 t/y of bismuth and 180 000 t/y of lead.

By June, Peñoles had reduced stock levels due to a month-long strike earlier in the year. At that time, Peñoles committed its output (approximately 40-50 t/m) through to the end of the year, almost half of which was going to one major North American consumer.

Republic of Korea

Korea Tungsten Mining Co. Ltd. announced that it would stop production of bismuth (which it produces as a by-product of scheelite) in the second half of the year. The company took this action in response to depressed tungsten prices, and this in turn affected its bismuth recovery. Korea Tungsten typically produces approximately 120-150 t/y of bismuth. However, in 1990, it produced 100 t and has estimated that it will produce 60 t in 1991. Production may resume if economic conditions improve.

United Kingdom

In February, Rio Tinto Zinc Corporation PLC (RTZ) closed its Capper Pass tin smelter. In 1990, Capper Pass recovered 150 t of bismuth as a by-product of tin production. The company indicated that the closure was due to a shortage of tin concentrates and the appreciation of the pound.

The principal refiner of bismuth in the United Kingdom, Mining and Chemical Products Ltd. (MCP), produced very little bismuth during the second quarter. Its main supplier, North Broken Hill-Peko (Australia), has decreased its ore production due to depressed market prices.

United States

ASARCO Incorporated is the sole primary producer of bismuth in the United States, but provides only one tenth of the total U.S. demand. Bismuth is recovered as a by-product of lead production at ASARCO's lead refinery at Omaha, Nebraska. Other potential resources include by-product recovery from molybdenum and tungsten processing. To date, most U.S. domestic reserves are uneconomic.

In February, the Defense Logistics Agency (DLA) sought Congressional approval to sell additional bismuth from the national stockpile after meeting its quota of 255 400 lb (115.85 t) for bismuth sales in the 1991 fiscal year. The total 1991 quota was awarded to Metalspecialities, the U.S. subsidiary of Metals & Chemical Products, in the United Kingdom. The DLA's goal is to reduce its inventory from the current amount of slightly less than 2 million lb (907.19 t) to 1.06 million lb (480.81 t).

In light of new restrictions being placed on lead use, the International Copper Association has been investigating bismuth as a future substitute for lead solder. At the same time, the U.S. copper industry continues to lobby Congress to fight these environmental restrictions.

In May, AT&T Bell Laboratories, a division of AT&T, announced its new lead-free copper alloy using bismuth instead of lead in the presence of tin and phosphorus to achieve free-machining properties. This alloy was developed in response to the U.S. Environmental Protection Agency's (EPA) pressures to eliminate lead-containing materials from potable water plumbing systems. (Eventually, only materials that are lead-free will be permitted.)

In September, the Argonne National Laboratory, in collaboration with Superconducting Products Co., announced one early result of their project to develop consistent production of 1000-foot lengths of practical wire using high-temperature superconductors. The product is a 30-inch coil of flexible superconducting tape made from a bismuth compound encased in silver. The tape loses all resistance to electricity when cooled by liquid nitrogen.

In October, Nibco Inc. revealed that it had become the first U.S. manufacturer of plumbing valves and fittings to offer a totally lead-free plumbing system. This development is in response to environmental and legislative pressures being exerted on the U.S. Congress to further restrict the use of lead as an alloy in plumbing products. Nibco is using the HydraPure system developed and patented by IMI Holdings of Yorkshire, England. The lead-free bronze fittings include phosphorous, tin, zinc and bismuth, which are combined with nonmetallic faucets.

At year-end, the United States was considering changing its trading practices with China (a key producer of strategic metals, including bismuth), which would include the imposition of special tariffs against China or the possible revocation of Most Favoured Nation (MFN) status.

USES

Bismuth is the most diamagnetic of all metals and its thermal conductivity is lower than any metal except mercury. It has a high electrical resistance, and has the highest Hall effect of any metal (i.e., the greatest increase in electrical resistance when placed in a magnetic field). *Bismanol* is a permanent magnet of high coercive force made of MnBi by the U.S. Naval Ordnance Laboratory.

Bismuth expands 3.32% on solidification which makes it particularly suited to forming sharp casings for objects subject to high temperatures. With other metals such as cadmium and tin, bismuth forms fusible low-melting alloys used extensively for safety devices in fire detection and extinguishing systems.

Bismuth is added to steel and aluminum to improve machinability, and to iron to improve processes for, and properties of, spheroidal graphite iron castings. Bismuth alloys provide self-lubricating properties to bearings. The metal is used as a thermocouple material (e.g., it has the highest negativity known) and has found application as a carrier for U^{235} or U^{233} fuel in atomic reactors.

Bismuth compounds are used in pharmaceuticals, medical diagnostics, cosmetics and chemicals. For example, bismuth subnitrate and subcarbonate are used in medicine. Bismuth salts are used in the treatment of indigestion and stomach ulcers. Bismuth oxychloride is used extensively in cosmetics: either deposited on mica or in dispersed form, it provides a pearlescent lustre to lipsticks, face powders, blushes, nail colour, eyeshadow and hairspray. Bismuth is also used in metallized paints. Catalysts containing bismuth are used in the production of acrylonitrile.

Bismuth is also being adopted as an alternative to cadmium in yellow pigment production both in North America and Europe. In Europe, there is strong environmental pressure on the use of cadmium in pigments and stabilizers. This is most widespread in Germany and the Nordic countries. To date, there has been a shift in consumption towards bismuth by major producers of pigments and stabilizers, such as BASF's move to organic alternatives such as bismuth vanadate.

In 1991, about 45% of bismuth was used in pharmaceuticals and chemicals, 33% in metallurgical additives, 20% in fusible alloys and solder, and 2% in other uses.

SUBSTITUTES

Substitutes are being found for most of bismuth's major end uses, although bismuth generally is the preferred material due to its lower cost and superior qualities. For example, bismuth pharmaceutical applications can be replaced by antibiotics, magnesium compounds and alumina compounds. Titanium dioxide-coated mica flakes, iron oxide-coated mica flakes and fish scales are substitutes in pigment uses. Cheaper lead salts are used where a non-toxic pigment is not necessary. Indium can replace bismuth in low-temperature solders, resins can replace bismuth alloys for holding jigs during machining, and glycerine-filled quartzite bulbs can replace bismuth alloys used to trigger devices for fire sprinklers.

HEALTH AND SAFETY AND REGULATORY DEVELOPMENTS

As a heavy metal, bismuth can be toxic. The metal is not listed by the U.S. EPA under the *Toxic Substances Control Act*, which regulates the manufacture, export and import of substances. AT&T toxicologists searched for recorded cases of bismuth poisoning or adverse health impacts and found none. However, concerns over possible health hazards of bismuth are prominent in the cosmetics industry. In July 1986, the Austrian government imposed a ban on the use of bismuth oxychloride in all cosmetics except nail varnish. To date, the use of bismuth oxychloride is unrestricted in Canada, the United States and European Community countries.

THE BISMUTH INSTITUTE

The Bismuth Institute was incorporated in 1973 in Bolivia and is now headquartered in Brussels, Belgium. This non-profit association is supported by financial contributions from its members in Australia, Belgium, Bolivia, England, Japan, Mexico and Peru. The Institute provides technical, research and market information on bismuth, solicits research proposals, and publishes a quarterly bulletin. At its June meeting in Mexico, the Institute focused on current market conditions, notably on increased demand and Western supply problems.

PRICES (US$)

At the beginning of 1991, the price of bismuth ranged from $0.90 to $2.80/lb in the consumer market and slightly lower, from $0.80 to $2.60/lb, for the inter-merchant market. In spite of increased Japanese imports in 1991, the expected price increase, possibly to $4.00/lb, did not materialize. (Japanese imports of bismuth including scrap totalled over 68.7 t during the January-March 1991 period.)

In April, bismuth prices remained firm, around $2.90-$3.15/lb, with producer sources reporting increased requests and sales of pharmaceutical-grade at $3.25/lb. According to the U.S. Bureau of Mines (USBM), U.S. consumption increased by 9% to 369.89 t over the fourth quarter of 1990. As expected, Mexico provided the bulk of U.S. imports of bismuth in the first quarter of 1991. However, supplies continued to be available from China at lower price levels of approximately $2.55/lb c.i.f., thereby deterring price increases.

At the end of May, in spite of increased demand, the price of bismuth remained at approximately $2.70-$3.00/lb due to the steady flow of Chinese material. Pharmaceutical-grade sales were reported at $3.00/lb. These prices remained firm at the end of the second quarter bucking the trend of other minor metals as there was no metal around. U.S. consumption of bismuth dropped 20% in the second quarter to 296.79 t, as reported by the USBM. This was attributed to decreased sales of bismuth chemicals and a reduction in the use of bismuth in the steel and aluminum industries.

By the end of the third quarter, bismuth traders reported firm demand and price quotes were generally at the upper end of the range of $3.10-$3.20/lb. At year-end, these prices remained firm.

OUTLOOK

The outlook for bismuth is somewhat encouraging given the broad scope of applications for the metal and increased long-term consumer demand, especially in the pharmaceuticals sector. To date, bismuth is classified as a "green" metal, and it will continue to replace other less-favoured metals on environmental grounds (e.g., lead, cadmium, etc.).

With increased uses being developed in all key applications and the development of new applications, which include reversible thermochromic pigments, high-temperature superconductors, and new alloys for use in solder and brass, the only barriers to a positive price outlook and ensured access to supply are the uncertainty in future lead production, depressed tungsten prices, and further shifts in U.S. trading practices with China.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2617.90.00.90	Bismuth ores and concentrates	Free	Free	Free	Free
8106.00.10	Unwrought bismuth, not alloyed; powders, not alloyed	Free	Free	Free	Free
8106.00.20	Unwrought bismuth, alloyed; waste and scrap; powders, alloyed; articles of bismuth	10.2%	6.5%	2%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, BISMUTH PRODUCTION AND TRADE, 1989-91, AND CONSUMPTION, 1988-90

Item No.		1989		1990		1991p	
		(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
PRODUCTION, All Forms[1]							
	New Brunswick	142 869	2 110	73 630	658	130 000	975
	British Columbia	13 000	192	637	6	9 042	68
	Yukon Territory	833	12	33	. . .	2	. . .
	Northwest Territories	25	. . .	–	–	–	–
	Total	156 727	2 315	74 300	664	139 044	1 043
EXPORTS						(Jan.-Sept.)	
8106.00	Bismuth and articles thereof, including waste and scrap						
	United States	27 258	433	130 166	848	23 128	199
	United Kingdom	500	. . .	–	–	–	–
	Total	27 758	433	130 166	848	23 128	199
IMPORTS							
8106.00.10	Unwrought bismuth, not alloyed; powders, not alloyed						
	United States	15 203	287	16 284	278	7 186	114
	Peru	–	–	–	–	4 014	28
	People's Republic of China	–	–	867	13	–	–
	Total	15 203	287	17 151	291	11 200	143
8106.00.20.10	Unwrought bismuth, alloyed; powders, alloyed; articles of bismuth						
	United States	10 012	225	12 945	245	12 302	278
	Total	10 012	225	12 945	245	12 302	278
8106.00.20.20	Bismuth waste and scrap						
	United States	2 107	33	9 807	147	555	9
	Total	2 107	33	9 807	147	555	9

	1988	1989a	1990p
		(kilograms)	
CONSUMPTION, Refined Metal (available data)			
Fusible alloys and other alloys	6 709b	15 890	11 882
Other uses	(c)	268	150
Total	6 709	16 158	12 032

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . . Amount too small to be expressed; p Preliminary.
a Increase in number of companies being surveyed. b Includes "other uses" to avoid disclosing confidential data. (c) Included in fusible alloys.
1 Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1975 AND 1980-91

	Production All Forms[1]	Consumption[2]
	(kilograms)	
1975	156 605	29 267
1980	149 366	10 271
1981	167 885	10 094
1982	189 000	10 074
1983	253 023	7 241
1984	166 177	9 398
1985	201 489	7 284
1986	152 930	6 617
1987	165 282	4 547
1988	180 907	6 709
1989	156 727	16 158[a]
1990	74 300	12 032[p]
1991[p]	139 044	. .

Source: Energy, Mines and Resources Canada.
. . Not available; [p] Preliminary.
[a] Increase in number of companies being surveyed.
[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2] Refined bismuth metal reported by consumers.

Cadmium

Elaine Koren

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-8200

(For additional information, telephone John Keating at (613) 992-4409.)

The word "cadmium" is derived from the Greek word *kadmeia*, an ancient name for calamine (zinc carbonate). Discovered by Stromeyer in 1817 from an impurity in a pharmaceutical zinc carbonate, cadmium was first extracted commercially in 1906. Although native cadmium has not been reported, the element is generally present as the sulphide minerals greenockite (CdS) and hawleyite (CdS) in zinc ore deposits, but also in other base-metal ores. The principal cadmium-bearing mineral in endogenetic deposits is sphalerite (Zn,Cd)S. Other sulphides and sulphosalts may also carry small amounts of the metal in endogenetic deposits. Table 3 outlines the cadmium content of minerals.

The crustal abundance of cadmium, which is ubiquitous in common igneous, sedimentary and metamorphic rocks, is outlined in Table 4. In general, cadmium is also predominantly associated with mineral substances in coal, mainly sphalerite, but other mineral associations may occur. For most coals, the cadmium content ranges from 0.1 to 3.0 parts per million (ppm). Most Australian coals range from 0.01 to 0.20 ppm Cd, averaging 0.08 ppm Cd, compared with the mean of 0.5 ppm Cd for coals used for power production in European Community (EC) countries.

Cadmium is principally recovered as a by-product of zinc smelting and refining; therefore, its reserves at any time are a function of zinc reserves. As the world's largest zinc producer, Canada's position as a major source of cadmium seems certain.

CANADIAN DEVELOPMENTS

Canada is the fourth largest source of refined cadmium in the world with an output of 1860 tonnes (t) in 1991, about 9% of world production. Output increased in 1991 over the previous year, up 1.3% from 1470 t. Due to the large quantities of zinc concentrates exported from Canada (about 658 510 t Zn content in 1991), the amount of refined cadmium of Canadian origin produced throughout the world is probably double the domestic refined production. Domestic refined production is from companies based in British Columbia, Manitoba, Ontario and Quebec, which recover cadmium as a by-product of smelting domestic and imported zinc concentrates.

Canada's largest source of cadmium is in concentrates imported by Cominco Ltd. from their Red Dog mine in Alaska; when it reaches full production in 1993, its total recoverable cadmium will be 1650 t/y. Major Canadian producers of cadmium in concentrates include Brunswick Mining and Smelting, Falconbridge Ltd., Hudson Bay Mining and Smelting Co. Ltd., Noranda Mines Ltd., and Westmin Resources Ltd.

Ontario was by far the largest source of cadmium-containing concentrates in Canada during 1991, producing 64.46% of contained cadmium production. The provincial division of contained cadmium production in 1991 is outlined in Table 5.

WORLD PRODUCTION

Belgium

Vieille Montagne (VM) will lose 400-600 t/y of 99.99% pure cadmium production when its Overpelt zinc and cadmium complex is closed in January 1992. This will reduce its European output to 1300-1500 t/y from 1900 t/y. The rest of VM's European production comes from its plant at Balen near Mol in Belgium. The company's worldwide output, which includes 500 t/y from Union Zinc in the United States, will be reduced to 1800-2000 t. As a result, VM is expected to be a more active buyer of 99.99% pure cadmium in order to fulfill its sales contracts.

France

At the Metal Bulletin's Third International Scrap and Secondary Metals Conference in Edinburgh, it was announced that scrap meets one third of the total amount of nonferrous metals required in France. On a national scale, mining meets only a small part of the French industry's requirements for nonferrous metals. In 1989, there was a trade deficit of 700 000 t. Without recycling, this figure would have more than doubled. Approximately 700 t of cadmium, which represents 51% of French production, came from recycling.

India

In October, Hindustan Zinc's new lead and zinc smelting complex at Chanderiya in Rajasthan started up. One of its main by-products will be 350 t/y of cadmium. This could boost Indian cadmium output from around 250 t/y to 600 t/y. Current domestic market consumption for cadmium is limited to 100-150 t/y, mainly for use in the pigments and stabilizers industries, with its surplus designated for export. The new smelter is also expected to produce some 74 t/y of silver, 10 t/y of bismuth, 30 t/y of mercury, and an unspecified amount of cobalt.

Japan

By mid-September, Japan's output of cadmium was expected to be 2500 t in 1991 compared with 2438 t in 1990, due mainly to stable production coupled with increased nickel-cadmium (Ni-Cd) battery production and a sharp decrease in stock levels. In the first six months of 1991, Japanese Ni-Cd battery production increased by 28.4% to 370 387 units from 288 436 units last year. Cadmium stocks are expected to drop to 160 t from 397 t in 1990, with exports down to 20 t from 248 t in 1990.

Considering other end uses for cadmium, a 3410-t shortfall in 1991 was predicted to be covered by imports. This compares with imports of some 1846 t in the previous year, against a shortfall of 2176 t and the destocking of 330 t.

At the end of November, the Cadmium Association's review of the first three quarters of 1991 was one of guarded enthusiasm. Japanese representatives reported that the Ni-Cd battery sector's demand for cadmium has continued to grow at 15%/y. According to the Cadmium Association, Japan's cadmium consumption could exceed 5000 t/y by the end of 1991.

Mexico

In September, Mexico's Peñoles publicly denied rumours that its cadmium metal deliveries were behind schedule. The company was not producing as much metal as it had in the past due to the fact that it had been concentrating its efforts more towards oxide, where it is able to obtain a 50¢ premium. During the first five months of 1991, Mexico supplied the United States with 123 t of cadmium compared to 345 t during the same period in 1990.

United States

In 1991, U.S. refined cadmium was produced by the following four companies, which each operate one zinc smelter: Asarco Incorporated, at Denver, Colorado; Jersey Miniere Zinc Co., at Clarksville, Tennessee; Zinc Corporation of America (ZCA), at Bartlesville, Oklahoma; and Big River Zinc Corporation, at Sauget, Illinois. The three latter companies recover cadmium as a by-product of smelting U.S. domestic and imported zinc concentrates, while Asarco Inc. recovers cadmium from other sources such as lead smelter baghouse dusts. According to the U.S. Bureau of Mines, 1991 refinery production of cadmium was estimated to be 1600 t, down 4.65% from 1678 t in 1990.

In October, the U.S. Department of Commerce announced that it would not revoke an anti-dumping duty order against cadmium from Japan as was proposed the month before. The duty on Japanese cadmium was first ordered in 1972. As long as the duty order is in force, entries of Japanese cadmium are subject to review upon request.

PROPERTIES AND USES

Cadmium, a soft, ductile silver-white electropositive metal, dissolves readily in mineral acids and is precipitated from solution by carbonate, hydroxide and sulphide ions. According to the Cadmium Association, cadmium has five main areas of application: Ni-Cd batteries (approaching 55%), coatings and plating (10%), pigments (20%), stabilizers in plastics and synthetic products (6%), and alloys (9%).

EVENTS AND TRENDS IN END USE

Belgium

In August, Matsushita Battery Industries (MBI) announced that it would begin manufacturing Ni-Cd batteries at the Philips Matsushita plant in Belgium, a joint venture of MBI and Philips. MBI and Philips were executing studies for the manufacturing plant, with production scheduled to start in 1992.

France

In January, the French Ni-Cd battery manufacturer Société d'Accumulateurs Fixés et de Traction (SAFT) took 100% control of the Swedish company SAB-NIFE, which specializes in Ni-Cd battery production and energy systems. SAFT has subsidiaries in 22 countries. At the same time, SAFT closed one of its three plants in the United Kingdom, which specialized in sealing portable and Ni-Cd batteries.

An electric car contract was concluded between the French group Jeanneau, which specializes in leisure boats, and the Swiss Ford distributor for some 1300 vehicles to be built between 1991 and 1992. It is believed to be the first firm contract for an electric car, since most projects have been at the design/prototype stage. SAFT was reportedly supplying the Ni-Cd batteries which will power the cars. Based on 1990 Ni-Cd conference estimates, each car would use between 84 and 220 kg of cadmium.

In November, Citroen announced its prototype of an electric vehicle, the Citela. The car has four seats, a 70-mph top speed, a 130-mile range and a 2-hour recharging time. Citroen adopted the Ni-Cd battery to power the car, which is scheduled to go into production in the mid-1990s. By 1995, the Citela should cost no more than £6000 for a basic model. This price does not include the cost of the battery which will cost an additional £2400 based on sales of 17 000 units per year. In response to environmental pressures seeking to ensure recycling of cadmium, it is likely that the batteries will be leased. To make the Citela a success, Citroen needs the cooperation of electrical utilities in installing recharging points in the streets and car parks of Europe's major cities.

Japan

In May, the Nissan Motor and Japan Storage Battery companies announced the joint development of a new battery recharging system and new Ni-Cd and lead-acid batteries for use in electric vehicles. Nissan company officials claim that the new recharging system will reduce recharging time by 80%. The company states that the new Ni-Cd battery can have 40% of its capacity recharged in 6 minutes, while the lead-acid battery can be returned to its original capacity in 12 minutes.

Nissan plans to place demonstration models in resort areas in order to get the public accustomed to the vehicle. Furthermore, as auto emission standards in the United States become more stringent, the Ni-Cd battery, due to its weight, may be "the answer" for the electric automobiles that are being made mandatory in some states, such as California.

United Kingdom

On March 6, Reckitt Colours closed its pigment manufacturing plant at Bletchley as a result of the downturn in the cadmium pigment industry and the high costs involved in meeting increasing environmental requirements. As one of six cadmium pigment manufacturers, its market share is expected to be absorbed by Blythe Colours of the United Kingdom. However, this closure is expected to be the beginning of industry-wide reductions as environmental pressures increase on the use of cadmium pigments.

Blythe Colours, restructured and renamed Johnson Matthey Colours in March, reduced its number of employees across the board by 70 to approximately 670 as a result of the recession and the "green lobby."

United States

In February, Ford and General Motors formed a research consortium to evaluate and develop advanced battery technologies for use in electric vehicles. This venture, called the United States Advanced Battery Consortium (USABC), was designed to develop advanced energy systems capable of providing future generations of electric vehicles with significantly increased range and performance.

Funding was estimated at US$1 billion over the next 12 years, which will come equally from the U.S. government and industry. The USABC has been working closely with the U.S. Department of Energy, the U.S. electric utility industry, and the Electric Power Research Institute.

In the United States, further incentive for a commercial launch of the electric automobile involves the tightening of exhaust emission and clean air regulations. For example, in California, 2% of all cars and light trucks sold in 1998 must be zero-emission vehicles (ZEVs). These ZEVs will generally be electric automobiles.

SUBSTITUTES

In April, the Japan Economic Journal reported that Hitachi Maxwell, Sanyo Electric and Matsushita Battery Industrial were conducting tests on nickel-hydrogen (NiH) batteries, which could eventually replace the Ni-Cd battery, especially in view of growing concerns over cadmium pollution.

In July, a California firm developed a new electric automobile battery–the zinc-air battery. Oxygen from the air combines with a zinc paste to produce electricity, which powers the vehicle. The zinc-air battery reportedly packs about eight times as much energy as the lead-acid battery and theoretically can power a car as far as 300 miles between charges. To date, it is seen as a battery that is safe (i.e., it operates at room temperature) and environmentally sound (i.e., it uses only non-toxic components and there is no problem if its battery container breaks). It may also be seen as another replacement for the nickel-cadmium battery and the lead-acid battery.

The battery system tested was a hybrid one relying on both a nickel-cadmium battery and a zinc-air battery pack. However, the zinc-air battery still has a number of technical problems and some of the claims made to date are still theoretical. For example, the zinc-air battery has yet to achieve the power density of the lead-acid battery.

According to the Cadmium Association, the NiH battery has failed to have an impact on the Ni-Cd market. The NiH battery was considered being limited to lightweight, high-capacity battery applications where cost was not a consideration.

According to the U.S. Bureau of Mines, zinc coatings, or vapour-deposited aluminum substitutes for some cadmium-plating applications, and tin may be used in place of cadmium pigments at the risk of reduced performance.

HEALTH AND SAFETY ISSUES

Cadmium, in all of its chemical forms, is considered highly toxic to living species as it does not decompose and is easily ingested through food, water and air but cannot be excreted. It is both bioaccumulated and biomagnified. Ingested cadmium accumulates in the liver, kidney, pancreas and thyroid. Excessive exposure to cadmium has been linked with the development of respiratory insufficiency (via occupational exposure), and renal disturbances and osteomalacia (via environmental and occupational exposure). Itai-itai disease is the most severe stage of chronic cadmium poisoning; the combination of osteomalacia and osteoporosis is requisite to its diagnosis.

Cadmium has also been implicated in the development of various types of cancer. Although cadmium is carcinogenic to specific animal species under certain exposure conditions and may enhance the occurrence of lung, and possibly prostrate, cancer in workers exposed to high airborne concentrations, there is no current epidemiological or experimental evidence substantiating that exposure to cadmium via food may be associated with an increased risk of cancer.

Cadmium can also form organic compounds, which can lead to mutagenic or teratogenic effects. It acts synergistically with other metals, thereby increasing its toxicity, particularly with copper and zinc.

The cadmium industry has, over the years, taken increasing measures to reduce risks to workers. Cadmium production and processing are subject to very strict controls in Canada, the European Community and the United States. It is generally accepted that the general population is exposed to very little cadmium. Main exposures occur by the oral route, possibly through the inhalation of tobacco smoke.

REGULATORY DEVELOPMENTS

At the beginning of January, the U.S. Environmental Protection Agency (EPA) announced that cadmium, chromium and mercury were on a list of 38 contaminants that it would regulate under its final drinking water standards. According to the Agency's statement, most of the 38 contaminants are only rarely found in public drinking water supplies. Tighter regulations would better protect the public, who would gain increased protection against cancer as well as against damage to the liver, kidney, circulatory and nervous systems.

The new rules set maximum contaminant level goals of a substance that can be present in drinking water. For example, the U.S. EPA set the goal for cadmium at 0.005 mg/L compared with 0.01 mg/L under current standards. Under the new rules, 80 000 drinking systems throughout the United States would be covered of which 60 000 are residential community systems with the remainder being non-residential community systems, such as those used by the mining industry and industrial plants.

At the end of January, the third Organization for Economic Co-operation and Development (OECD) report on the State of the Environment (1970-90) highlighted the risks posed by a group of metals as toxic trace air pollutants. These metals include arsenic, beryllium, cadmium, chromium, lead, mercury, nickel, thallium and vanadium. The major health hazards caused by each of these metals are outlined. The report also calls for tighter controls on heavy metals emissions.

The report stated that "... despite their name 'heavy' metals can remain in the atmosphere for one to ten days and be transported over distances of up to 2000 km." It also stated that "... to reduce the long-range transport of heavy metals, lower and strictly enforced emission levels need to be established for particulate matter given off by coal and waste combustion facilities and metal smelting plants."

In March, the EC Council Directive on batteries and accumulators containing dangerous substances (91/157/EEC) was approved. It established objectives and principles aimed at reducing and eliminating pollution and ensuring sound management of raw material resources on the basis of the "polluter pays" principle. The latter principle comes into force on January 1, 1994. It requires that member states take appropriate steps to ensure that spent batteries and accumulators are collected separately with a view to their recovery or disposal.

Batteries and accumulators covered by the directive include those with: (a) more than 25 mg mercury per cell, except alkaline manganese batteries, which are banned;

(b) more than 0.025% cadmium by weight;
(c) more than 0.4% lead by weight; and
(d) those alkaline manganese batteries containing more than 0.025% mercury by weight placed on the market as of the date provided in Article 11.

In April, the European Parliament backed tougher restrictions on cadmium, supporting the proposed ban on the use of cadmium in certain applications, namely pigments, plating and stabilizers. This was approved in June and will come into force at the end of 1992. However, the EC Council of Ministers rejected proposals by the European Parliament to bring forward by three years bans on a second list of cadmium-based products, which will be phased out by the end of 1995.

By the new rules, a list of uses for cadmium in pigments, stabilizers and certain types of surface treatment (which does not include batteries) will be banned by the end of 1992. The second ban, covering the marketing of certain finished products containing more than 0.01% Cd, will come into force three years later. Denmark and the Netherlands, which wanted tougher action on cadmium and voted against the modifications, made it clear that they wanted to retain their own stricter national law on cadmium restrictions.

At the EC Ministers' meeting, governments agreed to review all cadmium uses three years after the implementation of the new rules, which may involve extending the bans to other uses. Exemptions to this ban include the use of cadmium for markings on gas transit pipes and in materials for offshore industries where the EC is still not convinced of the viability of potential substitutes.

In September, the U.S. Occupational Safety and Health Administration (OSHA) re-opened the rule-making record on cadmium for 45 days. The re-opening would allow for the incorporation into the record of additional information on cadmium sulphide pigments concerning their relative insolubility in biological systems. The OSHA could also receive written comments on those additional comments that were submitted after the post-hearing comment period closed and that were not publicly discussed.

It is expected that the OSHA will report its findings and final rule in the second quarter of 1992. This process began in February 1990 when the OSHA published its proposed rule on occupational exposure to airborne cadmium.

In Canada, cadmium and its compounds have been listed in Group 1 of the Priority Substances List. Through the departments of the Environment and National Health and Welfare, cadmium and its compounds have been designated for assessment in 1992 to determine whether they are toxic according to the definition specified in Section 11 of the *Canadian Environmental Protection Act* (CEPA). The final report with its conclusions will be made available in the fourth quarter of 1992.

PRICES (US$)

At the beginning of 1991, the dealer price for a cadmium metal was placed at about \$3.00/lb (i.e., \$2.70-\$3.20/lb), approximately 40% less than prices quoted at the beginning of 1990. In the first six months of the year, prices fluctuated in a downward trend reaching as low as \$1.15-\$1.35/lb by June 20, 1991. However, the downward pressure on cadmium appeared to be easing somewhat in the beginning of July.

Cadmium

By September, cadmium was in a price run-up–about 18% in three weeks, driven by the demand from rechargeable battery manufacturers, lagging production of high-purity material, and brisk trading, especially from Japan. By the end of September, the price rallied to $2.20-$2.70/lb. This was followed by another downward price slump, ending the year on either side of $1.80/lb (i.e., $1.50-$2.10/lb).

OUTLOOK

Although by-product metals demand or price is always difficult to forecast, it is expected that growth will only occur in the Ni-Cd battery market segment, which faces competing pressures from potential substitutes, for example, the nickel-hydrogen battery and the zinc-air battery. Increasingly, demand for cadmium in other areas is subject to downward pressures as potential substitutes for cadmium become available on the market and as the increasing burden of regulatory costs and prohibitions/bans are established. In short, the long-term prospects for cadmium are not good.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
2617.90.00.30	Cadmium ores and concentrates	Free	Free	Free	Free	Free	Free
2825.90.90.10	Cadmium oxide	Free	Free	Free	1.4%	11%	5.8%
2830.30	Cadmium sulphide	Free	Free	Free	1.2%	6.9%	3.7%
8107.10.10	Unwrought cadmium, not alloyed; powders, not alloyed	Free	Free	Free	Free	4%	5.1%
8107.10.20	Unwrought cadmium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	2%	Free	4%	5.1%
8107.90	Cadmium and articles thereof, n.e.s.	10.2%	6.5%	2%	2.2%	6%	6.5%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Custom Tariff Schedules of Japan, 1991.
[1] GATT rate is shown; lower tariff rates may apply circumstantially.
n.e.s. Not elsewhere specified.

TABLE 1. CANADA, CADMIUM PRODUCTION AND TRADE, 1990 AND 1991, AND CONSUMPTION, 1988-90

Item No.		1990		1991p	
		(kilograms)	($000)	(kilograms)	($000)
PRODUCTION	(All Forms)[1]				
	Ontario	829 052	7 204	1 020 672	5 111
	British Columbia	176 007	1 529	287 630	1 440
	Manitoba	141 697	1 231	132 446	663
	Quebec	52 951	460	53 000	265
	New Brunswick	31 966	278	47 000	235
	Nova Scotia	33 041	287	23 580	118
	Saskatchewan	56	...	841	4
	Newfoundland	38 255	332	–	–
	Northwest Territories	30 608	266	–	–
	Yukon	31	...	–	–
	Total	1 333 664	11 588	1 565 169	7 837
	Refined[2]	1 470 229	..	1 859 568	..
IMPORTS				**(Jan.-Sept.)**	
2825.90.90.10	Cadmium oxide				
	United States	13 695	280	6 245	125
	United Kingdom	1 250	24	485	9
	Belgium	22 649	309	211	4
	Total	37 594	615	6 941	139
2830.30	Cadmium sulphide				
	United States	31 054	21	34 095	23
	Total	31 054	21	34 095	23
8107.10.10	Unwrought cadmium, not alloyed; powders, not alloyed				
	United States	29 572	279	2 143	21
	Germany[3]	57	2	–	–
	Total	29 629	281	2 143	21
8107.10.20.10	Unwrought cadmium, alloyed; powders, alloyed				
	United States	48	1	–	–
	Total	48	1	–	–
8107.10.20.20	Cadmium waste and scrap				
	Zaire	811	8	–	–
	Total	811	8	–	–
8107.90	Cadmium and articles thereof, n.e.s.				
	United States	17 216	252	9 597	125
	Total	17 216	252	9 597	125
EXPORTS					
2830.30	Cadmium sulphide				
	United States	–	–	149	2
	Total	–	–	149	2
8107.10	Unwrought cadmium; waste and scrap; powders				
	United States	730 542	6 236	591 985	2 948
	United Kingdom	128 967	1 130	75 194	1 133
	Netherlands	123 060	386	128 303	1 073
	Japan	254 209	2 414	141 522	661
	Other countries	36 920	518	130 425	912
	Total	1 273 698	10 684	1 067 429	6 727

TABLE 1 (cont'd)

Item No.		1990 (kilograms)	1990 ($000)	Jan.-Sept. 1991p (kilograms)	Jan.-Sept. 1991p ($000)
EXPORTS (cont'd)					
8107.90	Cadmium and articles thereof, n.e.s.				
	United States	8 900	118	38 616	176
	Germany[3]	–	–	5	3
	France	5	2	–	–
	Total	8 905	121	38 621	179

CONSUMPTION	1988	1989r	1990p
		(kilograms)	
Cadmium metal[4]			
Plating	15 486r	16 364	15 459
Solders, other alloys and other uses[5]	4 502r	12 462	19 735
Total	19 988	28 826	35 194

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary; r Revised.
1 Production of refined cadmium from domestic ores, plus recoverable cadmium content of exported ores and concentrates.
2 Refined metal from all sources and cadmium sponge. 3 Where applicable, data for East and West Germany have been combined. 4 Available data as reported by consumers. 5 Chemicals and pigments.

TABLE 2. CANADA, CADMIUM PRODUCTION AND EXPORTS, 1975 AND 1980-91

	Production		Exports
	All Forms[1]	Refined[2]	Cadmium Metal
		(kilograms)	
1975	1 191 674	1 142 508	637 797
1980	1 033 000	1 302 955	1 095 825
1981	833 788	1 293 265	1 452 904
1982	886 055	1 162 390	769 505
1983	1 107 000	1 296 000	1 365 111
1984	1 605 286	1 756 707	1 369 422
1985	1 716 731	1 696 192	1 477 415
1986	1 483 907	1 551 732	1 382 807
1987	1 481 496	1 571 444	1 156 555
1988	1 663 978	1 693 708	1 142 716
1989	1 710 527	1 619 798	1 433 144
1990	1 333 664	1 470 229	1 282 603
1991p	1 565 169	1 859 568	1 106 050[a]

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary.
a For 1991, first nine months only.
1 Production of refined cadmium from domestic ores plus recoverable cadmium content of exported ores and concentrates. 2 Refined metal and cadmium sponge from all sources.

TABLE 3. CADMIUM CONTENT OF MINERALS

Mineral	Chemical Composition	Range (in parts per million, except where noted)
Sphalerite	(Zn,Cd)S	0.0001-2%
Greenockite	CdS	77.8%
Hawleyite	CdS	77.8%
Chalcopyrite	$CuFeS_2$	<0.4-110
Marcasite	FeS_2	<0.3-<50
Arsenopyrite	FeAsS	<5
Galena	PbS	<.01-3000
Pyrite	FeS_2	<0.06-42
Pyrrhotite	$Fe_{(1-x)}S$	Trace
Tetrahedrite	$(Cu,Fe,Zn,Ag)_{12}SbAs_4S_{13}$	80-2000
Magnetite	Fe_3O_4	0-0.31
Cadmium oxide	CdO	87.5%
Limonite	Hydrous iron oxides	<5-1000
Wad and manganese oxides	Hydrous manganese oxides	<10-1000
Anglesite	$PbSO_4$	120->1000
Barite	$BaSO_4$	<0.2
Anhydrite and gypsum	$CaSO_4$; $CaSO_4 \cdot 2H_2O$	<0.2
Calcite	$CaCO_3$	<1-23
Smithsonite	$ZnCO_3$	0.1-2.35%
Otavite	$CdCO_3$	65.18%
Pyromorphite	$Pb_5Cl(PO_4)_3$	<1-8
Scorodite	$FeAsO_4 \cdot 2H_2O$	<1-5.8
Beudantite	$PbFe_3(AsO_4)(SO_4)(OH)_6$	100-1000
Apatite	$Ca_5(F,Cl)(PO_4)_3$	0.14-0.15
Bindheimite	$Pb_2Sb_2O_6(O,OH)$	100-1000
Silicates	Not applicable	0.03-5.8

Source: NRCC No. 16743.

TABLE 4. CADMIUM CONTENT IN CRUSTAL MATERIALS

Type of Rock	Range of Cadmium Content (mg/kg)
IGNEOUS	
Ultrabasic	No data
Basic	
Intrusives	<0.005-0.43
Extrusives	0.04-7.00
Intermediate	
Intrusives	0.10-1.00
Extrusives	No data
Acid	
Intrusives	<0.02-1.50
Extrusives	<0.02-0.48
Feldspathoid	<0.04-0.16
SEDIMENTARY	
Recent sediments	
River/stream sediments	0.60-74
Lake sediments	No data
Ocean sediments	0.02-0.97
Sandstone, arkose, conglomerate, etc.	<1-1.00
Shales and argillites	
Shales, mudstones and argillites	<1-1.00
Carbonaceous shales, bituminous shales, etc.	<1-3.00
Limestone, dolomite, etc.	<1
Evapourites	
Gypsum, anhydrite, halite, sylvite, etc.	<1
Rock phosphate	<7.2
METAMORPHIC	
Quartzites, etc.	<1-1.00
Amphibolites	<1
Hornfels and skarn	<1-5
Schists	<1-3
Gneisses	0.12-1.00
Marble, crystalline dolomite, etc.	<1

TABLE 5. CONTAINED CADMIUM PRODUCTION, BY PROVINCE, 1991

Province	Percentage
Ontario	64.46
British Columbia	19.45
Manitoba	8.39
Quebec	3.35
New Brunswick	2.97
Nova Scotia and Saskatchewan	1.38

Cement

Oliver Vagt

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-2667

In 1991, construction activity weakened considerably in all sectors of the economy. Housing starts continued to fall and were about 14% lower than in 1990, the lowest level since 1982. Total cement shipments were 9.4 million tonnes (Mt) valued at $816.8 million, a decrease of 18% compared to 1990, based on preliminary figures. At the same time, however, production capacity in Canada increased about 6% to about 15.4 Mt/y.

THE CANADIAN INDUSTRY

The Canadian cement industry is diversified and mainly integrated with the primary construction materials and products sectors. Many cement manufacturers also supply ready-mix concrete, crushed stone aggregates and concrete products such as slabs, bricks and pre-stressed concrete units. Restructuring during recent years has tended to result in a decentralization of operations and greater foreign control, now estimated to account for about 80% of capacity. Major international companies include S.A. Cimenteries CBR of Belgium (CBR), which owns Inland Cement Limited, and Société des Ciments Français (SCF) of France, which owns both Lake Ontario Cement Limited (LOC) and Miron Inc. SCF now uses the name "ESSROC" to identify all of its holdings in Canada and the United States. Accordingly, LOC also uses the name of ESSROC Canada Inc. Miron Inc., acquired in 1989 through ESSROC, is a major Quebec-based importer of cement and has associated ready-mix operations in Quebec and Ontario. Essroc's latest acquisition in Canada was Gormley Aggregates Ltd., a major producer of aggregates in the Toronto area.

Clinker-producing and finish-grinding capacities of cement plants, on a company-by-company basis, are listed in Table 2. Clinker production is more indicative of manufacturing capacity because clinker can be stockpiled for later use or sale. Accordingly, plant grinding capacities may vary considerably from associated capacities to produce primary-stage clinker. The average kiln capacity over the last 10 years increased from about 300 000 t/y to 380 000 t/y, with the average kiln age reported to be about 22 years.

The two plants in **Atlantic Canada** obtain raw materials on site or nearby. These account for about 4% of total Canadian clinker-producing capacity. Nova Scotia and Newfoundland are now the only producers of cement in the region since Lafarge Canada Inc. retired its Havelock, New Brunswick, plant in 1988.

In **Quebec**, four clinker-producing plants account for about 24% of national output. This is roughly in proportion to regional cement consumption of about 2.0 Mt, or 26% of total Canadian consumption. St. Lawrence Cement Inc. (SCL) is the dominant manufacturer of cement and a leading producer of concrete and aggregates in eastern Canada. Its major markets, in competition with Lafarge Canada Inc. and Ciment Quebec Inc., are in Quebec, the Maritime provinces and northeastern United States. Considering the Northeastern Region in context with the North American market as a whole, hydraulic cements are covered by CAN/CSA-A362-M88. Other types of cement manufactured in Canada but not covered by CSA standards generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

Consumption of cement or concrete is about evenly distributed among the residential, non-residential and public-related construction sectors.

Canada exports cement and clinker mainly to bordering states, particularly to New York, Vermont, Michigan, Minnesota and Washington. Canadian cement production efficiencies and a relatively strong American dollar continue to make Canadian cement and clinker competitive in U.S. markets. Low-cost marine transportation has influenced world trade considerably, with imports now accounting for about 20% of consumption in the large U.S. market.

TECHNOLOGY

Energy conservation programs by the Canadian cement industry reduced energy consumption per unit of production by about 22% between 1974 and 1989. Although the number of kilns has decreased, their individual capacities have increased and the more efficient dry-process plants now account for about 80% of total Canadian cement production. Work continues toward using cheaper fuels, improving methods for defining optimal particle sizes based on grinding, and using waste materials in kilns. Fuel mix has changed considerably away from natural gas and petroleum products toward coal/coke. In 1990, 50% of 20 clinker-producing plants were coal-fired and 25% were gas-fired. However, when the use of coke is considered together with coal, the related percentage increases to 55%. Six plants in 1990 reported using waste fuels as alternative sources of energy, according to the Canadian Portland Cement Association. In 1990, the Canadian cement industry consumed, on average, 4969 megajoules per tonne of production, of which 4452 megajoules were derived from fossil fuels.

Suitable waste materials are an attractive alternative fuel because pyro-processing accounts for more than 80% of total energy needs. Although there has been a growing acceptance that both the manufacturing process and the Portland cement product itself offer practical solutions to the management of certain types of waste, regulations governing incineration in kilns and other industrial furnaces have not been finalized. In the United States and Europe in particular, the use of waste-derived fuels and spent organic solvents has expanded. The monitoring of kiln emissions has generally confirmed that this is acceptable as a result of long residence times and the very high flame temperatures (1950°-2300°C) prevailing within. Materials generally established as being satisfactory include paints and coatings, surplus oils and greases, solvents, inks and cosmetics.

In Canada, the Canadian Portland Cement Association (CPCA), along with numerous co-sponsors, including the Canada Centre for Mineral and Energy Technology (CANMET), are planning an international symposium in 1992 on "Cement Industry Solutions to Waste Management." Considering sustainability issues, it is noteworthy that large-scale waste management involving incineration could lead to more meaningful conservation of some non-renewable fossil fuels.

Under the new *National Energy Efficiency and Alternative Energy Act*, CANMET plans to develop energy management research and development strategies for major industrial sectors, including cement and concrete. Under an initiative called the Industrial Targetted Program (ITP), CANMET plans to make cooperative investments in energy management research that may lead to development, field trials and technical transfer.

CANMET has also established cooperative arrangements for investigating the properties of concrete made with a high proportion of fly ash. The work, partially based on CANMET's technology allowing up to 60% of Portland cement replacement by fly ash, will be funded by the Electric Power Research Institute of Palo Alto, California. Past cooperative work concerning CANMET's research into supplementary cementing materials led to using blast furnace slag for making a slag cement. Reiss Lime Company of Canada, Limited now produces this type of cement at Spragge, Ontario, using granulated slag from The Algoma Steel Corporation, Limited's plant at Sault Ste. Marie. The capacity of the plant is 200 000 t/y of slag cement for complete or partial replacement of Portland cement.

CANMET was also a major sponsor of two workshops on concrete in 1991. Together with the American Concrete Institute (ACI), it sponsored the International Workshop on Silica Fume in Concrete held in Washington, D.C. The purpose of this workshop was to acquaint concrete specialists, contractors, and state and local authorities with the latest technology. Special emphasis was on durabilities, the use of silica fume concrete for rehabilitation work, and the role of silica fume in high-strength concrete. Similarly, along with ACI, CANMET sponsored the Second International Conference on Durability of Concrete held in Montreal.

Major cement-related research is carried out by the Portland Cement Association (PCA) based in Illinois. This is a non-profit research group conducting technical and market research on behalf of members and affiliates, including the CPCA. Lafarge Corporation, acting independently in technical research, operates its own research and technical centre in Montreal.

Moderate Sulphate-Resistance Cement (Type II) and Low-Heat-of-Hydration Cement (Type IV), designed for concrete poured in large masses, as in dam construction, are manufactured by several companies in Canada. Masonry cement (a generic name) includes such proprietary product 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%-65% by weight), and a plasticizer. The generic products do not necessarily consist of Portland cement and limestone, but may include mixtures of Portland cement, hydrated lime and/or other plasticizers.

OUTLOOK

Shipments of cement in 1992 are expected to be in the range of 9.5-10.0 Mt, considerably lower than the average of 12.2 Mt shipped over the three-year period from 1988 to 1990.

The recession that began in the first half of 1990 bottomed out in January 1991. Although interest rates continued to decline, the economy in 1991 shrank approximately 1.1% in terms of real Gross Domestic Product. Five-year conventional mortgage rates declined to 9.9% in late 1991; however, this failed to stop the downturn in housing and non-residential construction. Housing starts were 215 000 in 1989, 182 000 in 1990, and then fell to about 156 000 in 1991. Some forecasts predict housing starts will recover to about 180 000 for the year. Given the relatively high office and industrial vacancy rates in Canada and the United States, non-residential building construction is not expected to recover in 1992.

Groups representing the construction industry have said that attention should be given now to repair and reconstruct Canada's large infrastructure network, rather than delaying until major renovation is needed. They suggest that ongoing programs would allow more effective longer-term planning by the industry and the related minerals sector.

Energy management will continue to concentrate on gains in efficiency based on timely switching among the available choices of common fuels. However, most longer-term cost savings are expected to result from the partial substitution of fossil fuels by waste-derived fuels. For example, in the case of Refuse Derived Fuel (RDF), about 70% (by volume) of municipal solid waste (from post-recycled curbside garbage) could be used by the cement industry. This would reduce the volume of material for disposal as landfill by about two thirds. Under certain circumstances using RDF, a reduction in coal requirements of up to 20%-25% has been predicted.

The use of supplementary cements incorporating pozzolans or slags, and classified accordingly as various types of blended cements, is expected to become more important in modern concrete practices.

Note: Information contained in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2523.10	Cement clinker	Free	Free	Free	Free
	Portland cement:				
2523.21	White cement whether or not artificially coloured	81.59¢/t	54.25¢/t	Free	Free
2523.29	Other	Free	Free	Free	Free
2523.30	Aluminous cement	Free	Free	Free	Free
2523.90	Other hydraulic cements	Free	Free	Free	Free
68.10	Articles of cement, of concrete or of artificial stone, whether or not reinforced				
	Tiles, flagstones, bricks and similar articles				
6810.11	Building blocks and bricks	5%	Free	1%	1.9%
6810.19	Other	8%	Free	1.6%	1.9-8.4%
6810.20	Pipes	9.8%	6.5%	1.9%	1.9%
6810.91	Prefabricated structural components for building or civil engineering	6.8%-8%	Free-4.5%	1.3%-1.6%	1.9%
6810.99	Other	8%	Free	1.6%	1.9%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States 1991.

TABLE 1. CANADA, CEMENT PRODUCTION AND TRADE, 1989-91

Item No.		1989		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION[1] (All Forms)							
	Ontario	5 778 817	444 408	5 221 285	475 214	4 168 978	388 543
	Quebec	3 170 906	186 457	2 866 937	166 521	2 307 000	142 330
	Alberta	x	x	x	x	x	x
	British Columbia	x	x	x	x	x	x
	Manitoba	x	x	x	x	x	x
	Nova Scotia	x	x	x	x	x	x
	Saskatchewan	x	x	x	x	x	x
	Newfoundland	x	x	x	x	x	x
	New Brunswick	–	–	–	–	–	–
	Total	12 590 637	960 000	11 745 152	991 442	9 395 885	816 802
IMPORTS						(Jan.-Sept.)	
2523.10	Cement clinker						
	Colombia	27 500	1 512	20 634	631	76 408	2 400
	Japan	–	–	25 000	1 140	16 667	983
	Other countries	111 865r	5 651r	49 368	2 114	–	–
	Total	139 365r	7 164r	95 003	3 887	93 075	3 383
2523.21	Portland cement, white, whether or not artificially coloured						
	United States	6 514	1 149	7 973	1 472	6 269	942
	Japan	467	76	341	50	255	39
	Other countries	8 323	427	86	12	–	–
	Total	15 305	1 653	8 401	1 535	6 524	982
2523.29	Portland cement, n.e.s.						
	United States	330 844r	18 906r	419 207	23 976	305 375	17 579
	Turkey	–	–	126 120	5 739	–	–
	Other countries	108 669	4 752	9 451	658	4 099	235
	Total	439 514r	23 662r	554 779	30 374	308 474	17 815
2523.30	Aluminous cement						
	United States	12 986	4 731	15 998	6 587	7 884	3 287
	South Africa	37	26	–	–	94	45
	Other countries	3	2	5	2	–	–
	Total	13 026	4 760	16 003	6 589	7 978	3 332
2523.90	Hydraulic cement, n.e.s.						
	United States	58 623r	5 516r	17 904	3 076	41 159	4 340
	Other countries	3 338	313r	26 896	1 391	1 454	186
	Total	61 963r	5 829r	44 802	4 467	42 613	4 527
6810.11	Building blocks and bricks of cement, concrete or artificial stone						
	United States	..	4 911r	..	3 003	..	2 948
	Other countries	..	284	..	67	–	–
	Total	..	5 195r	..	3 070	..	2 948
6810.19	Tiles, flagstones and similar articles of cement/concrete or artificial stone						
	United States	..	5 260r	..	6 000	..	4 322
	Italy	..	4 719r	..	2 875	..	1 640
	Other countries	..	394r	..	780	..	270
	Total	..	10 373r	..	9 655	..	6 232
6810.20	Pipes of cement or concrete						
	United States	..	22	..	87	..	16
	Total	..	22	..	87	..	16
6810.91	Prefabricated structural components of buildings, etc., of cement/concrete, etc.						
	United States	..	1 528	..	2 875	..	2 340
	Netherlands	..	3	..	25	..	2
	Other countries	..	139	..	59	–	–
	Total	..	1 670	..	2 960	..	2 343

TABLE 1 (cont'd)

Item No.		1989		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
6810.99	Articles of cement, of concrete or of artificial stone, n.e.s.						
	United States	. .	3 076	. .	3 982	. .	3 921
	Other countries	. .	755r	. .	796	. .	545
	Total	. .	3 831r	. .	4 778	. .	4 466
EXPORTS							
2523.10	Cement clinker						
	United States	178 491	6 432	460 075	17 233	320 033	11 417
	Total	178 491	6 432	460 075	17 233	320 033	11 417
2523.21	Portland cement, white, whether or not artificially coloured						
	United States	34 440	3 503	107 445	12 323	88 156	10 109
	Other countries	526	415	26	2	–	–
	Total	34 966	3 918	107 471	12 326	88 156	10 109
2523.29	Portland cement, n.e.s.						
	United States	2 194 947	99 870	2 270 318	126 198	1 720 670	86 885
	Other countries	18 338	2 645	3 427	403	2 644	289
	Total	2 213 285	102 515	2 273 745	126 601	1 723 314	87 174
2523.30	Aluminous cement						
	United States	42 531	24	–	–	30	2
	Other countries	2	1	–	–	–	–
	Total	42 533	26	–	–	30	2
2523.90	Hydraulic cement, n.e.s.						
	United States	54 300	2 314	62 720	4 487	8 201	1 304
	Other countries	11 510	154	262	71	120	73
	Total	65 810	2 468	62 982	4 558	8 321	1 377
6810.11	Building blocks and bricks of cement, concrete or artificial stone						
	United States	. .	2 663	. .	4 189	. .	1 711
	Other countries	. .	212	. .	59	. .	181
	Total	. .	2 875	. .	4 248	. .	1 892
6810.19	Tiles, flagstones and similar articles of cement/concrete or artificial stone						
	United States	. .	1 654	. .	3 226	. .	3 110
	Other countries	. .	64	–	–	–	–
	Total	. .	1 719	. .	3 226	. .	3 110
6810.20	Pipes of cement or concrete						
	Uganda	–	–	–	–	. .	130
	United States	. .	59	. .	54	. .	90
	Other countries	–	–	–	–	. .	17
	Total	. .	59	. .	54	. .	239
6810.91	Prefabricated structural components of buildings, etc., of cement/concrete, etc.						
	United States	. .	39 952	. .	34 322	. .	30 556
	Other countries	. .	2 363	. .	6 695	. .	5 609
	Total	. .	42 315	. .	41 017	. .	36 165
6810.99	Articles of cement, of concrete or of artificial stone, n.e.s.						
	United States	. .	4 891	. .	9 398	. .	7 687
	Other countries	. .	90	. .	3	. .	23
	Total	. .	4 981	. .	9 402	. .	7 710

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; n.e.s. Not elsewhere specified; p Preliminary; r Revised; x Confidential.
1 Producers' shipments plus quantities used by producers.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CEMENT PLANTS, APPROXIMATE ANNUAL GRINDING CAPACITY, END OF 1990

Company	Plant	Wet (W) Dry (D) Preheater (x) Precalciner (c)	Fuel (Coal, Oil, Gas, Waste)	No. of Kilns	Grinding Capacity	Clinker Capacity
					(000 t/y)	
ATLANTIC REGION						
Lafarge Canada Inc.	Brookfield, N.S.	D	C,O	2	485	458
North Star Cement Limited	Corner Brook, Nfld.	Dx	O, Wa	1	275	152
Subtotal, Atlantic region				3	760	610
QUEBEC						
Lafarge Canada Inc.	Montreal East		–		600	–
Lafarge Canada Inc.	St. Constant	D	C,O,G	2	955	901
Ciment Québec Inc.	St. Basile	W,Dc	O,G, C	3	830	1 074
St. Lawrence Cement Inc.	Beauport	W	C, Wa	2	675	600
(Independent Cement Inc.)	Joliette	D	C,O	4	1 075	1 038
Subtotal, Quebec region				11	4 135	3 613
ONTARIO						
Lafarge Canada Inc.	Woodstock	W	C,G	2	535	504
	Bath	Dx	C,G	1	1 000	943
Federal White Cement Ltd.	Woodstock	D	C,O,G	1	198	151
Lake Ontario Cement Limited	Picton	D,Dx	C,G	4	927	1 468
St. Lawrence Cement Inc.	Mississauga	W,Dc	C,O,G, Wa	3	1 900	1 753
St. Marys Cement Company	Bowmanville	W	C, O	2	1 200	601
	St. Marys	Dx	C,G	1	850	672
Subtotal, Ontario region				14	6 610	6 092
PRAIRIES REGION						
Lafarge Canada Inc.	Fort Whyte, Man.		–	–	400	–
	Exshaw, Alta.	D,Dc	G	3	1 184	1 184
Inland Cement Limited- (S.A. Cimenteries CBR)	Winnipeg, Man.	W	G, O	1	408	387
	Regina, Sask.	D	G, O	1	237	221
	Edmonton, Alta.	Dc	G, Wa	1	860	802
Subtotal, Prairies region				6	3 089	2 594
BRITISH COLUMBIA						
Lafarge Canada Inc.	Kamloops	D	C,G	1	190	180
	Richmond	W	C,G, Wa	2	555	485
Tilbury Cement Limited- (S.A. Cimenteries CBR)	Delta	Dx	C,G, Wa	1	1 100	975
Subtotal, B.C. region				4	1 845	1 640
Total Canada (9 companies)				38	16 439	14 549

Source: Market and Economic Research Department, Portland Cement Association.
– Nil.

TABLE 3. CANADA, CEMENT PLANTS, KILNS AND CAPACITY UTILIZATION, 1979-91

	Clinker-Producing Plants	Sites	Approximate Cement Grinding Capacity[1]	Portland and Masonry Cement Production[2]	Clinker Exports	Approximate Total Production[3]	Capacity Utilization
			(t/y)	(t)	(t)	(t)	(%)
1979	24	51	15 985 000	11 765 248	1 530 537	13 295 785	83
1980	23	47	16 363 000	10 274 000	726 087	11 000 087	67
1981	23	48	16 771 000	10 145 000	524 006	10 669 006	64
1982	23	48	16 771 000	8 418 000	290 329	8 708 329	50
1983	23	49	17 900 000	7 870 878	404 793	8 275 671	46
1984	23	49	17 900 000	9 387 466	440 297	9 827 763	55
1985	23	49	17 900 000	10 192 442	676 596	10 869 038	61
1986	23	49	17 900 000	10 611 223	324 000	10 935 223	61
1987	20	40	16 600 000	12 603 164	767 338	13 370 502	81
1988	20	40	15 506 000	12 349 873	331 796	12 681 669	82
1989	20	38	15 546 000	12 590 637	178 491	12 769 128	82
1990	20	38	16 439 000	11 745 152	460 075	12 205 227	74
1991[p]	20	38	16 439 000	9 395 885	544 870	9 940 755	60

Sources: Statistics Canada; U.S. Bureau of Mines; Portland Cement Association (PCA).
[p] Preliminary.
[1] Includes plants that grind only. [2] Producers' shipments and amounts used by producers. [3] Cement shipments plus clinker exports.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1990 AND 1991

	Starts			Completions			Under Construction		
	1989	1990	% Diff.	1989	1990	% Diff.	1989	1990	% Diff.
Newfoundland	3 245	2 836	−13	3 127	3 219	+3	3 201	2 867	−10
Prince Edward Island	762	553	−17	683	722	+6	463	281	−39
Nova Scotia	5 560	5 173	−7	5 477	4 905	−10	3 376	3 567	+6
New Brunswick	2 683	2 872	+7	2 959	2 858	−3	1 359	1 366	+1
Subtotal, Atlantic provinces	12 250	11 434	−7	12 246	11 704	0	8 402	8 081	−4
Quebec	48 070	44 654	−7	52 630	42 720	−19	14 719	15 662	6
Ontario	62 649	52 794	−16	80 562	59 622	−26	47 808	40 599	−15
Manitoba	3 297	1 950	−41	4 028	2 190	−46	1 316	1 029	−22
Saskatchewan	1 417	998	−30	1 575	1 241	−21	809	509	−27
Alberta	17 227	12 492	−17	17 467	12 959	−26	5 973	5 497	−8
Subtotal, Prairie provinces	21 941	15 440	−30	23 070	16 390	−29	8 098	7 035	−13
British Columbia	36 720	31 875	−13	37 655	29 578	−21	21 645	23 658	+9
Total Canada	181 630	156 197	−14	206 163	160 014	−22	100 672	95 035	−6

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION BY PROVINCE,[1] 1989-91

	1989			1990			1991		
	Building Construction[2]	Engineering Construction[2]	Total	Building Construction[2]	Engineering Construction[2]	Total	Building Construction[2]	Engineering Construction[2]	Total
	($ millions)								
Newfoundland	1 050	608	1 659	1 065	609	1 674	1 169	1 172	2 341
Nova Scotia	1 821	737	2 558	1 880	907	2 787	1 705	1 076	2 780
New Brunswick	1 394	501	1 896	1 407	702	2 109	1 270	900	2 170
Prince Edward Island	269	92	361	268	92	360	265	111	376
Quebec	15 830	5 720	21 549	16 003	6 483	22 485	15 713	7 526	23 238
Ontario	32 434	7 828	40 263	29 705	7 809	37 514	28 380	9 538	37 917
Manitoba	1 967	1 115	3 082	1 854	1 348	3 202	1 802	1 384	3 186
Saskatchewan	1 797	1 633	3 431	1 809	1 908	3 717	1 846	2 082	3 928
Alberta	5 581	6 604	12 185	6 191	7 346	13 537	5 971	7 994	13 965
British Columbia, Yukon and Northwest Territories	9 096	4 332	13 428	9 993	4 480	14 473	9 070	4 827	13 897
Total Canada	71 238	29 174	100 412	70 174	31 684	101 858	67 189	36 609	103 798

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Actual expenditures 1989, preliminary 1990, intentions 1991. [2] Includes total value of new and repair work purchased.
Note: Numbers may not add to totals due to rounding.

Chromium

Louis Perron

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4828

USES

While many minerals contain chromium, chromite is the only commercial ore mineral. The theoretical formula for chromite is $FeCr_2O_4$, although it usually contains several other elements and is represented by the general formula $(FeMn)O\ (CrAlFe)_2O_3$. Traditionally, chromium ores have been classified as metallurgical, chemical and refractory grades, according to the expected industrial end uses. However, recent technological advances have allowed some degree of interchange in the usage of these three product categories so that the classification has become less meaningful. Current nomenclature is based upon chromite composition in addition to end use. High-chromium ores, defined by high Cr/Fe ratios, are used for making ferrochromium for metallurgical applications. High-iron chromites, previously limited almost entirely to the production of chromium-based chemicals, are now finding growing usage in the production of low-quality ferrochromium, refractories and foundry sands. High-aluminum chromites with relatively low iron and silica have application mainly for refractory purposes, primarily in the manufacture of magnesite-chromite and chromite-magnesite bricks.

The principal use of chromium ferroalloys is in the production of stainless and specialty steels, such as heat-resistant and tool steels. Most applications of stainless and heat-resistant steels or refractory metals are in corrosive environments, such as petrochemical processing; in high-temperature environments, such as turbines and furnace parts; and in consumer goods, such as cutlery and decorative trim. Chromium is added to alloy and tool steels to increase their hardening ability and 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 process equipment. Chromium-containing castings are usually used in high-temperature applications.

The refractory industry uses chromite in the manufacture of refractory bricks, castables, mortars and ramming gun mixes. Chromite castables, mortars and gunning mixes are used for repairs to, and in the bonding and coating of, basic (versus acid) bricks. They are also used in areas where the separation of various types of bricks by a chemically neutral substance is desirable.

Refractories containing both chromite and magnesite are used in furnaces wherever basic slags and dust are encountered, such as in the ferrous and nonferrous metal industries. In the ferrous industry, a chromite-magnesite brick is used in basic open-hearth and electric furnaces. The phasing-out of open-hearth furnaces 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 steel-making and, overall, chromite refractory consumption in the steel industry is expected to stabilize in the next few years. In the nonferrous industry, chromite-magnesite bricks are used mainly in converters. The increasing use of basic oxygen furnaces, which operate at higher temperatures, has changed refractory requirements to a higher magnesite-content brick, thereby decreasing the consumption of chromite in this application. The glass industry uses a chromite-magnesite brick in the reheating chambers of glass furnaces. The kraft paper industry requires a dense chromite brick in recovery furnaces to resist chemical attack by spent liquors.

Chromium chemicals, which make up less than 5% by weight of the chromium products consumed in Canada, have a wide variety of applications in several 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; as tanning agents for all types of leather; and for chromium electroplating, anodizing, etching 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 agents to promote water insolubility of various products such as glues, inks and gels.

CANADIAN DEVELOPMENTS

Canada imports nearly all of its chromium requirements, mostly as natural ores and concentrates, and as ferrochromium. The only domestic production is a small quantity of ferrochromium produced in Quebec. In the first nine months of 1991, imports of chromium ore fell significantly from previous years to 14 086 tonnes (t). Similarly, ferrochromium imports were lower than in previous years. Preliminary figures for the first nine months stood at 32 738 t compared to 43 222 t for the whole of 1990. In 1989, 48 551 t were imported. The fall in imports of the past two years reflects the depressed state of the Canadian stainless steel and specialty steel industry.

Atlas Stainless Steel, a division of Sammi Atlas, will invest $400 million by 1995 to expand production capacity at its steel plant located in Tracy, Quebec. The capacity will be increased to 300 000 t/y from its present 80 000 t/y. Part of the production will be exported to Korea. The plant expansion will result in a doubling of Canadian ferrochromium imports.

While there is no chromium ore presently mined in Canada, there are occurrences of various grades of ore in the Bird River area of Manitoba, in the Eastern Townships of Quebec, in the Port au Port Bay area of Newfoundland, and in the Big Trout Lake area in northwestern Ontario. Limited commercial production occurred early in the century and during the second world war in the Eastern Townships, but the operations became uneconomic at the end of the hostilities. Beginning in 1986, however, renewed exploration drilling was undertaken due to a rise in ferrochromium prices and increased concerns about security of supply for North America.

The Bird River deposit occurs along about 43 km of the Bird River Sill located in east-central Manitoba. The chromium-bearing zone, estimated to be about 60 metres (m) thick, consists of chromite crystals concentrated in very thin bands within layers of mafic and ultramafic rocks in igneous intrusions. Present reserve figures outlined for the sill are 7 million tonnes (Mt) at 6.9% Cr_2O_3, which incorporate mineralized material from four properties owned by as many companies or individuals.

Metallurgical tests were done on a Bird River deposit bulk sample through the Canada Centre for Mineral and Energy Technology (CANMET). Using heavy media separation, a concentrate grading 30% Cr_2O_3 was produced. The chromium-to-iron ratio is 0.84:1, which does not meet the current specifications of ferro-chromium used by the Canadian steel industry. However, the concentrate could be used with nickel sulphide to produce a chromium-nickel-iron master alloy. A potential market would be the producers of stainless steel. Additional research is in progress.

In the Eastern Townships of Quebec, chromite occurs as thin veins concentrated in mineralized zones 10-50 m thick. These zones are podiform shaped, discontinuous and hosted in ultramafic rocks of an ophiolitic complex. Exploration for chromium in the area is led by Coleraine Mining Resources Inc. (Coleraine) and Canchrome Mines Inc.

Coleraine is at a prefeasibility stage on the Hall deposit located near the town of Black Lake. Proven and probable reserves stand at 1 Mt grading 4.55% Cr_2O_3. The deposit is outlined to a depth of 60 m for an open-pit operation. It remains open at depth and is outlined over a strike length of 270 m. Metallurgical tests on a 3-t sample were done at the Centre de Recherches Minérales pilot plant in Quebec City. A concentrate of lumpy ore grading 51.7% Cr_2O_3 with a chromium-to-iron ratio of 2.5:1 was produced. In 1992, Coleraine intends to carry out a production energy balance on a process proposed for the production of ferrochromium. It also plans to complete the engineering design for a production plant.

Diamond-drilling activities will be carried out by Coleraine in January and February 1992 on the American Chrome deposit located near the Hall deposit.

Canchrome Mines Inc. has, in recent years, been studying the Reed-Bélanger and Sterret deposits. The Reed-Bélanger property is also located near Black Lake, and is said to host probable and possible resources of 5.5 Mt grading 6.62% Cr_2O_3. This deposit appears to be amenable to open-pit mining. The reserve base was delineated by an $800 000 diamond-drilling program carried out at the start of 1991. Further drilling, as well as metallurgical tests to rate the quality of the deposit material, is planned for 1992. The Sterret property is located 145 km east of Montreal, near the town of Asbestos. It has reported reserves of 150 000 t grading 25%-30% Cr_2O_3.

An occurence of chromium has been discovered in beach and shallow sand deposits on Port au Port Bay near Stephenville, Newfoundland. Preliminary sampling of the resource has been carried out by Canchrome Mines Ltd. and International Corona Corp. Beach sediments assayed as much as 6.5% Cr and the near-shore sediments as much as 5.0% Cr, both in the sand fraction. Further work is required to sample at depth and to acquire a sample to prepare a flow sheet for separation of the chromite.

The Big Trout Lake chromite mineralization is hosted in a layered intrusion. Chromite crystals are concentrated in thin bands which appear to extend for several kilometres. Grades between 4% and 14% Cr_2O_3 have been intersected over significant intervals in exploratory drilling. The resource is not well delineated but the potential for a large tonnage is good.

OUTLOOK

The demand for chromium ore and ferrochromium has followed the decline of world steel production, especially stainless steel and specialty steels. World production of specialty steels fell by about 7% in 1991 compared to 1990. These lower levels of demand, coupled with new capacity at all operation levels (mining, ferrochromium projects, etc.), resulted in excess supply and low prices through 1991. At year-end, there was evidence of improved demand but the upturn in the economy, especially in North America, was not vigorous. Moreover, the increase in ownership concentration observed in 1991 in South Africa, which accounts for 35% of world supplies, may herald an attempt at aggressive price leadership in the market in the near term. To that end, South African producers are trying to push the ferrochromium market price up to US$1.15/kg in the first quarter of 1992 despite lagging demand. If this fails, it may only result in a short-term loss of market share.

In the longer term, market growth is likely to resume in 1993. On average, more chrome is being used per tonne of steel produced and demand for stainless steel grew rapidly prior to the recession. This growth should resume when the effects of the recession dissipate. The increased demand may be matched by significant increases in world supply and prevent any significant price hike.

In Canada, low energy costs in Manitoba, Quebec and British Columbia may eventually render the upgrading of chromium ores to intermediate or processed chromium products an economically interesting venture. However, in the present situation of low prices, excess supply and difficult access to the market, Canadian chromium projects are developing very slowly.

Note: Information in this review was current as of January 31, 1992.

PRICES

Chromium prices published by *Metals Week*	December 25, 1989	December 24, 1990	December 23, 1991
		(US$)	
Chrome ore, dry basis, f.o.b. shipping point			
Transvaal 44% Cr_2O_3, no ratio (per tonne)	60.00-65.00	50.00-55.00	42.00-50.00
Turkish 48% Cr_2O_3, 3:1 ratio (per tonne)	175.00-185.00	120.00-135.00	120.00-130.00
Chromium metal			
Electrolytic 99.1% Cr, f.o.b. shipping point (per kg)	8.71	8.15	8.15
		(US¢)	
Ferrochromium, f.o.b. shipping point (per kg Cr content)			
Imported 50%-55% charge chrome	114.60-123.30	99.18-101.38	105.73-106.89
Imported 60%-65% charge chrome	112.40-120.12	94.77-96.98	103.04-103.59
MW, imported, low carbon, 0.05% C	207.18-231.42	220.40-231.42	198.36-200.01

f.o.b. Free on board.

TARIFFS

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
2610.00.00	Chromium in ores and concentrates	Free	Free	Free	Free	Free	Free
2610.00.00.10	Refractory grade	Free	Free	Free	Free	Free	Free
2610.00.00.90	Other (chrome content)	Free	Free	Free	Free	Free	Free
2819.10.00.00	Chromium trioxide	12.5%	8%	Free	1.4%	13.4%	4.9%
2819.90.00.00	Other	12.5%	8%	2.5%	1.4%	13.4%	4.9%
28.33	Sulphates; alums; peroxo-sulphates (persulphates)						
2833.23	of chromium						
2833.23.10.00	Chromium sulphate, basic	Free	Free	Free	1.4%	9%	4.9%
2833.23.90.00	Other chromium sulphates	9.2%	6%	1.8%	1.4%	9%	4.9%
	Chromium ferroalloys						
7202.41.00.00	Containing by weight more than 4% of carbon	10.2%	6.5%	Free	Free	8%	8%
7202.49.00.00	Other	10.2%	6.5%	Free	Free	8%[a]	8%
7202.50.00	Silico-chromium ferroalloys	10.2%	6.5%	Free	Free	4.9%	3.7%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Custom Tariff Schedules of Japan, 1991.
[a] Exemptions may apply circumstantially.
[1] GATT rate is shown, lower tariff rates may apply circumstantially.

TABLE 1. CANADA, CHROMIUM IMPORTS, 1989-91

Item No.		1989		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
2610.00	Chromium in ores and concentrates						
	United States	7 183	1 647	4 975	970	5 576	1 057
	Philippines	21 466	2 510	11 192	1 559	5 171	752
	South Africa	1 994	329	5 142	504	3 339	391
	New Caledonia	3 200	608	–	–	–	–
	Total	33 843	5 094	21 309	3 034	14 086	2 201
2819.10	Chromium trioxide						
	United States	524	1 231	1 335	2 825	1 283	2 796
	Germany[1]	600	1 548	390	997	266	592
	United Kingdom	173	540	120	420	20	79
	Italy	160	410	78	175	18	35
	Belgium	–	–	17	34	–	–
	Japan	–	–	16	32	–	–
	Total	1 457	3 729	1 956	4 483	1 587	3 504
2819.90	Chromium oxides n.e.s.; chromium hydroxides						
	United States	746	1 535	381	1 057	330	1 021
	United Kingdom	406	1 317	219	735	131	477
	Germany[1]	27	113	7	44	6	28
	Romania	2	5	–	–	–	–
	Total	1 181	2 970	607	1 837	467	1 527
2833.23	Chromium sulphates						
	Germany[1]	594	527	474	444	278	255
	Mexico	173	152	40	31	6	5
	United States	129	176	19	18	2	2
	United Kingdom	790	716	382	301	–	–
	Italy	–	–	38	37	–	–
	Israel	1	1	2	4	–	–
	Total	1 687	1 572	955	838	286	262
7202.41	Ferrochromium containing by weight more than 4% carbon						
	South Africa	29 478	29 696	26 174	15 220	15 865	8 796
	Sweden	3 250	3 859	–	–	8 279	4 961
	United States	2 339	3 460	2 639	2 737	2 036	2 207
	Zimbabwe	1 129	1 696	270	342	1 677	1 408
	Finland	1 071	2 364	3 134	2 467	1 040	1 161
	U.S.S.R.	3 104	3 951	–	–	–	–
	Other countries	442	608	302	367	359	317
	Total	40 813	45 634	32 519	21 133	29 259	18 851
7202.49	Ferrochromium n.e.s.						
	United States	1 134	2 692	1 432	2 518	1 044	1 943
	South Africa	5 459	7 778	8 338	7 588	1 693	1 728
	Germany[1]	979	2 359	717	1 518	601	1 313
	Zimbabwe	166	351	109	207	139	265
	Italy	–	–	107	190	–	–
	Total	7 738	13 180	10 703	12 021	3 479	5 250
7202.50	Ferro-silico-chromium						
	United States	2 435	4 239	871	1 288	640	882
	Zimbabwe	–	–	300	381	185	239
	South Africa	–	–	21	21	–	–
	Total	2 435	4 239	1 192	1 691	825	1 122

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; n.e.s. Not elsewhere specified; p Preliminary.
[1] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

Manitoba coal consumption in 1991 was expected to be below the 1990 consumption level of 461 000 t. Traditionally, Manitoba coal consumption is divided about 60:40 between utility and industrial demand. Virtually all of the coal used in Manitoba is lignite coal imported from Saskatchewan.

Saskatchewan is a producer, consumer and seller of lignite coal. Production in 1991 is expected to be down by about 4% to 9 Mt compared with 1990. The decrease is primarily due to a drop in shipments to Ontario Hydro. However, Saskatchewan's new 300-MW Shand power station, scheduled to enter service in mid-1992, should result in an increase in demand for Saskatchewan lignite to 1.5 Mt/y. Nearly three quarters of Saskatchewan's electricity is generated from coal.

Alberta continues to be Canada's largest coal-producing and coal-consuming province. After a downward dip in 1990 (the first in many years), Alberta production increased in 1991 by an estimated 6% to reach 32.4 Mt. The 1991 statistics reflect an increase of about 5% in demand by power plants in Alberta, and an increase of about 8% in exports. Approximately two thirds of Alberta's coal production is sub-bituminous coal produced for mine-site power stations, while the remainder is bituminous coal produced for Canadian and export markets.

Most opportunities for increased coal sales in Alberta will occur in the sub-bituminous market because of the development of new coal-fired power stations. Alberta, which leads all provinces in the amount of electricity produced from coal (82%), now has seven coal-fired power stations with a combined capacity of nearly 5300 MW. The next generating addition will be the second 400-MW Genesee unit, which is expected to come on stream in late 1994. This plant will increase demand for sub-bituminous coal by about 1.5 Mt/y.

Although British Columbia consumes very small amounts of coal, it is Canada's most important producer in terms of value. Production in 1991 was up about 500 000 t over 1990 to approximately 25 Mt. British Columbia represented 35% of the volume and 52% of the value of Canada's 1991 production.

Most of the coal produced in British Columbia is metallurgical, which commands higher prices than thermal coal. B.C. coal is primarily exported to Asian-Pacific markets, although some is sold to Europe and Latin America.

EXPORTS

Preliminary statistics indicate that Canada's coal exports in 1991 approached 34 Mt, the highest level ever. Metallurgical coal comprises about 85% of all coal exports.

Three quarters of Canada's coal exports come from British Columbia. In 1991, B.C. coal exports remained at 1990 levels of slightly over 23 Mt. About 90% of all coal produced in British Columbia is exported.

The significant increases in exports came from two provinces. Alberta's exports were up about 1 Mt to approximately 8 Mt, split about 3:1 between metallurgical and thermal coal. Nova Scotia's exports were up about 800 000 t to approximately 1.7 Mt, divided fairly evenly between metallurgical and thermal coal.

OUTLOOK

The Canadian coal industry faces important challenges in the 1990s. Coal demand is forecast to grow internationally, but primarily in the thermal market. Traditionally, only about 15% of Canadian coal exports are thermal coals, and many exporters in Canada and elsewhere are not making acceptable returns on the sale of this type of coal at today's prices.

A report prepared for the B.C. government in 1991 on coal prospects in the province concluded that coal producers are not making adequate returns on investment, and cooperation between all sectors of the industry is needed to counter coal's historical image and to publicize the ways that new technology has addressed many environmental concerns.

Japan, the world's largest single purchaser of coal, settled prices and volumes in December 1991 with its Australian and some Canadian suppliers for its 1992 purchases of metallurgical coals. The Japanese steel industry has announced plans to cut 1992 tonnage by 10% from 1991 levels.

Financial and related market difficulties have led to structural changes in the Canadian coal industry. In 1989, Luscar Ltd. took over Obed Mountain Coal Ltd. In 1990, two mines (Line Creek and Byron Creek) were put up for sale. In 1991, the Line Creek mine was purchased from Shell Canada Limited by Line Creek Resources Ltd., a wholly owned subsidiary of Manalta Coal Ltd. The Byron Creek mine was still for sale as of January 1992.

The Quintette mine in northeastern British Columbia, managed by Teck Corporation, continued its restructuring efforts in 1991. These efforts are expected to culminate in an arrangement which should allow Quintette to continue operating.

In conclusion, Canada continues to be one of the world's major coal exporters, with an enviable record as one of the most secure and reliable coal suppliers. The Canadian coal industry has the capacity to produce and export more coal to help meet the growing energy and raw materials needs of the 1990s. Canada's high-quality metallurgical coals and low-sulphur thermal coals should help meet domestic and international demands for a long time.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. SUMMARY OF COAL SUPPLY BY TYPE AND VALUES, 1987-91

	1987		1988		1989		1990		1991p	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
DOMESTIC[1]										
Bituminous										
Nova Scotia	2 925	179 000	3 540	216 000	3 512	199 000	3 415	191 000	4 134	242 000
New Brunswick	533	33 000	542	34 000	520	34 000	548	37 000	498	34 000
Alberta	7 202	239 000	9 561	299 000	9 907	309 000	9 153	296 000	10 312	355 000
British Columbia	21 990	948 000	24 911	974 000	24 840	948 000	24 581	1 002 000	24 962	986 000
Subtotal	32 650	1 399 000	38 554	1 723 000	38 779	1 490 000	37 697	1 526 000	39 906	1 617 000
Sub-bituminous										
Alberta	18 537	150 000	19 910	160 000	20 918	156 000	21 252	165 000	22 242	178 000
Lignite										
Saskatchewan	10 020	92 000	12 148	122 000	10 816	100 000	9 407	99 000	8 981	94 000
Total domestic	61 207	1 641 000	70 612	2 005 000	70 513	1 746 000	68 356	1 790 000	71 129	1 889 000
IMPORTED[2]										
Bituminous and anthracite briquettes	14 719	899 000	17 248	974 000	14 660	808 000	14 204	616 000	12 415	567 000
Total supply	75 926	2 540 000	87 860	2 979 000	85 173	2 554 000	82 560	2 406 000	83 554	2 456 000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] F.o.b. mines. [2] Value at United States port of exit.
p Preliminary figures or estimates.

TABLE 2. PRODUCERS' DISPOSITION OF CANADIAN COAL, 1990

Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	Canada
	Deliveries From					
	(kilotonnes)					
Newfoundland	–	–	–	–	–	–
Prince Edward Island	7	–	–	–	–	7
Nova Scotia	2 352	–	–	–	–	2 352
New Brunswick	7	548	–	–	–	555
Quebec	102	–	–	–	–	102
Ontario	–	–	1 366	1 812	909	4 087
Manitoba	–	–	410	–	59	469
Saskatchewan	–	–	7 622	1	9	7 632
Alberta	–	–	–	21 603	1	21 604
British Columbia	–	–	–	7	253	260
Total Canada	2 468	548	9 398	23 423	1 231	37 068
Shipments for export	948	–	9	6 982	23 349	31 288
Total	3 416	548	9 407	30 405	24 580	68 356

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

TABLE 3. SUMMARY OF COAL SUPPLY-DEMAND, 1980-91

Year	Canada Production				Imports				
	Bituminous	Sub-Bituminous	Lignite	Total	Anthracite	Bituminous	Total Available	Domestic Consumption	Exports
	(million tonnes)								
1980	20.2	10.5	6.0	36.7	0.3	15.5	52.5	37.3	15.3
1981	21.7	11.6	6.8	40.1	0.4	14.4	54.9	38.4	15.7
1982	22.3	13.0	9.5	42.8	0.3	15.5	58.6	41.5	16.0
1983	22.5	14.5	7.8	44.8	0.3	14.4	59.5	43.6	17.0
1984	32.1	15.4	9.9	57.4	0.2	18.1	75.7	48.6	25.1
1985	34.2	16.8	9.7	60.7	0.3	14.6	75.6	48.7	27.4
1986	32.2	17.3	8.3	57.8	0.4	12.7	70.1	44.6	25.9
1987	32.7	18.5	10.0	61.2	0.4	14.3	75.9	50.1	26.7
1988	38.6	18.9	12.1	70.6	0.4	16.8	87.8	54.4	31.7
1989	38.8	20.9	10.8	70.5	0.4	14.3	85.2	53.9	32.7
1990	37.7	21.3	9.4	68.4	0.4	13.8	82.6	49.0	31.0
1991p	39.9	22.2	9.0	71.1	0.2	12.2	83.5	50.3	34.1

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

TABLE 4. COAL USED BY THERMAL POWER STATIONS IN CANADA, BY PROVINCE, 1972-91

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskat-chewan	Alberta	Total Canada
				(000 tonnes)			
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	771	151	9 097	341	4 585	8 029	22 914
1979	644	198	9 901	73	4 956	9 181	24 956
1980	1 052	315	10 779	240	4 972	10 424	27 782
1981	1 126	515	11 460	332	4 935	11 445	29 813
1982	1 300	548	12 484	184	5 897	13 242	33 656
1983	1 400	564	13 025	109	6 625	14 492	36 216
1984	2 974	610	13 413	163	7 925	16 123	40 208
1985	2 235	521	10 985	253	8 290	18 112	40 396
1986	2 137	469	9 172	111	6 786	17 719	36 394
1987	2 077	526	12 016	457	7 672	19 077	41 825
1988	2 266	678	13 079	780	8 637	20 538	45 978
1989	2 141	705	12 809	327	8 534	21 410	45 926
1990	2 184	496	10 362	298	7 462	21 340	42 142
1991p	2 291	426	10 862	231	7 549	22 486	43 845

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

Cobalt

David Fong

The author is with the Mineral Policy Sector, EMR Canada.

(For additional information, telephone Louis Perron at (613) 992-4828.)

SUMMARY

Western World cobalt production in 1991 was 19 490 tonnes (t), compared to 20 270 t for 1990, according to the Cobalt Development Institute (CDI). Production by Zaire, the world's largest cobalt producer, fell substantially during the last quarter of the year due to the effect of civil unrest. Zaire produced 8790 t of cobalt in 1991 compared to 10 030 t in 1990.

The problems in Zaire and the lack of producer stocks caused intense speculation in the free market; prices rose to a 12-year high at year-end. The soaring market led Zaire and Zambia to announce joint price increases for the first half of 1992. Zaire also informed its contract customers of a 60% quota for the 1992 delivery based on the 1991 level.

Consumption of cobalt in 1991, according to industry estimates, was 21 500 t, down 4% from 1990. The reduction was due mainly to lower demand in the superalloys sector, especially from the aerospace industry in the United States, which was reported to have declined 7% during 1991. Demand from the chemical sector, however, remained strong compared to 1990.

CANADIAN DEVELOPMENTS

Canadian cobalt production in 1991 was an estimated 2160 t valued at $62 million, compared to 2184 t valued at $50 million for 1990. Most of the gain in value was due to the large increases in cobalt prices during the last quarter of 1991.

Inco Limited and Falconbridge Limited, Canada's two largest producers, both recover cobalt as a by-product of nickel-copper operations. Sherritt Gordon Limited of Fort Saskatchewan, Alberta, also produces cobalt from purchased and toll-refining materials from both domestic and imported sources.

Inco announced in the fourth quarter that the company was cutting back its nickel production in Canada due to falling demand. The cutback was accomplished through the closure of three nickel-copper mines in the Sudbury area, including the Creighton No. 3 mine which had been reactivated in October 1990. Despite a 4500-t cutback in nickel output, Inco's cobalt production in 1991 increased by about 12% to 1540 t.

Inco also suspended development of the McCreedy East mine, which had been scheduled to come on stream in 1993. At year-end, the company announced a summer vacation shut-down for 1992. Mining and milling in both Ontario and Manitoba will be shut down for four weeks, and the Port Colborne nickel-cobalt refinery will close for five weeks, starting in July.

At Port Colborne, Inco's nickel furnace that produces utility nickel for the stainless steel industry was out of commission and had to be rebuilt at year-end. However, no damage was reported to the refinery building and output of cobalt was not affected.

Inco made two major new finds in 1991: one, the Victor deposit, is about 25 km northeast of Sudbury, and the other is about 900 metres (m) from the McCreedy East mine. Both are high-grade nickel-copper deposits located in deep zones. At year-end, Inco was reported to be planning to sink a deep shaft at Victor to conduct underground exploration. Ore at the other new find will likely be integrated into the new mining plan of the McCreedy East.

Falconbridge recovers cobalt at its Nikkelverk, Norway, refinery from the nickel-copper matte produced in Sudbury. Its 1991 cobalt output was slightly lower than in 1990 as a result of the shut-down over the Christmas period. At capacity, the refinery can annually produce 60 000 t of nickel, 2000 t of cobalt and 36 000 t of copper. About 60% of Falconbridge's nickel output comes from its Sudbury operations and 25% from Botswana. The remaining 15% is obtained mainly from Russia. However, it has been estimated that about half of its cobalt production comes from non-Canadian sources.

Sherritt's cobalt production in 1991 was about 820 t compared to 690 t in 1990. The higher output was due to the introduction of new feed materials. Sherritt was reported to have acquired feeds containing about 55% nickel and 5% cobalt from Cuba. Sherritt's cobalt production is expected to continue to rise through 1993.

Besides producing s-grade cobalt powder, Sherritt has also resumed production of cobalt briquettes after a long hiatus. The decision to produce briquette was due to increased feedstock and the need to exploit new markets because of the loss of the U.S. powder market. The U.S. government has a trade embargo which bans imports of materials originating in Cuba.

In December, Geddes Resources Limited announced a 60% increase in reserves for its Windy Craggy copper-cobalt deposit located in the Saint Elias Mountains in northwest British Columbia, near the Alaska border. Reserves in 1991 stood at 297 Mt grading 1.38% copper and 0.06% cobalt, giving a reported total cobalt content of about 180 000 t. This makes Windy Craggy the largest cobalt deposit in Canada.

At year-end, Geddes was awaiting the B.C. government's response to its environmental impact studies before proceeding to the final feasibility study. The company submitted the stage I impact report to B.C.'s Mine Development Review Committee in February 1990.

INTERNATIONAL DEVELOPMENTS

Zaire, which is the largest producer in the world, has a production capacity of 16 000 t of cobalt. It had planned to produce 13 500 t but, due to problems caused by civil unrest, produced only 8790 t.

Mine production by La Générale des Carrières et des Mines du Zaire (Gécamines), the Zaire state-owned company, has been well below capacity for several years. The cave-in of the Kamoto mine near Kolwezi in 1990 (Zaire's largest underground copper-cobalt operation) hampered its capabilities to expand output.

Although the Kamoto mine was later brought back into production, it was operating only at partial capacity. To offset the production losses, Gécamines started recovering cobalt from hydrates that had been stockpiled for many years.

Zambia's cobalt production was 4820 t in 1991 compared to 4840 t in 1990. Similar production is projected for 1992. Zambia has no plans to expand its cobalt output despite the current market situation, due mainly to operational limitations.

Zambia's cobalt output has been maintained at the current level since the mid-1980s, while copper output has been on a steady decline, due mainly to lower-grade copper ores being mined. Cobalt and copper are produced in Zambia by Zambia Consolidated Copper Mines Ltd. (ZCCM), the world's second largest cobalt producer.

Zambia has been frequently experiencing transportation problems, partly because of its location in the heartland of Africa. During the past two years, however, part of the export problem was resolved by lifting restrictions on the use of trade routes through South Africa because of the improved political climate. Also, a fourth route has been added through Namibia by rail to the seaport. Tanzania and Mozambique are the other countries through which Zambia exports its metals.

The Federation of Russia is another major cobalt producer and, in 1991, an estimated 1500-2000 t of cobalt were reported to have been exported to the Western World. According to industry reports, much of the Russian exports came from the former Soviet government's stockpiles.

Russia has quite a large cobalt production capacity, estimated at about 4500 t/y. At the Yuzhuralnikel complex near Orsk in the southern Urals, cobalt production capacity was reported at 2500 t/y. However, not all of the cobalt produced at this location was from domestic sources; up to 1991, about 40% of its output was derived from Cuba. Cuban nickel-cobalt sulphides were shipped to Russia to be processed to anodes at Buruktal and were subsequently refined at Yuzhuralnikel. Buruktal is about 200 km west of Orsk.

The Noril'sk complex is located in north-central Siberia and is one of the world's largest nickel-producing regions. Noril'sk is reported to produce metallic and electrolytic cobalt and metal powder. In addition, some of the cobalt is refined elsewhere in Russia as well as by Falconbridge in Norway.

Another major cobalt producer is Cuba. The largest cobalt output from this source is from the Moa Bay area. The laterite is acid or ammonia leached to produce a crude nickel-cobalt-copper sulphide with the cobalt-enriched fraction being shipped to the Soviets for refining. The Cuban-Soviet arrangement was reported due to expire in 1991. Cuban cobalt reserves are very large, about double those of Zaire, but Cuba is currently supplying only 5%-10% of the world's needs.

Cia Niquel Tocantins of Brazil started production of electrolytic cobalt in 1990 at its São Miguel Paulista nickel plant in the state of São Paulo. The company, which is Brazil's first cobalt producer, was reported to have produced about 150 t in 1991.

Rehabilitation of the idled Nonoc nickel mine and refinery in the Philippines was reportedly about 40% complete by year-end. Philnico Mining and Industrial Corporation, the owner, is awaiting the outcome of negotiations with the World Bank on future financing. The total cost for the project is estimated at $US95 million.

Once financing is in place, Philnico has estimated that it will take another nine months to bring Nonoc into production at an annual capacity of 25 400 t of nickel and about 1500 t of cobalt. Billiton is to market the plant's Class 1 metal; Outokumpu will be refining and marketing the nickel and cobalt to be recovered from mixed sulphides.

The U.S. government is considering lowering its National Defense Stockpile requirements. In the 1991 report to Congress for approval, the Department of Defense (DOD) submitted two alternate scenarios that include three-year and three-month wars, both to be followed by mobilization periods. In either case, there would be excess cobalt from the stockpiles available for disposal; the current cobalt in stockpiles is 24 126 t. DOD proposed to dispose of 1361 t of cobalt during each of the 1992 and 1993 fiscal years.

PRICES (US$)

Cobalt prices in the free market started the year at $15.25-$15.75/lb for good-grade cathode, and dropped to $12.50-$12.90/lb in July. The prices rose sharply at the end of September following reports of civil unrest in Zaire. Political uncertainty and supply disruptions resulted in the free-market prices reaching a 12-year high of $31-$34/lb in December.

The official producer price of $US11/lb was maintained throughout 1991 despite the market volatility and the more than doubling of prices in the dealers market. In October, Zaire and Zambia announced a joint price increase to $13.00/lb effective January 1, 1992, for a six-month period. In December, this was changed to $US25/lb to bring it more in line with free market prices.

USES

One of the major uses for cobalt is in superalloys where it improves the strength, wear and corrosion-resistance characteristics of alloys at elevated temperatures. The major use of cobalt-based superalloys is in turbine blades for aircraft jet engines and in gas turbines for pipeline compressors. Cobalt-based superalloys normally contain 45% or more cobalt, while nickel- and iron-based superalloys contain 8%-20% cobalt.

The demand for cobalt in the production of magnets has been declining in recent years. Substitution of neodymium-iron-boron magnets for cobalt-rare earth magnets has been a major factor. However, cobalt-rare earth permanent magnets will continue to be used where the specific advantage of reliability and good performance is required. In addition, there was a recent report that the Alnico magnet is staging a comeback, especially in automobile anti-lock braking systems.

Cobalt-based alloys are also used in specialized applications such as machining very hard materials or where high abrasion-resistance qualities are required. In such applications, the most important group of cobalt-based alloys is the stellite group, which contains cobalt, tungsten, chromium and molybdenum as principal constituents. Hard-facing or the coating of tools with cobalt alloys provides greater resistance to wear, heat, impact and corrosion.

Cobalt metal powder has an important application as a binder in the production of cemented tungsten carbides for heavy-duty and high-speed cutting tools. In chemical applications, cobalt oxide is an important additive in paint, glass and ceramics.

Cobalt is also used to promote the adherence of enamel to steel for applications such as appliances, and steel to rubber for construction of steel-belted tires. A cobalt-molybdenum-alumina compound is used as a catalyst in hydrogenation and for petroleum desulphurization.

OUTLOOK

The cobalt market will likely continue to go through a period of tight supply and high prices in 1992 despite a resumption of production at Zaire's mining operations. The political uncertainty and deteriorating mining infrastructure in Zaire will seriously hamper its production capability. These factors, together with the absence of producers stocks, will continue to be the major factors affecting the cobalt market in 1992.

There is an urgent need, however, for major producers to boost their production and rebuild cobalt stocks in order to maintain market stability. In the near term, this remains in the hands of Zaire. Zambia has maintained that it has very limited flexibility in terms of raising cobalt output.

In Canada, because of its by-product nature, cobalt output is unlikely to increase from domestic sources. Inco and Falconbridge are expected to produce about the same amount in 1992 as in the previous year. Sherritt Gordon would be the only producer to boost its cobalt output in the next two years as the company continues to raise its throughput of imported nickel-cobalt ores.

In addition, the U.S. government is considering lowering its National Defense Stockpile requirements. A release from the U.S. stockpiles, if it materializes in 1992, could provide much-needed relief for cobalt metal availability in the market.

Consumption of cobalt in the near term is expected to remain flat; supply reliability and high prices remain the main concern. Demand from the superalloys sector is expected to continue to slacken as defence spending cuts hamper the military aircraft industry. In addition, the economic recession is having a big impact on the commercial aircraft industry. For the latter, despite record orders made in the late 1980s, airlines are either delaying taking deliveries and/or cutting back options. The use of cobalt in the chemical sector is likely to remain the only bright spot.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2605.00	Cobalt ores and concentrates	Free	Free	Free	Free
2822.00.10	Cobalt hydroxides	Free	Free	Free	1¢/kg
2822.00.90	Cobalt oxides, commercial cobalt oxides	9.8%	Free	1.9%	1¢/kg
2827.34	Cobalt chloride	12.5%	8%	2.5%	1.6%
2833.29.00.40	Cobalt sulphate	9.2%	6%	1.8%	0.5%
2836.99.00.20	Cobalt carbonates	12.5%	8%	Free	Free
2915.23	Cobalt acetates	12.5%	8%	2.5%	1.6%
8105.10.10	Cobalt mattes and other intermediate products; unwrought cobalt, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	2%	2.2%
8105.10.20	Unwrought cobalt, not alloyed; powders, not alloyed	Free	Free	Free	Free
8105.90.10	Cobalt bars and rods, not alloyed	6.8%	Free	1.3%	2.2%
8105.90.90	Cobalt and articles thereof, n.e.s.	10.2%	6.5%	2%	2.2%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.
n.e.s. Not elsewhere specified.

TABLE 1. CANADA, COBALT PRODUCTION AND TRADE, 1990 AND 1991, AND CONSUMPTION, 1988-90

Item No.		1990		1991p	
		(kilograms)	($000)	(kilograms)	($000)
PRODUCTION[1] (All Forms)					
	Ontario	1 877 944	42 235	1 796 539	49 816
	Manitoba	305 676	7 328	362 495	11 949
	Total	2 183 620	49 563	2 159 034	61 764
EXPORTS				(Jan.-Sept.)	
2605.00	Cobalt ores and concentrates	–	–	–	–
2822.00	Cobalt oxides and hydroxides; commercial cobalt oxides				
	United Kingdom	381 148	7 820	336 053	8 250
	United States	–	–	9 900	244
	Hong Kong	5 140	107	–	–
	Australia	5 054	78	–	–
	Total	391 342	8 006	345 953	8 494
2915.23	Cobalt acetates	2 108	11	–	–
8105.10	Cobalt, unwrought, matte and other intermediate products, waste, scrap and powders				
	Norway	1 205 668	21 588	1 181 307	29 164
	United States	1 266 475	24 981	811 132	21 366
	United Kingdom	289 075	6 360	214 554	6 283
	Belgium	204 000	3 946	119 000	2 982
	Other countries	53 277	2 741	62 504	2 678
	Total	3 018 495	59 616	2 388 497	62 473
8105.90	Cobalt and articles thereof, n.e.s.				
	Germany[4]	4 817	491	2 524	278
	Sweden	759	106	1 319	171
	United States	11 441	343	5 170	140
	Other countries	3 919	434	725	161
	Total	20 936	1 374	9 738	750
IMPORTS					
2605.00	Cobalt ores and concentrates				
	Zaire	–	–	117 600	3 157
	United States	19 892	439	1 811	36
	Belgium	–	–	1 000	28
	Total	19 892	439	120 411	3 222
2822.00.10	Cobalt hydroxides				
	Belgium	42 435	743	14 000	331
	Finland	8 708	128	5 120	118
	United States	5 420	119	5 164	111
	Total	56 563	991	24 284	561
2822.00.90.10	Cobalt oxides				
	United States	356	8	2 921	66
	Belgium	12 000	218	2 000	36
	Finland	3 164	71	–	–
	United Kingdom	400	8	–	–
	Total	15 920	307	4 921	102
2822.00.90.20	Commercial cobalt oxides				
	France	–	–	24	...
	United States	9	...	21	...
	United Kingdom	7	...	–	–
	Total	16	...	45	...
2827.34	Cobalt chlorides				
	United States	261 934	1 051	126 667	617
	Belgium	400	2	900	8
	Total	262 334	1 054	127 567	626

TABLE 1 (cont'd)

Item No.		1990 (kilograms)	1990 ($000)	Jan.-Sept. 1991p (kilograms)	Jan.-Sept. 1991p ($000)
IMPORTS (cont'd)					
2833.29.00.40	Cobalt sulphates				
	United States	20 729	160	10 291	127
	Belgium	42 000	241	12 860	98
	Other countries	3 275	16	–	–
	Total	66 004	417	23 151	226
2836.99.00.20	Cobalt carbonates				
	United States	20 251	344	5 433	99
	Belgium	7 015	103	2 950	52
	Other countries	4 753	76	3 905	64
	Total	32 019	523	12 288	215
2915.23	Cobalt acetates				
	United States	12 361	77	16 452	161
	Italy	–	–	4 750	48
	United Kingdom	11	...	4 000	41
	Total	12 372	78	25 202	252
8105.10.10.10	Unwrought cobalt; powders; mattes and other intermediate products				
	United States	19 687	772	16 087	588
	Other countries	1 218	58	1 353	65
	Total	20 905	830	17 440	653
8105.10.10.20	Cobalt waste and scrap				
	Zaire	452 256	7 926	224 742	5 877
	United States	134 184	1 615	94 893	1 020
	Other countries	73 200	1 412	88 751	1 406
	Total	659 640	10 953	408 386	8 303
8105.10.20.10	Unwrought cobalt, not alloyed				
	Zaire	–	–	912 664	27 657
	Belgium	33	1	419 200	11 246
	U.S.S.R.	–	–	26 278	862
	United States	27 020	526	13 966	384
	Other countries	12 000	388	391	18
	Total	39 053	915	1 372 499	40 167
8105.10.20.20	Cobalt powders, not alloyed				
	United States	22 387	918	30 965	1 492
	Belgium	3 755	143	3 575	160
	Other countries	3 107	140	107	8
	Total	29 249	1 201	34 647	1 660
8105.90.10	Cobalt bars and rods, not alloyed				
	United States	858	70	1 103	116
	Germany[4]	381	26	57	2
	Total	1 239	97	1 160	118
8105.90.90	Cobalt and articles thereof, n.e.s.				
	United States	61 380	3 852	33 162	2 742
	United Kingdom	567	23	917	45
	Other countries	55	5	319	29
	Total	62 002	3 880	34 398	2 816

	1988	1989	1990p
	(kilograms)		
CONSUMPTION[2]			
Cobalt contained in:			
Cobalt metal and metallic compounds	69 153	68 585	76 068
Cobalt pigments, feed and ground coat frit	15 342	9 107	13 068
Cobalt salts and driers and other uses[3]	74 795	69 607	105 069
Total	159 290	147 299	194 205

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; ... Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary.
[1] Production (cobalt content) from domestic ores. [2] Available data reported by consumers. [3] Other uses include glass and chemicals. [4] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, COBALT PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1980-91

		Exports			Imports	
	Production[1]	Cobalt Metal	Cobalt Oxides and Hydroxides	Cobalt Ores[2]	Cobalt Oxides and Hydroxides[3]	Consumption[4]
	(tonnes)					
1975	1 354	431	561	. .	. .	123
1980	2 118	325	1 091	2	26	105
1981	2 080	677	601	24	20	101
1982	1 274	585	212	2	30	81
1983	1 410	885	192	45	30	101
1984	2 123	1 487	373	14	27	113
1985	2 067	1 551	268	36	192	101
1986	2 297	1 805	374	20	31	96
1987	2 490	1 875	440	45	38	120
1988	2 398	3 062	953	98[r]	37	159
1989	2 344	3 262	371	22	33	147
1990	2 184	3 039	391	–	72	194
1991[p]	2 158	2 398[a]	346[a]	–[a]	29[a]	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; [p] Preliminary; [r] Revised.
[a] First nine months only.
[1] Production from domestic ores and cobalt content of intermediate products exported, including cobalt content of Inco Limited and Falconbridge Limited shipments to overseas refineries. [2] Cobalt content. [3] Gross weight.
[4] Consumption of cobalt in metal, oxides and salts.

Copper

Geoff Bokovay

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4093

Copper prices remained relatively strong during 1991, despite some weakening of demand and an increase in world metal supply. The market was buoyed by the threat of serious supply disruptions at a number of large mining operations around the world. These included labour problems in Chile, Mexico, Peru and Canada, as well as difficulties associated with political turmoil in Zaire. Prices, which averaged US$1.06/lb in 1991 compared to $1.21/lb in 1990, were also supported by concerns relating to the possible shortage of world copper-smelting capacity.

CANADIAN DEVELOPMENTS

Copper shipments (recoverable copper) from Canadian mines in 1991 rose to about 776 900 tonnes (t) from 771 400 t in 1990. The estimated value of these shipments in 1991 was $2.10 billion versus $2.43 billion in 1990. During 1991, refined copper production increased to 538 000 t from 516 000 t in 1990.

While output at most mines was generally higher in 1991 than during the previous year, this was partially offset by the closure of several mining operations due to the combination of lower metal prices and higher operating costs, or the exhaustion of ore reserves. Output at a number of other mines was reduced by labour problems.

In 1991, exploration remained a major focus of activity for the Canadian copper industry. While Canadian copper mine production is expected to fall in the medium term as new capacity is unable to match expected mine closures or the decline of capacity at existing operations, encouraging exploration results in recent years point to a recovery of output levels by the end of the decade.

British Columbia

In the extreme northwest corner of British Columbia, Geddes Resources Limited continued work on its Windy Craggy deposit, which hosts reserves of 272 Mt grading 1.44% copper, 0.07% cobalt, 0.2 g/t gold and 3.8 g/t silver. At a planned mining rate of 30 000 t/d, the mine should have an average annual output of 140 000 t of contained copper during the first 14 years of operation. It is expected that the project will provide an estimated 500 jobs during the three years of development and construction and over 600 positions when in full production.

At year-end, Geddes was still waiting for a response to its Stage 1 Environmental and Socioeconomic Impact reports which were prepared for British Columbia's Mine Development Review Process. This response will summarize the comments from various reviewing agencies and provide the terms of reference for more detailed studies that may be required.

The Windy Craggy project has provoked considerable public debate on the issue of environmental protection versus economic development. While the company has modified its development plans to reduce potential risk to the environment, opponents of the proposal contend that any risk from the potential development is too great for the delicate ecosystem of the area.

Early in 1992, Placer Dome Inc. announced that it would not proceed, for the time being, with the development of its

Mount Milligan copper-gold property northwest of Prince George. The forecasted return on investment was considered to be insufficient to justify an investment of between $500 million and $600 million, which would be required to bring the property into production. Mount Milligan contains mineable reserves of about 300 Mt grading 0.22% copper and 0.45 g/t gold.

Noranda Minerals Inc. announced that it will close its Bell copper mine and mill at Granisle, British Columbia, in June 1992 due to the depletion of ore reserves. It is expected that about 235 jobs will be lost. The mine, which produced over 20 000 t/y of copper in concentrate, was brought on stream in 1972.

The Goldstream copper-zinc mine near Revelstoke, which is owned by Bethlehem Resources Corporation and Goldnev Resources Inc., resumed production in May. The mine, originally developed by Noranda Inc., was operated briefly in 1984 until low metal prices and low zinc recoveries forced its closure. The Goldstream property contains reserves of 1.86 Mt grading 4.8% copper and 3% zinc, plus silver. Annual output at the Goldstream mine is expected to total 16 000 t of contained copper and 3000 t of contained zinc. The copper concentrate is being sold to Nippon Mining Co. Ltd. under a long-term contract.

In July, Minnova Inc. and Rea Gold Corp. announced that they would proceed with the underground development of their polymetallic Samatosum mine located northeast of Kamloops. Although reserves are expected to be depleted by the end of 1992, mining activity could continue in the area with the possible development of the Chua Chua deposit for which Minnova is the operator. While exploration on the latter is continuing, the upper portion of the deposit contains reserves of about 1 Mt grading 2.98% copper, plus zinc, silver and gold.

The Afton Operating Corp., a partnership of Teck Corporation and Metall Mining Corporation, closed its Afton copper mine in August for an indefinite period. The closure of the operation, located southwest of Kamloops, was attributed to high operating costs. At the time of closure, the mine employed 200 workers. In 1990, the mine produced almost 11 000 t of copper in concentrate.

In October, the union at the 170 000-t/y Highland Valley copper mine, which is owned 50% by Cominco Ltd., 33.3% by Rio Algom Limited and 13.9% by Teck, ratified a new three-year labour contract.

In September, workers at Princeton Mining Corporation's Similco mine near Princeton ratified a new labour agreement, thereby ending a four-month strike. It was reported that the contract incorporates annual wage increases of 3.75%, 4.0% and 4.5% over the life of the agreement as well as pension improvements tied to cash flows. Production at the mine resumed in October.

At the Island Copper mine of BHP-Utah Mines Ltd. on Vancouver Island, workers went on strike on May 24 to back demands for higher wages and severance pay guarantees. With the acceptance of a new three-year labour contract, employees returned to work on June 12, 1991.

Westmin Resources Ltd. announced in the second half of 1991 that it was eliminating 98 positions from the workforce of its Myra Falls copper-zinc operation on northern Vancouver Island in order to improve profitability. During 1991, the company also reported that it had discovered several new high-grade ore zones on its Myra Falls property that could increase both the mine's life and future revenues.

In 1992, PRM Resources Ltd. plans to undertake a full feasibility study for its copper smelter/refinery project at Kitimat. It is expected that the $500 million facility, which would likely have a capacity of 200 000 t/y, would process both Canadian and offshore concentrates. At present, the bulk of the copper concentrates produced in British Columbia is exported to Japan. While the attractiveness of treatment and refining charges offered by Japanese smelters to Canadian concentrate producers has discouraged consideration of any B.C. smelter proposal in the past, the dramatic escalation of these charges in 1991 will undoubtedly improve the potential viability of such a project.

In northwestern British Columbia, Redfern Resources Ltd. continued exploration on the Tulsequah Chief property located 100 km south of Atlin. Preliminary reserves of the deposit total almost 8 Mt grading 1.6% copper, 1.2% lead and 6.5% zinc, plus silver and gold.

Further south, Consolidated Rhodes Resources Ltd. conducted additional exploration on its Copper Canyon project in the Galore Creek area. Preliminary reserve estimates for the Central Zone deposit total 32.4 Mt grading 0.75% copper, 17.1 g/t silver and 1.2 g/t gold. In the Iskut River region, Placer Dome Inc. is proceeding with exploration at its Kerr deposit, which hosts reserves of about 125 Mt grading 0.62% copper and 0.3 g/t gold.

At the South Kemess property owned by El Condor Resources Ltd. (60%) and St. Philips Resources Inc. (40%), located in the Toodoggone area, further exploration has resulted in a significant increase in ore reserves. The preliminary reserve estimate now stands at 228 Mt grading 0.23% copper and 0.65 g/t gold. The preliminary reserve estimate for the North Kemess deposit, owned 100% by El Condor, totals 116 Mt grading 0.19% copper and 0.38 g/t gold.

During 1991, Taseko Mines Ltd. obtained encouraging exploration results at its Fish Lake gold-copper prospect located southwest of Williams Lake. Preliminary reserve estimates for the deposit now total almost 600 Mt grading 0.32% copper and 0.55 g/t gold.

During 1991, Jordex Resources Inc. was involved in continuing exploration on several properties near Port Hardy on Vancouver Island. (Jordex acquired Moraga Resources Ltd. in August 1991.) This included work on the Hushamu deposit, on which the company can earn a 45% interest from BHP-Utah Mines Ltd., and also on the Red Dog property, on which Jordex was working to earn a 50% interest from Crew Natural Resources Ltd. Mineable open-pit reserves at the former property are estimated at over 173 Mt grading 0.25% copper, 0.3 g/t gold and 0.01% molybdenum, while the Red Dog deposit is estimated to have reserves of about 45 Mt grading 0.32% copper and 0.4 g/t gold.

Manitoba

During 1991, exploration work continued on new zinc-copper zones at the Trout Lake mine, which is owned by Hudson Bay Mining and Smelting Co., Limited (HBMS), Granges Inc., and Manitoba Mineral Resources Ltd. Although this exploration concentrated on the testing of several known orebodies, the new No. 10 lens was also discovered. While further work will be required to fully delineate the actual size of the new ore zones, the additional reserves should be sufficient to extend the life of the mine by several years.

Ontario

Falconbridge Limited experienced a metal leak in September at its copper converter at the Kidd Creek copper smelter near Timmins. According to a company report, approximately 200 t of copper metal and 35 t of slag spilled onto the smelter floor. Copper refinery operations continued, although at a reduced rate. The company expected that the accident would result in the loss of at least 3500 t of cathode production.

Minnova Inc. completed exploration drilling at its Pick Lake project located 1.5 km southwest of the main shaft of its Winston Lake mine near Schreiber. This work has outlined reserves of 1.6 Mt grading 1.1% copper and 17.7% zinc.

In September, Inco Limited announced that it was suspending production at its Creighton No. 3 mine as well as at several small deposits adjacent to the main Garson mine and at the Whistle Open Pit. It is expected that these closures will result in about a 4% annual reduction in the company's Sudbury copper production. Later in the year, Inco announced a four-week suspension of its Sudbury area mining and milling operations during the summer of 1992. Falconbridge also announced a five-week summer shut-down of its Sudbury area mines for 1992.

Also in September, Inco announced the discovery of two new high-grade copper-nickel-precious metal deposits in the Sudbury area. The Victor deposit, located on the northwest rim of the Sudbury Basin, hosts outlined reserves of over 4 Mt grading 7.3% copper, 2.25% nickel and 13 g/t precious metals. While the potential exists to delineate additional reserves, the orebody is deep with the richest zone being below 8000 feet. The other deposit, located between the Levack and McCreedy East mines, contains currently outlined reserves of about 4.2 Mt grading 11% copper, 0.8% nickel and 12 g/t precious metals.

In mid-January 1992, Inco was forced to declare force majeure on copper cathode shipments from its Copper Cliff copper refinery due to the failure of one of the two copper anode furnaces. The company estimated that the problem would take about six weeks to rectify, during which time copper output would be reduced by about 70%, or 7700 t.

Quebec

Aur Resources Inc. announced in October that the final feasibility study for its 55%-owned Louvicourt deposit in northern Quebec had confirmed the viability of the proposed development. The operation, which will likely begin production in 1994, is expected to cost $326 million. When completed, Louvicourt will produce approximately 55 000 t/y of contained copper and 17 000 t/y of zinc, as well as significant amounts of gold and silver. Geological reserves of the deposit are estimated at 39 Mt grading 3.3% copper, 1.8% zinc, 21.6 g/t silver and 0.7 g/t gold.

At the Mobrun mine near Rouyn-Noranda, an agreement was reached between the owners, Audrey Resources Inc. and Minnova Inc., regarding the development of the new 1100 (B) lens. Under the terms of the agreement, Minnova will transfer its 50% interest in production above the 4850-ft level of the 1100 lens to Audrey Resources in return for a 4% royalty interest. Production from this section of the mine, which will begin as early as mid-1993 if necessary financing can be obtained, will be at a rate of 1500 t/d. Mine production could eventually be increased to 2800 t/d when mining begins on the lower part of the 1100 lens. Ore reserves of the 1100 lens above the 5000-ft level total 21.6 Mt. This includes 17 Mt between the 4600-ft and 5000-ft levels grading 0.79% copper, 3.69% zinc, 33 g/t silver and 1.2 g/t gold, and 4.6 Mt between the 4500-ft and 4600-ft levels grading 0.85% copper, 2.84% zinc, 35 g/t silver and 1.2 g/t gold.

In January 1992, Audrey Resources announced that it had temporarily suspended production at the Mobrun mine due to the exhaustion of ore reserves in the upper portion of the mine. The mine is expected to re-open after the 1100 lens is developed. At the time of closure the mine employed 155 workers.

At the end of June, Minnova Inc. ceased production at its Opemiska mine due to the depletion of ore reserves. The company will maintain the Opemiska mill on a stand-by basis in the event that another mine in the area is developed.

In the Chapais area, work continued on the Lac Frotet copper-gold deposit owned by Minnova and Kerr Addison Mines Limited. Geological reserves at Lac Frotet are estimated at 42.3 Mt grading 1.6 g/t for both gold and silver and 0.12% copper.

In June, Breakwater Resources Ltd. suspended operations at its Estrades polymetallic massive sulphide mine near Joutel. The company attributed the decision to low metal prices. At the end of 1990, reserves at Estrades totalled 940 000 t grading 10.7% zinc, 0.94% copper, 0.92% lead, 182 g/t silver and 5.6 g/t gold.

Exploration by partners VSM Exploration Inc. and Serem Quebec Inc. on the Grevet project near Lebel-sur-Quévillon continued in 1991. On the basis of this work, preliminary reserves are now estimated at 18.4 Mt grading 7.2% zinc, 0.41% copper and 31.3 g/t silver, plus minor lead values.

During 1991, Falconbridge Ltd. continued work on its Raglan nickel-copper deposit in the Ungava region of Quebec. Reserves are estimated at 16 Mt grading 3.13% nickel and 0.88% copper.

Nova Scotia

In September, Rio Algom announced that it would close its East Kemptville tin mine in early 1992 due to what the company described as low tin prices and the high Canadian dollar. The operation produced a small quantity of by-product copper.

Yukon

During 1991, Thermal Exploration Co. and Western Copper Holdings increased preliminary reserves of the oxide zone of their Williams Creek deposit located 140 miles north of Whitehorse. The revised reserve for this zone now totals 13.2 Mt grading 1.06% copper, of which 86% is oxide copper. Potential development of this property would utilize solvent extraction/electrowinning (SX-EW) technology.

Downstream Processing

In April, Noranda Inc. announced that it would sell its Canada Wire and Cable division to Alcatel Cable SA of France. Canada Wire manufactures power cable, magnet wire for the electronics industry, and copper and fibre-optics cable for the telecommunications and electronic information-processing industries.

Also in April, Wolverine Tube (Canada) Inc. closed its copper tube plant in New Westminster, British Columbia, resulting in a loss of 180 jobs. The company blamed the closure on an overcapacity in the Canadian copper tube industry.

WORLD DEVELOPMENTS

During 1991, Western World mine production of copper was expected to increase to 7.37 Mt from 7.19 Mt in 1990. The production of Western World refined copper, which includes metal derived from both primary and secondary material, declined in 1991 to an estimated 8.39 Mt from 8.52 Mt a year earlier.

Chile

With a significant increase of copper mine capacity due to the commissioning of Escondida, copper output in Chile increased to 1.8 Mt in 1991 compared to 1.588 Mt in 1990.

Copper production at the mines of Government-owned Corporacion Nacional del Cobre (Codelco) totalled 1.125 Mt, down from 1.190 Mt in 1990. Output at the company's Chuquicamata mine, which was affected by a two-week labour strike in July, totalled slightly more than 640 000 t in 1991. At Codelco's El Teniente mine, which was affected by a three-week strike in August and by continued rockbursts in the Sub-Level Six section of the mine, production fell to below 280 000 t.

Faced with declining ore grades at several of its existing mines, Codelco plans to spend US$450 million over the next several years to boost production. This includes the mining of low-grade sulphides at the Chuquicamata mine, the Inca project at the Salvador mine, and the underground Quebrada Teniente development. By 1995, Codelco plans to develop its Radomiro Tomic deposit (formerly Chuqui Norte), which will produce an estimated 100 000 t/y of contained copper, and also to complete an expansion of its Andina mine that will increase capacity by 90 000 t/y. Other potential developments include the El Abra deposit, a large copper oxide orebody located north of Chuquicamata, which will produce 120 000 t/y of copper cathode by the end of the decade, and the Mansa Mina deposit near the Chuquicamata mine. The latter, which will likely produce about 120 000 t/y, could be brought into production by 1997.

With the likely passage of new Chilean legislation which will allow Codelco to grant private mining companies controlling interest in future joint ventures, the company's ability to increase production should be further enhanced.

The new La Escondida complex, which is owned by The Broken Hill Proprietary Company Limited (BHP) (57.5%), RTZ Corporation PLC (30%), a Japanese consortium (10%) and International Finance Corp. (2.5%), produced approximately 300 000 t of contained copper in concentrate during 1991. It has been reported that the owners of the mine are considering an expansion of the operation which would raise capacity to 400 000 t/y of contained copper in concentrate by 1995.

Other projects in Chile include the 20 000-t/y Los Pelambres project controlled by Minera Anaconda Chile Ltda (20%), Midland Bank (40%) and Lucky Goldstar International Corp. (40%), which is scheduled to come on stream in 1992, as well as the El Lince project of Compania Minera Carolina de Michilla SA (60%) and Outokumpu Resources Inc. (40%), which is expected to reach full production in the first half of 1992. The latter SX-EW operation is expected to produce approximately 20 000 t/y of copper.

Elsewhere in Chile, Minera Disputada de Las Condes S.A., a subsidiary of Exxon Minerals Chile, Inc., is proceeding with an expansion of its Los Bronces operation to increase production of copper in concentrate to 125 000 t/y by 1993.

At the end of 1991, Cominco Ltd. announced that it was proceeding with its 75 000-t/y Quebrada Blanca SX-EW project. It is expected that the development work will take about 30 months to complete and will cost US$300 million. The Quebrada Blanca property is owned 43% by Cominco, 32% by Teck Corporation, 10% by Empresa Nacional de Mineria (Enami), 10% by Cominco Resources International Ltd., and 5% by Sdad Minera Pudahuel Ltda y Cia CPA (SMP). Copper oxide reserves at Quebrada Blanca, which total 85 Mt grading 1.35% copper, are sufficient to sustain the operation for at least 14 years.

Outokumpu Oy's Zaldivar SX-EW project is expected to begin production in 1994 and to reach 90 000 t/y of copper cathode by 1997. The La Candelaria project of Phelps Dodge Corporation and Sumitomo Metal Mining Co. Ltd., which will likely come on stream at the beginning in 1995, is expected to produce about 120 000 t/y of contained copper. The total cost of this project is estimated at US$540 million. Geological reserves at La Candelaria total 350 Mt grading 1.14% copper, plus gold. During 1991, Phelps Dodge announced that it had increased the throughput capacity of its Pedro Aguirre concentrator from 1600 t/d to 3500 t/d and thereby also increased capacity to 25 000 t/y of contained copper. The cost of the expansion was US$18 million.

In January 1992, the Government of Chile approved the proposed investment by Rio Algom Ltd. in the Cerro Colorado mining project in the northern part of the country. Capital costs for the project are estimated at US$290 million. Annual production at the mine is expected to total between 40 000 t and 60 000 t of copper cathode. The Cerro Colorado deposit contains reserves of 79 Mt grading 1.39% copper. Production is expected to begin in late 1994.

In July, Placer Dome Inc. announced that it had concluded an agreement with Empresa Nacional de Mineria (ENAMI) for the evaluation and possible development of the Andacollo copper deposit in northern Chile. The company expects to complete a feasibility study by the middle of 1992. Should a development decision be made, the Andacollo mine could be brought on stream by 1996 at a planned capacity of about 70 000 t/y of copper. The deposit contains estimated reserves of about 250 Mt grading 0.62% copper.

In early 1992, Falconbridge Limited announced that it had discovered large additional copper reserves at its Collahuasi project in northern Chile. Reserve estimates on the Rosario deposit now total over 1 billion t of primary copper mineralization grading 0.92% copper and 50 Mt of secondary copper mineralization grading 1.5% copper. The Ujina deposit, located 6 km to the east, contains a preliminary reserve estimate of more than 100 Mt of secondary copper mineralization grading 2% copper. The project, which is equally owned with Chevron Minera Corp. and Shell Chile SA, is expected to be brought into production in 1997 at a planned rate of at least 150 000 t/y and to reach 300 000 t/y by 1999.

A relatively small SX-EW operation is under consideration by North Lily Mining Co. and its Canadian subsidiary, International Mahogany Corp., on their Tuina copper property. Production is expected to begin in 1992.

Compania Minera Disputada is proceeding with a US$175 million expansion and modernization of its 44 000-t/y Chagres smelter. The modernization is required in order for the smelter to comply with new air quality standards introduced by the Chilean government. When completed, the capacity of the smelter will be raised to 120 000 t/y. In early 1992, SNC-Lavalin

Chile SA and Fenco Engineers Inc, units of the Canadian-based SNC Group Inc., were awarded a contract to build a US$23 million sulphuric acid plant for the smelter.

Other copper smelter projects in Chile include a proposal by Refimet SA for a 35 000-t/y smelter near Antofagasta. The cost of the facility is estimated at US$50 million. In addition, Codelco and Enami are reported to be considering an expansion of the Ventanas smelter/refinery from 500 000 t/y of concentrates to approximately 800 000 t/y. The cost of the project is estimated at about US$160 million. Codelco is also considering expansions to its Caletones and Potrerillos smelters. Each project (including sulphuric acid plants), which would increase throughput capacity by 200 000 t/y of concentrates, would cost US$120 million.

A new greenfield smelter that would treat approximately 600 000 t/y of concentrates is also under consideration by Fundacion y Refineria del Pacifico, a consortium of companies which includes Empresa Nacional de Mineria (ENAMI), Lac Minerals Inc. and ACEC-Union Minière. The cost of this project is estimated at about US$450 million. A feasibility study for the project is scheduled to be completed in April 1992.

Minera Escondida, the operator of the La Escondida mine, announced that it was considering a US$200 million project to produce about 80 000 t/y of copper cathodes. According to the company, the plant would utilize a new hydrometallurgical process that can produce refined copper cathode directly from copper concentrate. The process uses an ammonia leach to treat the concentrate while copper cathodes are produced by electrowinning.

Peru

Although the threat of labour unrest in Peru during 1991 loomed over that country's mining industry, there was relatively little strike action in comparison to 1990. As a result, total copper output in Peru during 1991 increased to 381 000 t from 318 000 t in 1990. With the threat of new labour problems in 1992, it is uncertain whether these higher production levels will be sustained.

At the beginning of 1992, Peru announced that it would privatize several of the nation's publicly owned mining companies, including Empresa Minera del Centro del Peru S.A. (Centromin Peru) and Empresa Minera del Peru (Minero Peru SA).

Southern Peru Copper Corporation (SPCC), owned 52% by ASARCO Inc., announced that it will spend US$300 million over the next five years for new projects as well as for the renovation of production equipment and new technology. Projects include a 150 000-t/y sulphuric acid plant at the company's Ilo smelter and a mine tailings control project in the Ilo area. In addition, SPCC will invest in SX-EW plants at its Toquepala and Cuajone mines, which will increase copper output by about 35 000 t/y.

Mexico

A 46-day strike at the copper mine of Mexicana de Cananea SA in Mexico, which began on May 31, 1991, resulted in an estimated production loss of about 35 000 t of copper in concentrate. Also in Mexico, the La Caridad smelter of Mexicana de Cobre was closed for approximately two months for routine maintenance.

United States

During 1991, copper mine production in the United States totalled 1.65 Mt, up 4.2% from 1990. Further increases are expected in 1992.

In January 1992, Kennecott Corporation completed a US$227 million expansion project at its Bingham Canyon mine. The expansion will increase copper production at the company's Utah operations from 215 000 t/y to 245 000 t/y. The company has also announced that it plans to replace its existing 150 000-t/y Garfield smelter with a new 273 000-t/y plant by 1995. The new smelter, which will cost an estimated US$880 million, will use flash smelting technology developed by Kennecott in cooperation with Outokumpu Oy. It is expected that the new smelter will capture 99.9% of the sulphur contained in the concentrate feed.

In Michigan, Kennecott's Flambeau mining project was halted when opponents of the project won an injunction against further development work at the site. The court subsequently issued a temporary restraining order to stop construction until 30 days after the state completes a supplemental environmental impact report concerning the mine's impact on threatened species in the area. The operation, which is expected to produce about 27 000 t/y of copper over a six-year period, had been expected to come on stream in late 1992. Ore from the mine has an average grade of 10.5% copper.

In early 1992, Mitsubishi Metal Corporation announced that it would not proceed with its planned US$200 million copper smelter at Texas City, Texas. The company attributed the decision to delays in securing the necessary environmental approvals.

In April, Cerro Copper Products Co. was forced to declare force majeure on shipments from its 45 000-t/y Sauget, Illinois, copper refinery after the plant's anode casting furnace was damaged. The company lifted the force majeure at the end of May.

ASARCO Incorporated completed an expansion and upgrade of its Mission, Arizona, operations in October. The US$100 million project is expected to increase mine capacity to about 113 000 t/y of copper in concentrate. In early 1992, the company announced that it had also completed a US$24 million expansion to its Ray mine in Arizona that increased the capacity of the operation by almost 60 000 t/y to about 165 000 t/y of contained copper. ASARCO is also proceeding with a new $54 million SX-EW plant at its Silver Bell operation in Arizona. The project, which is expected to be completed in 1994, is expected to yield about 16 000 t/y of copper cathode. Meanwhile, a US$194 million expansion of the Ray copper mine in Arizona is expected to begin as soon as one final permit is issued. This project will increase the capacity of the operation to about 165 000 t/y of contained copper.

Although ASARCO expected that a modernization and expansion of its El Paso, Texas, smelter would be completed by the end of 1991, the project was unable to proceed due to delays in obtaining necessary regulatory approvals. The work, which will increase capacity by about 20 000 t/y of copper, is now expected to be completed in 1993.

In November, a fire at Cyprus Minerals Company's Miami, Arizona, smelter resulted in the shut-down of the plant. As a result of this accident and in order to minimize production losses, the company decided to speed up work on an expansion and modernization program of the facility originally scheduled to commence in 1992. The new Isasmelt furnace, which will increase throughput capacity to 600 000 t/y of concentrate, is now expected to begin production at the end of March 1992 and to reach full capacity by July 1993. In view of the company's temporary shortage of smelter capacity, Cyprus announced at the beginning of 1992 that it would delay restarting operations at its expanded copper mine at Pinos Altos, New Mexico. In February 1991, Cyprus announced the closure of its Tonopah molybdenum-copper mine in Nevada due to high operating costs and depressed metal prices.

Phelps Dodge Corporation announced in October that it would close the sulphide concentrator at its Tyrone mine in New Mexico. However, the company expects that it will continue to mine low-grade oxide and sulphide material for its SX-EW operations at that site.

Magma Copper announced that it would undertake several projects at its San Manuel smelter which will increase the capacity of the plant by over 20 000 t/y. The company also reported that it was considering a further capacity expansion. At the beginning of 1992, Magma announced that it had received favourable results from a feasibility study undertaken on its Robinson mining project near Ely, Nevada. The mine, which could be fully on stream by the end of 1994, would produce almost 57 000 t/y of contained copper in concentrate as well as significant amounts of gold and silver.

During 1991, Magma re-opened its Superior underground mine in Arizona. This mine, which was closed in 1982, is expected to produce between 10 000 and 15 000 t/y of copper in concentrate.

Arimetco International Incorporated completed a new 10 000-t/y SX-EW facility at its Yerington mine in Nevada. The company has announced plans to renovate the original Yerington SX-EW plant to process solutions derived from ore mined at the nearby McArthur property in which the company has a 50% interest. In addition, Arimetco also plans to eventually dewater the Yerington pit and build a 15 000-t/d concentrator to process an estimated 360 Mt of sulphide ore grading 0.4% copper.

It has been reported that the U.S. government is considering a significant reduction of its National Defense stockpile of strategic and critical metals and materials. Such a reduction would include the complete elimination of almost 27 000 t of copper metal in the stockpile.

Australia

In Australia, an explosion in August at the Port Kembla smelter of Southern Copper Co. Ltd. (formerly Electrolytic Refining & Smelting Co. of Australia Ltd.) forced the suspension of operations for about two months. At the time of the accident, the company was in the process of recommissioning the plant following the installation of a new Noranda continuous reactor that will increase the smelter's capacity to 80 000 t/y.

In October, it was reported that MIM Holdings Ltd. had commenced an expansion and modernization of its Mount Isa copper smelter that will increase capacity by 30 000 t/y to 210 000 t/y and lower production costs by 10%. The A$100 million project, which is expected to be completed by the end of 1992, will utilize Isasmelt technology. Also in Australia, it was reported that Western Mining Corporation Holdings was proceeding with a US$51 million expansion of its Olympic Dam mine that will increase copper output by 40% to 66 000 t/y.

Papua New Guinea

In Papua New Guinea, the Bougainville copper mine remained closed in 1991. Although negotiations between secessionist rebels and the Government of Papua New Guinea did begin, the talks were abandoned before a solution could be reached. At the beginning of 1992, the International Water Tribunal ruled that waste from the large Ok Tedi gold-copper mine constituted a major threat to the environment. The tribunal stated that the dumping of mine waste into the Ok Tedi River had disrupted the river's ecosystem, caused flooding, and affected subsistence fishing.

Philippines

In the Philippines, the eruption of Mount Pinatubo forced the temporary closure of Benguet Corporation's Dizon open-pit mine located 100 km northwest of Manila. At the beginning of 1992, it was reported that Atlas Consolidated Mining and Development Corp. had resumed work on its Carmen underground mine project. The project had been suspended in September 1991 after the company had reported record net losses for the first half of 1991. It is expected that production at the Carmen mine will begin in September 1992. In order to concentrate its efforts on the Carmen project, Atlas announced that it would suspend mining operations at its Biga mine.

Philippine Associated Smelting & Refining Corp. (Pasar) was reported to have begun a US$52 million smelter modernization and expansion project at its smelting operation. The work, which will increase capacity to about 155 000 t/y of copper cathode, is expected to be completed in mid-1993.

In August, it was reported that the Asian Development Bank would provide Marcopper Mining Corporation with US$40 million in loans to develop its San Antonio copper mine project on Marinduque Island. The project is expected to produce 32 660 t/y of contained copper along with significant quantities of gold and silver.

Indonesia

At the end of 1991, Freeport-McMoran Copper & Gold Inc. announced a significant increase in the proven and probable ore reserves at its Grasberg copper-gold orebody in Indonesia. Reserves now total 768 Mt grading 1.45% copper, 1.66 g/t gold and 3.86 g/t silver. The company stated that it expected throughput at the Grasberg mill to reach a sustained rate of at least 57 000 t/d in the first quarter of 1992. At the beginning of 1992, Freeport announced that it would participate with Metallgesellschaft AG in a US$450 million-$580 million copper smelter and refinery project to be built at Gresik in eastern Java. Other partners in the 150 000-t/y facility include Nippon Mining Co. Ltd., the Indonesian government and local business interests.

Japan

During 1991, modernization projects were completed at several copper smelters in Japan, thereby boosting overall Japanese smelting capacity by about 3.5%. These include the Hibe Kyodo smelter at Tamano, the Saganoseki smelter, the Onahama smelter, and the Naoshima smelter.

Thailand

In Thailand, it was reported that a consortium of companies was considering a new 120 000-150 000-t/y copper smelter/refinery project. The cost of the project is estimated at about US$585 million. The consortium would include Padaeng

Industry Co. Ltd., Mitsubishi Materials Corporation, Mitsubishi Corporation, Mitsui & Co. Ltd., MIM Holdings, Ltd. and Marc Rich & Co. AG.

Pakistan

Although work began in 1991 on the Saindak gold and copper development in Pakistan, a joint venture between Pakistan's Resources Development Corporation and Metallurgical Construction Corporation of China, it was reported at the beginning of 1992 that the project was experiencing financial problems. The project, which includes both mining and processing operations, is expected to produce up to 16 000 t/y of copper and 1600 kg/y of gold.

People's Republic of China

In the People's Republic of China, the China National Nonferrous Metals Corp. plans to increase production at the Dexing and Wushan copper mines in Jiangxi Province. The expansion of the Dexing mine is expected to increase production from 45 000 t/y of copper in concentrate to 130 000 t/y by 1993. It has also been reported that the construction of a new 60 000-t/y copper smelter at Tianjin, 200 km southeast of Beijing, would begin at the end of 1991.

At the end of 1991 and into 1992, China was reported to have purchased large quantities of copper concentrate, blister copper, refined copper and copper scrap. This increase in buying activity reflects significant economic growth in that country.

Zambia

During 1991, copper output in Zambia was affected by serious shortages of spare parts due to chronic foreign exchange problems. It is expected that production for the financial year ending March 31, 1992, will total 450 000 t and may decline to 400 000 t in 1992. In December, the country's 200 000-t/y Mufulira smelter was reported to have resumed production after a seven-month shut-down for renovations.

Zaire

Copper output in Zaire has continued to be adversely affected by a lack of investment in new capacity and the maintenance of existing mining infrastructure. Beginning in September, the situation was aggravated by serious political unrest in the country during which mining areas experienced looting and riots. With the Kamoto mine expected to remain closed in 1992 as a result of a cave-in during 1991, Generale des Carrieres et des Mines (Gecamines) expects to sell between 200 000 and 230 000 t of copper, compared to 250 000 t in 1991 and over 400 000 t/y in the late 1980s.

Namibia

In Namibia, Revere Resources SA Ltd. announced that it will develop its Haib copper-molybdenum deposit. The first phase of the project, which consists of an 1800-t/y SX-EW operation, is scheduled to come on stream by the end of 1992. The eventual development of the property's sulphide reserves will yield an additional 75 000 t/y of contained copper. Total ore reserves of the deposit are estimated at 600 Mt grading 0.32% copper.

Portugal and Finland

At the beginning of 1991, Outokumpu Oy announced that it was delaying plans to participate in the Sines copper smelter/refinery project in southern Portugal in which it would have held a 60% interest. The US$300 million smelter had been expected to come on stream in 1994. As an alternative, the company stated that it would examine the feasibility of expanding its own Harjavalta smelter in Finland at some future date.

U.S.S.R.

In September, it was reported that five copper mines (Uchalay, Sibay, Gay, Buribay and Karabash) in the Ural Mountains of the former U.S.S.R. might be closed. With the closure of the Karabash smelter, high freight costs to other smelting facilities had rendered these mines uneconomic. In 1990, it was reported that copper mine production in the U.S.S.R. was about 600 000 t of contained metal.

United Kingdom and France

In Europe, the development of two promising deposits has been delayed due to financing difficulties. These include the Parys Mountain deposit of Anglesey Mining plc in the United Kingdom with reserves of 6.5 Mt grading 2.3% copper, 2.6% lead, 5.4% zinc, 0.3 g/t gold and 39 g/t silver, and the deposit of Société Minière de Chessy near Lyon in France with mineable reserves of 4.1 Mt grading 7.8% zinc and 2.5% copper. It is now expected that development work on both projects will begin in 1992.

Germany

In July, Norddeutsche Affinerie AG announced that it would close its flash copper smelter in Germany for two months beginning in August for routine maintenance.

International Copper Study Group

In January 1992, sixteen nations, accounting for approximately 54% of the world trade in copper, agreed to establish the new International Copper Study Group (ICSG). This group comprised Begium/Luxembourg, Chile, Finland, France, Germany, Greece, Italy, the Netherlands, Norway, Peru, the Philippines, Poland, Portugal, Spain, the People's Republic of China, and the United States, as well as the European Economic Community. Several other countries, including Canada, Japan and Zambia, announced that they also intend to join this organization. The group plans to hold its inaugural meeting in June 1992 at which time a headquarters location will likely be decided.

Intergovernmental Council of Copper Exporting Countries

The Intergovernmental Council of Copper Exporting Countries (CIPEC) was scheduled to hold a meeting in March 1992 to discuss the declining membership and, undoubtedly, the future of that organization. CIPEC's recent membership has fallen to just three countries, namely, Chile, Zaire and Zambia, who collectively account for about 20% of world copper production. This compares with previous membership which represented approximately 60% of total copper output.

CONSUMPTION AND USES

Canadian refined copper consumption in 1991 was estimated to have increased to approximately 192 000 t from 184 500 t in 1990. Western World consumption of refined copper in 1991 was estimated to have declined slightly to 8.73 Mt (this includes refined copper from both primary and secondary material) from 8.89 Mt in 1990. In 1990, about 3 Mt/y of copper scrap was used directly by consumers. Altogether 4.25 Mt, or about 37%, of the copper consumed in the Western World was derived from recycled materials in 1990.

Copper's high electrical and thermal conductivity, combined with its good tensile strength and mechanical properties, elevated melting point (1083°C), non-magnetic properties and resistance to corrosion, make it and its alloys very attractive for electrical transmission, water tubing, castings and heat exchangers. Copper is the most efficient conductor of electrical power, signals and heat of all of the industrial metals (aluminum's electrical and thermal conductivity is only 72% and 76%, respectively, of copper's). In Canada, more than half of the refined copper consumed annually is used for electrical applications, mostly wire.

Detailed copper consumption statistics are not officially collected in Canada. The Canadian Copper and Brass Development Association (CCBDA), an association of producers and fabricators, collects certain statistics for its members. The CCBDA disseminates information to copper users and provides technical assistance to encourage and foster copper consumption in Canada. Besides its traditional uses, copper is consumed in Canada for retrofitting fire suppression systems, natural gas tubing in residences, central vacuuming, and roofing. Changes are being contemplated that would require fire suppression systems in all new residential dwellings, and copper is the preferred material for such systems.

Table 8 presents preliminary end-use data for 1989 and 1990 collected by the Copper Development Association Inc. for the United States. Building construction represented the largest market for copper with 39.5% of the total in 1990. Electrical and electronic products accounted for about 26% of U.S. copper usage, followed by industrial machinery and equipment (13.9%), transportation equipment (11.2%), and consumer and other products (9.4%). The average North American automotive vehicle contained about 23 kg of contained copper in 1990 compared to 22 kg in 1986 and 17 kg in 1980. This change has largely been due to the increasing complexity of automotive electrical systems. A typical vehicle, which had about 500 electrical circuits in 1981 and about 750 circuits in 1986, will likely contain up to 1200 circuits in 1992.

NEW MARKETS

A number of promising new markets for copper could well provide significant growth opportunities for the industry by the end of the century. These include applications in roofing, fire suppression systems, natural gas systems inside houses and buildings, as well as solar power generation, data communications, and the storage of spent nuclear fuel. While copper use in original-equipment automobile radiators has declined due to the market penetration of aluminum radiators, copper and brass radiators continue to predominate in the replacement market. In addition, the use of copper in an increased number of automotive electrical circuits is expected to more than offset declining non-electrical copper consumption in vehicles.

Despite a number of technological advances in the communications and telecommunications sectors in recent years that promised to reduce copper consumption, including fibre optics, multiplexing and gauge reduction, copper continues to find application in that expanding industry. Meanwhile, copper also continues to be the preferred metal for electrical wiring applications in building construction. As houses increase in size and incorporate more labour-saving electrical devices, the use of copper in household wiring applications could increase by up to 40%. At present, the average new home in the United States contains about 420 lb of copper, up from 230 lb in the early 1980s.

TRADE

In 1990, about 1.67 Mt of copper in concentrate was exported by Western World countries. Canada was the largest exporter (348 800 t) followed by the United States (258 200 t) and Chile (256 500 t). Blister and anode copper exports by Western nations totalled 616 000 t/y, while refined copper exports were about 3.46 Mt/y. In 1990, Eastern Bloc countries enjoyed a trade surplus of about 250 000 t for refined copper. It is estimated that this surplus increased to about 315 000 t in 1991.

During 1991, it was reported that the European Community and the United States were seeking the elimination or reduction of Japan's 21 yen/kg import duty on refined copper during the ongoing Uruguay Round of multilateral trade negotiations. Within Japan, the Electric Wire and Cable Manufacturers Association also supports the elimination of this duty since it increases the cost of refined copper in that country.

The governments of Canada, the United States and Mexico initiated discussions in 1991 on a North American Free Trade Agreement (NAFTA). Such an accord, which would pave the way for the elimination of tariffs on the movement of goods between the three countries, would effectively create a single North American market with a population of 360 million. In the event that an agreement is reached, it is expected that existing tariffs would be gradually eliminated under a schedule similar to that contained in the Canada-U.S. Free Trade Agreement which came into effect in 1989.

For the Canadian copper industry, one of the principal issues under discussion at the NAFTA negotiations pertains to "Rules of Origin" for copper products that will be traded within the proposed free trade area. One of the principal shortcomings of the existing Free Trade Agreement with the United States has been that Canadian refined copper loses its "free trade" territorial status if it contains any material that was derived from offshore scrap.

In October 1991, the U.S. brass industry filed an anti-circumvention petition against Wolverine Tube (Canada) Inc., alleging that sales of brass plate to the United States constituted a circumvention of a 1987 anti-dumping order against brass sheet and strip from Canada. The original order was assessed against Noranda Metal Inc., who later sold its brass strip and sheet business to Wolverine. The U.S. Department of Commerce subsequently ruled that since the brass mill operated without interruption and there was minimal change in management or its customer base, Wolverine is essentially the same business and should therefore be liable for its predecessor's duty.

In November, it was reported that the Department of Commerce would exclude Ratcliffs (Canada) Limited from a dumping order applicable to brass sheet and strip in view of the extremely low rate at which dumping was occurring. However, the Department ruled that Outokumpu Copper Rolled Products AB of Sweden has continued to dump brass sheet and strip into the U.S. market.

In early 1992, U.S. producers of medium-voltage underground distribution cable, made primarily of aluminum and copper, filed a petition with the U.S. Department of Commerce alleging dumping by Canadian producers. The petition also alleged that at least one Canadian producer, Alcatel Canada Wire Inc., was selling cable at less than fair market value.

HEALTH AND THE ENVIRONMENT

Human and animal health depends on an adequate dietary intake of copper (as it does on many other trace metals). Copper combines with proteins to form many enzymes critical for life. One such important enzyme is superoxide dismutase, which removes the superoxide radicals in the human body. Superoxide radicals are the "residues" of metabolic processes which otherwise could build up to toxic levels. Copper is also required to transport iron from absorption sites to the bone marrow where red blood cells are produced.

Many regulatory agencies have chosen 1 part per million (ppm) as the maximum desirable concentration of copper in drinking water. It signifies more of an aesthetic limit than a health limit; water containing more than 1 ppm can stain laundry, and persons with a keen sense of taste may perceive a metallic flavour in the water.

Copper tube used for the distribution of potable water supplies inhibits bacterial growth. In addition to the suppression of bacteria such as *Legionnella pneumonillia* in a water system, copper also discourages biofilm formation under which bacteria can survive.

Most of the environmental concerns that arise from producing copper are associated with the sulphur dioxide emissions that result from copper smelting. Under a 1985 Ontario government regulation, Inco and Falconbridge must reduce their emissions of sulphur dioxide to 265 000 t and 100 000 t, respectively, by 1994.

At Inco's Sudbury operations, work is under way on those projects which will be required to achieve compliance with the regulation. These include two oxygen flash furnaces, a new sulphuric acid plant, an additional oxygen plant, and a novel oxygen flash smelting converter for the production of blister copper. By the end of 1991, Inco had commissioned the first of the flash furnaces, the oxygen plant and the sulphuric acid plant. Inco estimates that the total sulphur dioxide abatement project will cost $600 million.

During 1991, HBMS began work on a $187 million modernization program at its Flin Flon smelting complex that will reduce sulphur dioxide emissions by 25% and particulate emissions by 50%. The project will also enable the smelter to meet environmental regulations under the Manitoba *Environment Act* which will come into force on January 1, 1994.

The modernization project is directed at both zinc- and copper-processing facilities. In the case of copper, the principal changes include the replacement of concentrate roasting and calcine smelting processes with Noranda continuous converter technology. While SO_2 emissions will not initially be captured at the copper smelter, the volume of off-gases will be reduced, making collection at some point in the future more practical and effective.

In order to facilitate the necessary financing for the company's share of the modernization project, HBMS was purchased in 1991 by Minorco SA from Inspiration Resources Corp. Despite the sale, ultimate control of HBMS remained basically the same since Minorco owned 56% of the equity of Inspiration at the time of the purchase.

INTERNATIONAL REGULATION ON THE TRANSBOUNDARY MOVEMENT OF RECYCLABLES

Basel Convention

The Basel Convention involves the transboundary movement of hazardous wastes. It was negotiated in March 1989 for the purpose of controlling international hazardous waste movements, especially to developing countries. The difficulties for the metals recycling industry lie in the definitions. For control purposes, recycling is defined as a means of disposal; therefore, recyclables are defined as wastes.

Basel specifies operations whose waste streams are to be controlled. As well, Basel defines wastes to be controlled as ones that have various specified elements. Wastes requiring special consideration include ones from households, and the incineration of household wastes. While compounds and elements are specifically mentioned, no concentrations are specified. It has been left to individual countries to define when the presence of specific elements makes the waste hazardous. Copper compounds are specifically mentioned in the Basel Convention Annex I as requiring control of wastes.

Momentum to bring the Basel Convention into force has continued and, at the end of 1991, the number of ratifiers was approaching the 20 required to bring the Convention into force. Basel will come into force on the ninetieth day after the twentieth nation ratifies it.

Once the Convention is ratified, Basel Convention members will not be permitted to trade Basel wastes with nations who are not members of the Basel Convention. However, if there is a bilateral or multilateral agreement pursuant to the Basel Convention Article 11, and one of the parties of the agreement is a member of the Basel Convention, then there can be trade between the Basel nations and non-Basel nations who are party to the agreement. Canada has such an agreement with the United States; it came into effect in 1986.

Events in the United States suggest that legislators will not ratify the Basel Convention until domestic programs and regulations affecting waste disposal and recycling have been dealt with under the *Resource Conservation and Recovery Act* (RCRA) re-authorization. It is unlikely that the United States will ratify the Basel Convention during 1992. The United States is, however, the largest exporter of metal scrap and metal recyclables. An unknown amount of U.S. scrap exports falls under the Basel Convention according to some of the nations which have ratified the Convention. This consideration has helped create additional incentive for the Organization for Economic Co-operation and Development (OECD) to continue negotiations for an agreement to cover the transboundary movement of wastes destined for recovery operations. Approximately US$15 billion or more worth of recyclables, mostly metallic, are traded between the 24 OECD member states.

OECD Agreement

The OECD sponsored meetings of an advisory panel in Vienna, Austria, in June, and in Ottawa, Canada, in August. Governments sent delegations consisting of government officials, industry and environmental groups. Canada presented a control scheme for recyclables graduated for the different types of recyclables: a "green" control scheme for recyclables that could move as normal commercial goods, subject to the usual provisions of transportation of dangerous goods; a "red" control scheme for recyclables to travel under full Basel provisions; and an intermediate "amber" scheme for materials posing intermediate risks. No single criterion of potential hazard or manner of handling was to be used to decide the appropriate control scheme. Non-dispersible forms of copper scrap are included on the "green" list and would therefore be subject to almost no shipping controls in international trade. Ashes, sludges and dusts containing copper, as well as dispersible forms of the metal, which would be put on the "amber list," would be subject to some controls and permitting requirements.

In October, the Waste Management Policy Group (WMPG) sponsored a discussion prior to its usual meeting at which delegates met to further discuss draft terms of an agreement and the lists of materials to be controlled under the three control systems. Unfortunately, from the Canadian perspective, there was no consensus to accept materials on the "green" list that possessed **any** hazard characteristics, regardless of their values, their history, or how they were handled. A further meeting was held in November to complete additional work on the lists. In December, the Environment Committee of the OECD referred the draft decision back to the WMPG. A special meeting of the WMPG has been called for the end of January to complete the negotiation of the process.

STOCKS

Combined copper stocks on the London Metal Exchange (LME) and the Commodities Exchange, Inc. (COMEX), which totalled almost 197 000 t at the beginning of 1991, increased steadily throughout the year to over 354 000 t at the end of December. Figure 2 shows both LME copper stocks and prices for the period 1989-91.

The American Bureau of Metal Statistics reported that total refined copper stocks held by U.S. refineries at the end of November totalled almost 38 000 t compared to approximately 47 250 t at the end of 1990. The Bureau also reported that copper stocks at other Western World refineries totalled 323 000 t in December 1991 compared to about 217 000 t at the end of 1990.

While the absolute volume of total stocks at the end of 1991 was not particularly large when viewed from an historical perspective, the inventory management practices of consumers have changed radically in the past decade. As such, inventory levels at year-end were significantly higher than that which would now be considered to reflect a balance between copper supply and demand. However, at the same time, it should be pointed out that at least a portion of the build-up of stocks on the LME during 1991 represented recent consumer de-stocking.

PRICES

Copper prices declined slightly during the course of 1991, although significantly less than anticipated a year ago. As mentioned earlier, this relatively strong performance was due in large part to the possibility of serious supply disruptions. The average LME settlement price in 1991 was US$1.06/lb compared to $1.21/lb in 1990.

From a high of US$1.19/lb LME in early January 1991, prices declined through the month due to uncertainty related to the war in the Persian Gulf. From a low of $1.05/lb on January 23, the markets strengthened once again during the remainder of the month and remained relatively stable through February, March and April. Prices during this period averaged between US$1.10 and $1.12/lb. In May, a sudden increase in LME stocks caused the copper price to decline sharply. By month-end, the LME price had reached a low for the year of 97¢/lb. With concerns about supply disruptions due to labour problems in Chile, prices recovered to over $1.00/lb in June and traded at slightly above this level through June, July and August. Prices strengthened somewhat in September due to supply concerns relating to political instability in central Africa and production problems at a number of smelters around the world. Through the months of October and November, prices were relatively stable with concerns about possible production disruptions caused by political problems in Zaire and labour problems in Canada providing support for the market. Prices for both months averaged slightly more than US$1.07/lb. In December, copper prices experienced significant downward movement as the market finally reacted to the metal's weakening fundamentals. At the end of the month, copper was quoted at US98.4¢/lb.

The LME and COMEX predominate in establishing copper prices worldwide. Both trade in spot or "cash" metal, as well as in futures contracts. Figure 1 shows daily LME cash prices from 1989 to 1991 in US$/lb. Canadian producers sell refined copper in the United States at COMEX plus a premium of between US2.5¢ and 3¢/lb, in Canada at the Canadian dollar equivalent of COMEX plus between 3¢ and 3.5¢/lb, and in Europe at LME plus £8-10/t (payment terms may differ between regions).

In December 1991, the LME imposed a backwardation limit of £25/t per market day to reduce the possibility of market manipulation. In addition, the LME now requires broker members to make daily reports of futures and options positions that exceed 25 000 t of copper.

In New York, COMEX announced a plan to offer trading in physical grade-one metal. No firm date was established for the commencement of this new contract.

During 1991, there was a significant escalation of treatment and refining charges (TC/RCs) for copper concentrates. At the beginning of 1992, it was reported that combined TC/RCs on the spot market had risen to US40¢/lb or more. This increase is thought to be the result of a worldwide shortage of smelting capacity combined with an oversupply of copper concentrate in the market.

MARKET OUTLOOK

Industrial demand for copper has remained reasonably strong during the current economic downturn, but it is unlikely that there will be a significant improvement for the remainder of 1992. Although there are indications that the economy in the United States is showing signs of recovery, it is anticipated that the Japanese and European economies will experience a downturn in 1992. Assuming that there will be no major supply disruptions, it is expected that prices will ease somewhat in 1992, particularly in view of the continued overall growth of world copper output. As such, it is anticipated that copper prices for the year will average between US90¢ and 95¢/lb.

While copper consumption is expected to experience significant growth beginning in 1993, prices to 1995 are likely to be adversely affected by further increases in copper mine capacity. After 1995, it is expected that prices will strengthen due to a slowdown in the growth of world copper supply accompanied by strong demand.

Copper

For the period 1992 to 2000, copper prices are expected to average between US75¢ and 95¢/lb (constant 1990 dollars), assuming that copper consumption grows at an annual average rate of between 1.5% and 2.0%.

Should the transformation of the former Eastern Bloc countries to market economy systems be accomplished quickly, the growth of consumption for copper will likely be higher than the forecast provided above. The development of modern infrastructure and the retooling of industry will require large quantities of copper.

Note: Information in this review was current as of March 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
2603.00	Copper ores and concentrates						
2603.00.00.10	Copper content	Free	Free	Free	Free	Free	Free
2825.50	Copper oxides and hydroxides	Free	Free	Free	1.5%-2.0%	3.2%	7.2%
28.33	Sulphates; alums; peroxosulphates Sodium sulphates:						
2833.25	Of copper						
2833.25.10	Cupric sulphate	6.8%	Free	1.3%	0.5%	3.2%	5.8%
74.01	Copper mattes; cement copper (precipitated copper)						
7401.10	Copper mattes	Free	Free	Free	0.2¢/kg on copper content	Free	Free
74.03	Refined copper and copper alloys, unwrought Refined copper:						
7403.11	Cathodes and sections of cathodes	Free	Free	Free	0.4%	Free	21 yen/kg
7403.12	Wire-bars	4.0%	Free	0.8%	0.4%	Free	21 yen/kg
7403.13	Billets	Free	Free	Free	0.4%	Free	21 yen/kg
7403.19	Other						
7403.19.10	Ingots, ingot-bars and slabs	Free	Free	Free	0.4%	Free	21 yen/kg
7403.21	Copper-zinc base alloys (brass)						
7403.21.10	Ingots, ingot-bars, slabs and billets	4.0%	Free	0.8%	0.4%	Free	21 yen/kg
7403.22	Copper-tin base alloys (bronze)	10.3%	6.5%	2.0%	0.4%	Free	21 yen/kg
7404.00	Copper waste and scrap						
7404.00.10	Not alloyed	Free	Free	Free	Free	Free	Free
	Alloyed:						
7404.00.21	Copper-zinc base alloys (brass)	4.0%	Free	Free	Free	Free	Free
7405.00	Master alloys of copper	10.3%	6.5%	2.0%	1.0%-2.4%	Free	6.0%
74.06	Copper powders and flakes						
7406.10	Powders of non-lamellar structure						
7406.10.10	Not alloyed	4.0%	Free	2.4%	3.7%	1.4%	7.2%
7406.20	Powders of lamellar structure; flakes						
7406.20.10	Not alloyed	4.0%	Free	2.4%	2.1%	6.2%	7.2%
74.07	Copper bars, rods and profiles						
7407.10	Of refined copper Unworked:						
7407.10.11	Bars and rods, of a maximum cross-sectional dimension not exceeding 12.7 mm	4.5%	3.0%	2.7%	0.7%-4.4%	6.0%	7.2%
	Of copper alloys:						
7407.21	Of copper-zinc base alloys (brass) Unworked:						
7407.21.11	Bars and rods, of a maximum cross-sectional dimension not exceeding 12.7 mm	4.5%	3.0%	Free	1.3%-2.2%	6.0%	7.2%
7407.21.12	Bars and rods, of a maximum cross-sectional dimension exceeding 12.7 mm; profiles	4.0%	Free	Free	1.3%-2.2%	6.0%	7.2%

TARIFFS (cont'd)

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
74.08	Copper wire						
	Of refined copper:						
7408.11	Of which the maximum cross-sectional dimension exceeds 6 mm						
	Not exceeding 12.7 mm:						
7408.11.11	Not coated or covered	4.5%	3.0%	2.7%	0.7%-2.8%	6.0%	7.2%
	Exceeding 12.7 mm:						
7408.11.21	Not coated or covered	4.0%	Free	2.4%	0.7%-2.8%	6.0%	7.2%
74.09	Copper plates, sheets and strip, of a thickness exceeding 0.15 mm						
	Of refined copper:						
7409.11	In coils						
7409.11.10	Unworked	4.0%	Free	2.4%	4.6%	6.0%	6.5%
7409.19	Other						
7409.19.10	Unworked	4.0%	Free	2.4%	3.2%	6.0%	6.5%
	Of copper-zinc base alloys (brass):						
7409.21	In coils						
7409.21.10	Unworked	4.0%	Free	2.4%	1.3%	6.0%	6.0%
7409.29	Other						
7409.29.10	Unworked	4.0%	Free	2.4%	1.3%	6.0%	6.0%
74.10	Copper foil (whether or not printed or backed with paper, paperboard, plastics or similar backing materials) of a thickness (excluding any backing) not exceeding 0.15 mm						
	Not backed:						
7410.11	Of refined copper						
7410.11.10	Unworked	4.0%	Free	2.4%	0.7%	6.5%	6.0%
74.11	Copper tubes and pipes						
7411.10	Of refined copper						
7411.10.10	Unworked	4.0%	Free	2.4%	1.0%	6.0%	6.5%
	Of copper alloys:						
7411.21	Of copper-zinc base alloys (brass)						
7411.21.10	Unworked	4.0%	Free	2.4%	0.9%	6.0%	6.5%
74.12	Copper tube or pipe fittings (for example, couplings, elbows, sleeves)						
7412.10	Of refined copper	10.3%	6.5%	6.1%	7.8%	6.5%	5.8%
7412.20	Of copper alloys	10.3%	6.5%	6.1%	2.2%	6.5%	5.8%
7413.00	Stranded wire, cables, plaited bands and the like, of copper, not electrically insulated	10.3%	6.5%	6.1%	2.8%-3.9%	Free-6.5%	7.2%
74.15	Nails, tacks, drawing pins, staples (other than those of heading No. 83.05) and similar articles, of copper or of iron or steel with heads of copper; screws, bolts, nuts, screw hooks, rivets, cotters, cotter-pins, washers (including spring washers) and similar articles, of copper						
7415.10	Nails and tacks, drawing pins, staples and similar articles	10.3%	6.5%	6.1%	3.5%	6.5%	5.8%
	Other threaded articles:						
7415.31	Screws for wood	10.2%	6.5%	6.1%	3.8%	4.9%	5.8%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Customs Tariff Schedules of Japan, 1991.
[1] GATT rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, COPPER PRODUCTION AND TRADE, 1990 AND 1991p

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
SHIPMENTS[1]					
	Nova Scotia	x	x	x	x
	New Brunswick	8 620	27 142	10 138	27 535
	Quebec	99 198	312 334	110 189	299 268
	Ontario	273 448	860 979	266 274	723 187
	Manitoba	55 506	174 768	56 922	154 598
	Saskatchewan	x	x	x	x
	British Columbia	333 883	1 051 262	329 575	895 110
	Yukon	–	–	–	–
	Northwest Territories	–	–	–	–
	Total	771 433	2 428 935	773 640	2 101 168
	Refinery output	515 835	. .	535 000	. .
EXPORTS				(Jan.-Sept.)	
2603.00.10	Copper ores and concentrates				
	Copper content				
	Japan	268 010	621 908	180 254	367 930
	Spain	23 927	62 431	18 852	40 656
	Philippines	12 922	33 736	16 153	34 462
	South Korea	32 858	75 124	11 615	25 320
	Other countries	21 837	53 825	7 672	14 556
	Total	359 553	847 032	234 545	482 927
2604.00.10,	Other ores and concentrates				
2607.00.10,	Copper content				
2608.00.10	United States	613	1 097	241	394
	Belgium	24	51	–	–
	Japan	2	21	–	–
	South Korea	. .	5	–	–
	Total	640	1 175	241	394
2825.50	Copper oxides and hydroxides				
	United States	–	–	1	4
	Total	–	–	1	4
7401.10	Copper mattes				
	Norway	13 734	34 928	15 428	40 939
	United Kingdom	948	3 025	674	1 865
	Total	14 682	37 953	16 103	42 805
7403.11 to	Refined copper				
7403.19	United States	184 280	559 925	148 124	402 429
	United Kingdom	57 832	159 304	38 405	105 528
	Netherlands	33 352	98 800	34 285	98 155
	Italy	25 204	71 950	22 563	64 416
	Other countries	35 273	104 214	47 012	131 242
	Total	335 941	994 201	290 389	801 777
7403.21 to	Other copper alloys				
7403.29	Netherlands	75	156	87	225
	United States	165	389	70	204
	Germany[2]	285	683	48	126
	Taiwan	43	100	21	49
	Norway	–	–	2	38
	Spain	–	–	. .	2
	Other countries	143	349	–	–
	Total	711	1 681	227	647

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
7404.00	Copper waste and scrap				
	United States	85 738	214 292	51 776	107 145
	South Korea	3 077	7 640	4 056	9 768
	Japan	1 413	3 471	1 820	4 284
	People's Republic of China	478	894	1 618	2 242
	India	3 739	6 567	768	1 351
	South Africa	–	–	227	1 045
	Other countries	9 800	18 942	1 853	2 927
	Total	104 245	251 828	62 117	128 771
7405.00	Master alloys of copper				
	Norway	1	22	–	–
	Total	1	22	–	–
7406.10, 7406.20	Copper powders and flakes				
	United States	67	504	73	557
	Taiwan	54	483	29	281
	South Korea	20	214	11	159
	Thailand	12	110	30	121
	Other countries	46	261	14	152
	Total	199	1 583	159	1 270
7407.10 to 7407.29	Copper and copper alloy rods and profiles				
	United States	4 279	18 466	4 040	16 613
	Other countries	350	1 266	516	1 567
	Total	4 629	19 735	4 556	18 184
7408.11 to 7408.29	Copper and copper alloy wire				
	United States	243	1 226	262	1 154
	Chile	10	98	97	599
	Other countries	55	431	106	352
	Total	308	1 766	465	2 112
7409.11 to 7410.22	Copper and copper alloy plates, sheets, strip and foil				
	United States	8 291	36 778	6 144	24 902
	Saudi Arabia	185	769	487	2 015
	United Kingdom	342	1 383	105	438
	Taiwan	–	–	51	219
	Other countries	154	682	106	456
	Total	8 972	39 629	6 893	28 030
7411.10 to 7411.29	Copper and copper alloy tubes and pipes				
	United States	6 297	32 382	5 614	29 637
	Israel	1 099	4 685	925	3 526
	Taiwan	326	1 664	167	856
	Other countries	192	980	136	644
	Total	7 914	39 720	6 842	34 668
7412.10, 7412.20	Copper and copper alloy tube and pipe fittings				
	Germany[2]	..	2 232	..	8 327
	United States	..	5 423	..	3 554
	Spain	..	2 072	..	1 971
	Other countries	..	1 679	..	1 088
	Total	..	11 416	..	14 940

TABLE 1 (cont'd)

Item No.		1990 (tonnes)	1990 ($000)	Jan.-Sept. 1991p (tonnes)	Jan.-Sept. 1991p ($000)
EXPORTS (cont'd)					
7413.00	Stranded wire, cables, plaited bands and the like, of copper, not electrically insulated				
	United States	5	81	5	85
	India	–	–	31	49
	Other countries	24	91	2	11
	Total	30	179	38	146
7414.90, 7415.10 to 7415.39, 7416.00, 7419.10 to 7419.99	Cloth, fasteners and other items of copper				
	Malaysia	–	–	. .	12 043
	United States	. .	7 880	. .	6 037
	Mexico	. .	143	. .	141
	United Kingdom	. .	135	. .	128
	Israel	. .	89	. .	93
	France	. .	200	. .	86
	Other countries	. .	1 869	. .	292
	Total	. .	10 336	. .	18 836
IMPORTS					
2603.00.00.10	Copper ores and concentrates Copper content				
	United States	12 672	31 469	23 499	49 652
	Portugal	9 109	23 295	13 223	25 597
	Other countries	9 418	10 304	8 225	9 163
	Total	31 198	65 070	44 948	84 415
2604.00.00.10, 2608.00.00.10	Other ores and concentrates Copper content				
	Total	2 043	5 538	1 229	2 881
2825.50	Copper oxides and hydroxides	532	2 042	381	1 643
2833.25	Copper sulphates	5 078	3 971	3 030	2 631
7401.10	Copper mattes	3 032	7 138	4	17
7403.11 to 7403.19	Refined copper and copper alloys, unwrought Refined copper				
	Total	2 594	9 508	1 490	4 846
7403.21 to 7403.29	Refined copper and copper alloys, unwrought Other copper alloys				
	Total	3 239	12 242	2 589	7 974
7404.00	Waste and scrap, copper or copper alloy				
	United States	60 961	93 862	36 205	50 161
	Other countries	4 562	15 761	106	217
	Total	65 523	109 623	36 311	50 381
7405.00	Master alloys of copper	49	213	25	112
7406.10, 7406.20	Copper powders and flakes				
	Total	1 300	5 613	907	3 934

TABLE 1 (cont'd)

Item No.		1990 (tonnes)	1990 ($000)	Jan.-Sept. 1991p (tonnes)	Jan.-Sept. 1991p ($000)
IMPORTS (cont'd)					
7407.10 to 7407.29	Bars, rods and profiles of refined copper				
	United States	20 433	68 465	14 211	43 132
	Japan	1 716	5 634	1 179	3 618
	Brazil	786	2 162	709	1 918
	Peru	560	1 425	326	827
	Germany2	248	994	144	758
	United Kingdom	199	905	139	670
	New Zealand	456	1 550	181	626
	Other countries	2 148	7 162	365	1 228
	Total	26 545	88 297	17 252	52 797
7408.11 to 7408.29	Copper and copper alloy wire Total	9 075	38 577	7 336	27 306
7409.11 to 7409.90, 7410.11 to 7410.22	Copper and copper alloy plates, sheets, strip and foil Total	17 508	73 409	11 066	43 644
7411.10	Pipes and tubes, refined copper	6 923	27 740	6 651	24 049
7411.21	Pipes and tubes, copper-zinc base alloy	2 880	17 493	1 869	10 846
7411.22	Pipes and tubes, copper-nickel base alloy or copper-nickel-zinc base alloy	356	2 695	158	1 308
7411.29	Plates and tubes, copper alloy, n.e.s.	325	2 148	224	1 390
7412.10	Fittings, pipe or tube, of refined copper	533	4 406	781	5 561
7412.20	Fittings, pipe or tube, copper alloy	3 182	25 817	2 666	19 061
7413.00	Stranded wire, cable, plaited bands and the like, of copper, not electrically insulated	3 517	14 906	2 202	9 295
7414.90	Cloth, grill and netting of copper wire and expanded metal of copper	79	507	58	381
7415.10	Nails, tacks, drawing pins, staples and similar articles of copper or of iron or steel with copper heads	66	433	112	534
7415.21	Washers, copper, including spring washers	..	926	..	763
7415.29	Articles of copper, not threaded, n.e.s., similar to those of headings 7415.10 and 7415.21	..	981	..	702
7415.31	Screws, copper, for wood	..	263	..	135
7415.32	Screws, bolts and nuts of copper, excluding wood screws	..	3 753	..	2 087
7415.39	Articles of copper, threaded, n.e.s., similar to bolts, nuts and screws	..	1 452	..	1 356
7416.00	Copper springs	..	168	..	26
7419.10	Chain and parts thereof of copper	..	306	..	353
7419.91	Articles of copper, not further worked than cast, moulded, stamped or forged	909	6 030	618	3 856
7419.99	Articles of copper, n.e.s.	..	26 239	..	17 712

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available or not applicable; n.e.s. Not elsewhere specified; p Preliminary; x Confidential.
1 Anode copper recovered in Canada from domestic concentrates plus exports of payable copper in concentrate and matte.
2 Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, COPPER PRODUCTION, TRADE[1] AND CONSUMPTION, 1970, 1975, 1980 AND 1985-91

	Production		Exports			Imports	Consumption[3]
	Shipments[2]	Refinery Output	Concentrates and Matte	Refined	Total	Refined	Refined
	(tonnes)						
1970	610 279	493 261	161 377	265 264	426 641	13 192	229 026
1975	733 826	529 197	314 518	320 705	635 223	10 908	196 106
1980	716 363	505 238	286 076	335 022	621 098	13 466	208 590
1985	738 637	499 626	320 619	280 033	600 652	19 131	222 466
1986	698 527	493 445	341 390	306 822	648 212	20 901	225 586
1987	794 149	491 124	381 126	288 800	669 926	16 583	231 288
1988	758 478	528 723	348 404	268 680	617 084	4 659	236 280
1989	704 432	515 216	348 739r	321 690	670 429r	4 408	218 571
1990	771 433	515 835	374 875	335 941	710 816	2 594	184 480
1991p	773 640	535 000	250 889a	290 389a	541 278a	1 490a	191 990

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; r Revised.
a January to September 1991.
1 Beginning in 1988, Exports and Imports are based on the new Harmonized System and may not be in complete accordance with previous method of reporting. 2 Anode copper recovered in Canada from domestic concentrate plus exports of payable copper in concentrates and matte. 3 Producers' domestic shipments of refined copper plus imports of refined shapes.

TABLE 3. WESTERN WORLD PRODUCTION OF RECOVERABLE COPPER IN CONCENTRATES, 1990 AND 1991

	1990	1991
	(000 t)	
Chile	1 588	1 820
United States	1 587	1 654
Canada[1]	771	777
Zaire	356	286
Zambia	496	423
Peru	318	381
Australia	327	256
Mexico	291	265
Philippines	182	144
Papua New Guinea	170	205
Indonesia	170	204
Other	936	958
Total	7 192	7 373

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
[1] Data are for shipments.

TABLE 4. WESTERN WORLD PRODUCTION OF REFINED COPPER,[1] 1990 AND 1991

	1990	1991
	(000 t)	
United States	2 017	1 991
Chile	1 192	1 233
Japan	1 008	1 076
Canada	516	538
Germany[2]	533	393
Zambia	479	428
Belgium	332	293
Australia	274	259
Peru	182	244
Other	1 989	1 933
Total	8 522	8 388

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
[1] Includes primary, secondary and electrowon copper. [2] Includes statistics for the Federal Republic of Germany and the German Democratic Republic.

TABLE 5. WESTERN WORLD CONSUMPTION OF REFINED COPPER, 1990 AND 1991

	1990	1991
	(000 t)	
United States	2 150	2 060
Japan	1 577	1 613
Germany[1]	1 028	947
Italy	475	470
France	478	483
Belgium	390	387
United Kingdom	317	269
South Korea	324	344
Canada	185	192
Taiwan	265	397
Brazil	137	145
Other	1 567	1 421
Total	8 893	8 728

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
1 Includes statistics for the Federal Republic of Germany and the German Democratic Republic.

TABLE 6. COPPER AND COPPER-NICKEL SMELTERS IN CANADA, 1991

Company and Location	Product	Rated Annual Capacity	Remarks
		(tonnes of concentrates)	
Falconbridge Limited Falconbridge, Ontario	Copper-nickel matte	600 000	Fluid bed roasters and electric furnaces; 1800 t/d sulphuric acid plant treats roaster gases. Matte from the smelter is refined in Norway.
Inco Limited Sudbury, Ontario	Molten "blister" copper, nickel sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	500 000	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.
Falconbridge Limited Timmins, Ontario	Molten "blister" copper	440 000	Mitsubishi-type smelting, separation and converting furnaces, acid plant and oxygen plant to treat continuous copper concentrate feed stream to yield molten 99% pure copper.
Noranda Inc. Horne smelter Noranda, Quebec	Copper anodes	770 000[a]	One continuous Noranda process reactor and five converters. Acid plant became operational at end of 1989. Treats concentrates from Noranda's mining operations in Quebec and Ontario as well as custom concentrates and scrap.
Noranda Inc. Gaspé smelter Murdochville, Quebec	Copper anodes	221 500[a]	Green charge reverberatory furnace, two converters, rotary anode furnace and an acid plant. Treats Gaspé and custom concentrates.
Hudson Bay Mining and Smelting Co., Limited (HBMS) Flin Flon, Manitoba	Copper anodes	320 000	Five roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrate as well as custom copper concentrates; zinc plant residues and stockpiled zinc-plant residues fed to reverberatory furnace. Project under way to replace concentrate roasting and calcine smelting with Noranda continuous converter technology.

Source: Data provided by each company.
[a] Concentrate and copper scrap.

TABLE 7. COPPER REFINERIES IN CANADA, 1991

Company and Location	Rated Annual Capacity	Remarks
	(tonnes)	
Noranda Inc. Division CCR East Montreal, Quebec	350 000	Refines anodes from Noranda's Horne and Gaspé smelters, from the Flin Flon smelter, and also from purchased scrap. Precious metals, selenium and tellurium recovered from slimes.
Inco Limited Copper Cliff, Ontario	170 000	Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium cake recovered from anode slimes, which are further processed at Port Colborne to recover platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue.
Falconbridge Limited Timmins, Ontario	95 000	Refines anode from the Kidd Creek smelter.
Gibraltar Mines Limited McLeese Lake, British Columbia	5 000	Dissolved copper-in-solution from heap leaching operations is treated in a solvent extraction plant and then electrowinned to produce copper cathode.

Source: All data provided by the companies.

TABLE 8. SUPPLY OF WIRE MILL, BRASS MILL, FOUNDRY AND POWDER PRODUCTS, AND THEIR CONSUMPTION IN END-USE MARKETS, 1989 AND 1990

United States	1989		1990p	
	(000 t)	(% of total)	(000 t)	(% of total)
SUPPLY				
Domestic mill products				
Building wire	494	15.7	489	16.2
Magnet wire	235	7.5	220	7.3
Communication wire	316	10.1	334	11.1
Power cable	149	4.7	151	5.0
Automotive wire and cable	110	3.5	103	3.4
Other wire and cable	206	6.6	207	6.9
Strip, sheet, plate and foil	415	13.2	404	13.4
Rod and bar	401	12.8	390	12.9
Tube and pipe	424	13.5	372	12.3
Mechanical wire	31	1.0	30	1.0
Foundry products	217	6.9	214	7.1
Powder products	19	0.6	17	0.6
Total	3 017	96.1	2 932	97.3
Imported mill products	122	3.9	80	2.7
Total supply	3 140	100.0	3 013	100.0
USES				
Building construction	1 268	40.4	1 191	39.5
Electrical/electronic products	772	24.6	781	25.9
Industrial machinery/equipment	437	13.9	419	13.9
Transportation equipment	360	11.5	338	11.2
Consumer and general products	302	9.6	283	9.4
Total	3 140	100.0	3 013	100.0

Source: Copper Development Association Inc.
p Preliminary.
Note: Percentages may not add due to rounding.

TABLE 9. YEARLY AVERAGE COPPER PRICES[1]

Year	LME
	(current US¢/lb)
1980	99.3
1981	79.5
1982	67.2
1983	72.2
1984	62.6
1985	64.9
1986	62.3
1987	80.1
1988	118.0
1989	129.0
1990	121.1
1991	106.2

Source: Metals Week.
1 Settlement price for highest grade of copper sold.

TABLE 10. MONTHLY AVERAGE COPPER PRICES, 1990 AND 1991

	LME[1]		COiMEX[2]	
	1990	1991	1990	1991
	(current US¢/lb)			
January	107.3	111.0	104.4	110.6
February	107.1	111.1	107.3	110.7
March	119.1	109.6	124.2	109.1
April	121.8	112.1	122.4	108.4
May	124.4	104.6	120.3	101.1
June	117.2	100.7	112.9	99.7
July	125.6	101.4	121.9	99.9
August	134.1	101.3	130.5	101.5
September	137.5	105.4	130.5	106.9
October	124.4	107.2	126.4	106.9
November	117.3	107.9	115.8	105.3
December	112.7	100.8	112.4	98.3

Source: Metals Week.
1 LME settlement price for Grade A copper. 2 COMEX First Position Settlement price.

Figure 1

DAILY LONDON METAL EXCHANGE COPPER PRICES

HIGHEST GRADE SOLD

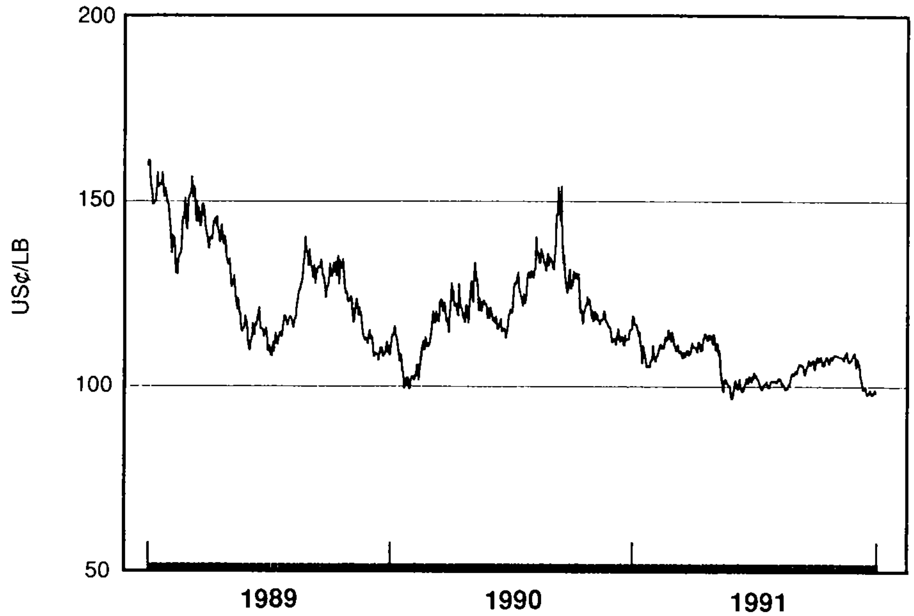
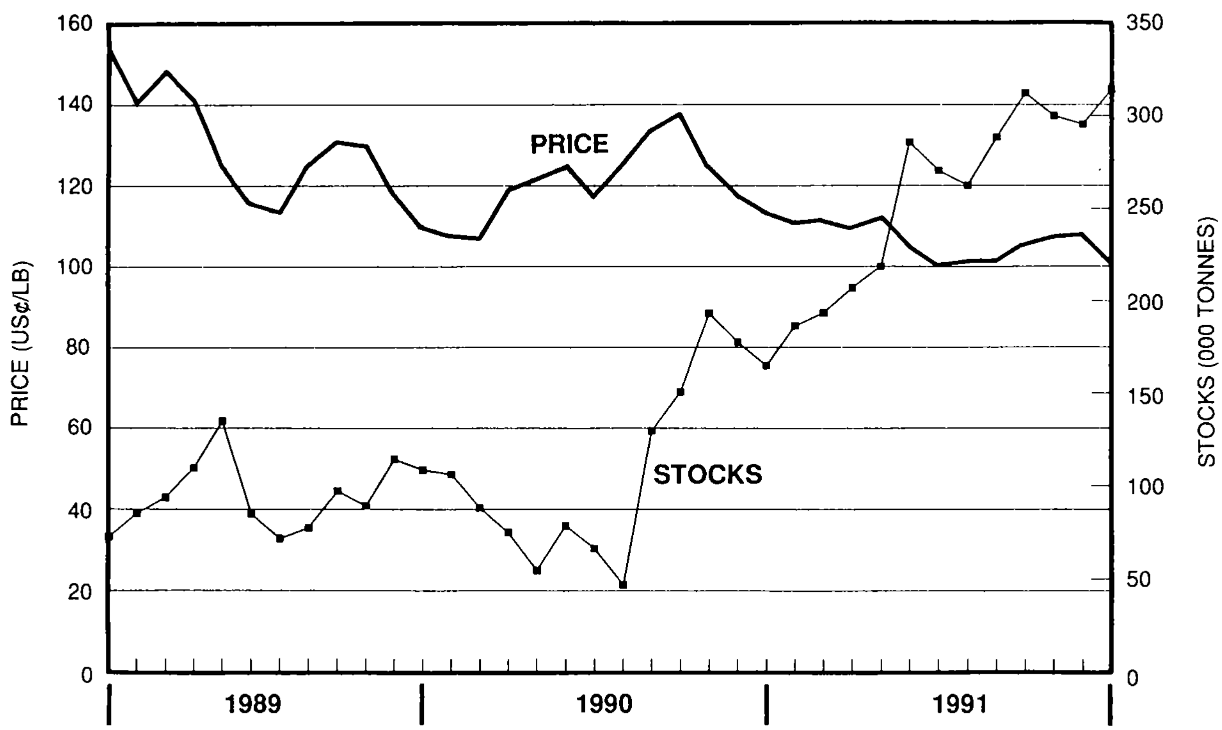
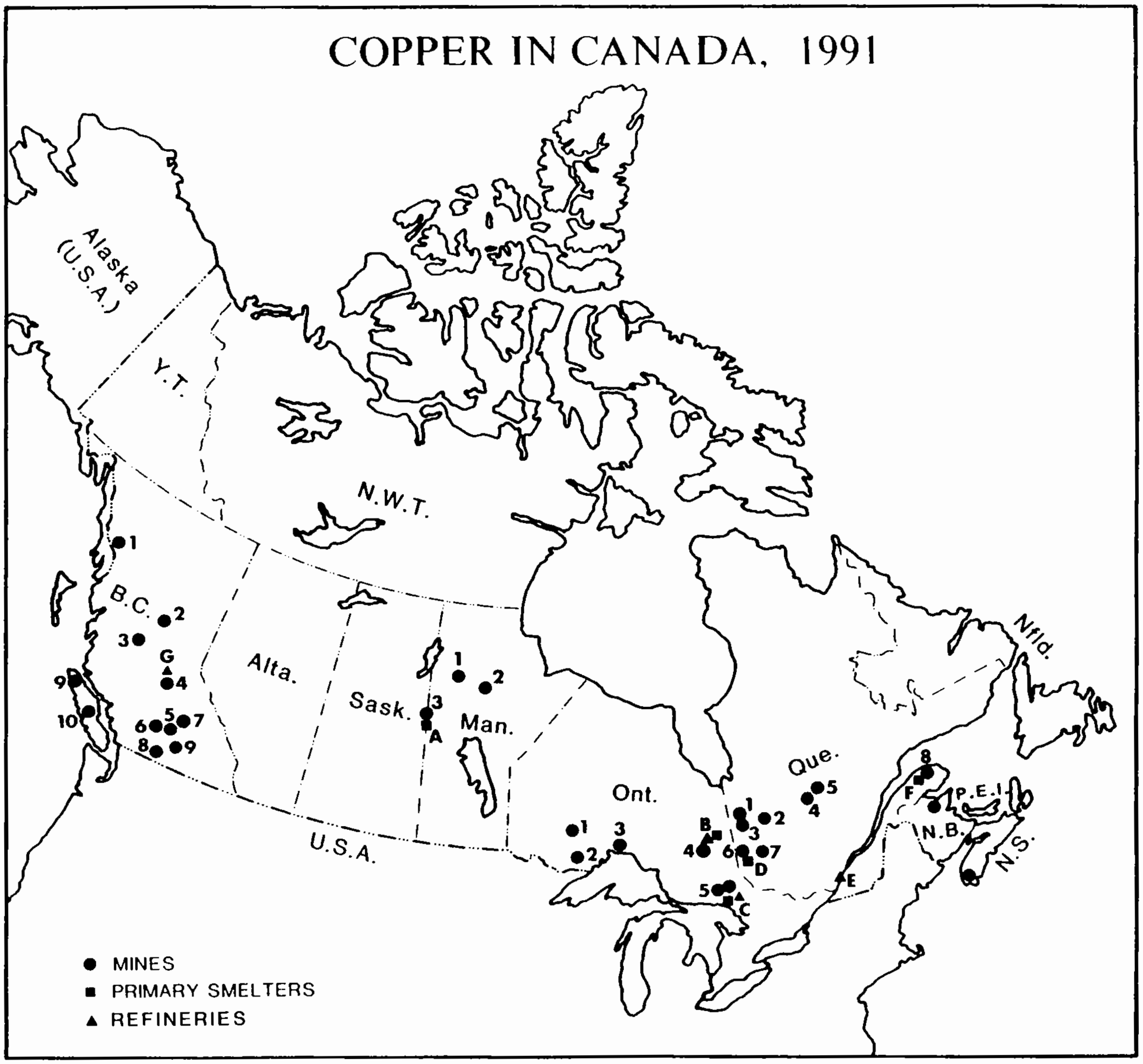


Figure 2

LME COPPER STOCKS AND PRICES

MID-MONTH STOCKS AND AVERAGE MONTHLY PRICES




COPPER IN CANADA, 1991
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
MINES
PRIMARY SMELTERS
REFINERIES

COPPER PRODUCERS IN 1991

(numbers and letters correspond to those on map "Copper in Canada 1990")

British Columbia

1. Skyline Gold Corporation (Iskut River)
2. Noranda Inc. (Bell mine)
3. Equity Silver Mines Limited
4. Gibraltar Mines Limited
5. Highland Valley Copper[1]
6. Teck Corporation (Afton)
7. Minnova Inc. (Samatosum)
8. Princeton Mining Corporation (Similco)
9. BHP-Utah Mines Ltd.
10. Westmin Resources Limited

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited (HBMS), (Flin Flon)

Manitoba

1. Hudson Bay Mining and Smelting Co., Limited (HBMS), (Ruttan mine)
2. Inco Limited (Thompson mine)
3. Hudson Bay Mining and Smelting Co., Limited (HBMS), Flin Flon area mines
   Hudson Bay Mining and Smelting Co./ Outokumpu Mines Ltd. joint venture (Namew Lake mine)

Ontario

1. Noranda Inc., Lyon Lake Division
2. Noranda Inc., Geco Division
3. Minnova Inc. (Winston Lake mine)
4. Falconbridge Limited (Timmins)
5. Falconbridge Limited (Sudbury area)
   Inco Limited (Sudbury area)

Quebec

1. Les Mines Selbaie
2. Noranda Inc., Mattagami Lake Division
3. Breakwater Resources Ltd., Estrades mine
4. Minnova Inc., Opemiska Division
5. Westminer Canada Limited
   Campbell Resources Inc.
6. Audrey Resources Inc. (Mobrun mine)
   Agnico-Eagle Mines Limited (La Ronde mine)
   Minnova Inc. (Ansil mine)
7. Lac Minerals Ltd., Est Malartic Division
8. Noranda Inc., Division Mines Gaspé

New Brunswick

Brunswick Mining and Smelting Corporation Limited
Noranda Inc. (Heath Steele mine)

Nova Scotia

Rio Kemptville Tin Corporation

COPPER SMELTERS

A. Hudson Bay Mining and Smelting Co., Limited (HBMS), (Flin Flon)
B. Falconbridge Limited (Timmins)
C. Inco Limited (Sudbury area)
   Falconbridge Limited (Sudbury area)
D. Noranda Inc. (Noranda)
F. Noranda Inc. (Division Mines Gaspé)

COPPER REFINERIES

B. Falconbridge Limited (Timmins)
C. Inco Limited (Sudbury)
E. Noranda Inc. (Division CCR)
G. Gibraltar Mines Limited (SX-EW)

---

[1] Highland Valley Copper is a partnership of Cominco Ltd., Teck Corporation and Rio Algom Limited.

An inventory of undeveloped Canadian copper deposits is available in the publication "Canadian Mineral Deposits Not Being Mined in 1990," Energy, Mines and Resources Canada. Report MR 223. ISBN 0-660-14371-3.

For detailed production and ore grade information, refer to the table of Nonferrous Mines following the last commodity chapter.

Gold

Gilles Couturier

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4404

Canada's gold production, which had increased rapidly during the 1980s, reached a record 176.7 tonnes (t) in 1991, compared to 167 t in 1990 and 30 t in 1980. In 1991, Canada was the fifth largest gold producer behind South Africa, the United States, the former U.S.S.R., and Australia.

The average price of gold was US$362/oz in 1991, compared to $384/oz in 1990 and $381/oz in 1989. Increased uncertainty in the Middle East brought prices to the $404/oz level by the middle of January 1991. However, soon after the Iraq war, the price of gold declined to the $350-$370/oz range and remained there for most of the year. Gold traded at $344/oz in mid-September, its lowest level since 1985. Other factors influencing the price of gold in 1991 were strong production levels by Western World producers, increased exports by socialist countries, uncertainty caused by the collapse of the U.S.S.R., and relatively low inflation and interest rates in most industrialized nations.

CANADIAN DEVELOPMENTS

There were 60 primary gold mines in Canada at the end of 1991, and these accounted for about 80% of the 176.7 t of gold produced during the year. Total employment in gold mines is estimated to have increased slightly from 12 000 in 1990 to around 12 400 in 1991.

British Columbia

In 1991, British Columbia's gold production reached 18.7 t, compared to 16.1 t in 1990.

In January, Cominco Ltd. started production at its Snip gold-copper-silver project, held jointly with Prime Resources Group Inc. The $65 million project has a mill capacity of 300 t/d. Reserves are 936 000 t of ore with an average gold content of 30 g/t. The mine employs 150 persons.

The SB Project of Westmin Resources and Tenajon Resources Corp. started production in June 1991. The ore is processed at Westmin's Premier gold mine milling facilities.

REA Gold Corporation acquired the Q.R. gold project from QPX Minerals Inc. The Q.R. gold project had previously received approval in principle by the Mine Development Review Committee and is awaiting a production decision. This project has estimated reserves of 1.2 Mt grading 5.2 g/t gold.

International Shasta Resources Ltd. temporarily shut down the Shasta mine in November due to an underground mine collapse. The 180-t/d operation is scheduled to re-open in May 1992.

After reaching a conditional agreement which would have shared the ownership of the Eskay Creek project on a 50:50 basis with Corona Corporation, Placer Dome Inc. elected not to proceed following a thorough review of the project. However, the companies agreed to convert Placer's 44% indirect interest in Stikine Resources Ltd. to a 22% joint-venture interest in the Eskay Creek gold property.

A preliminary study, based on a 450-t/d operation, estimated that the capital cost at Eskay Creek would be $210 million with production of 250 000 oz/y of gold. A $10 million feasibility study will be completed in 1992 and production could start by 1994 or 1995. The project is estimated to contain 1 Mt of ore grading 63.8 g/t gold and 2564.5 g/t silver. Prime Resources Inc. and Stikine Resources Ltd. each own 50% of the Eskay Creek property and both companies are controlled by Corona Corporation.

Placer Dome Inc. announced that it will not proceed with development of the Mount Milligan copper-gold property located near Prince George, British Columbia. According to feasibility estimates, the $420 million project would process some 60 000 t/d. Placer Dome stated that the low price of gold was the main factor in its decision. The Mount Milligan deposit contains 300 Mt of reserves grading 0.23% copper and 0.56 g/t gold.

After acquiring Corona Corporation's 38% interest in the Mount Polley copper-gold deposit, Imperial Metals Corporation decided to seek potential buyers for its majority interest in the property. Despite good feasibility study results on the Mount Polley deposit, Imperial Metals has had difficulty in arranging financing for the $132 million open-pit project. Reserves at Mount Polley are estimated at 48 Mt grading 0.38% copper and 0.55 g/t gold.

In the northwestern part of the province, the Windy Craggy copper-gold deposit of Geddes Resources Limited has been undergoing an environmental assessment. Geddes Resources Inc. has also been looking for potential investors for the $500 million project. Current probable and possible reserves at the deposit are about 130 Mt grading 1.8% copper, 0.18 g/t gold, 3.62 g/t silver and important cobalt values.

Northwest Territories

Gold production in the Yukon and Northwest Territories increased to 21.6 t in 1991, up from 20.2 t in 1990.

The Colomac mine of NorthWest Gold Corp., a subsidiary of Northgate Exploration Limited, was officially put on a care-and-maintenance basis in June. Low recoveries and grades resulted in higher operating costs. The company decided to suspend the operation because of its inability to arrange the financing necessary to re-supply the mine. In order to re-open the mine, an agreement with the project's bankers on restructuring the debt and refinancing the operation would have been required, as well as a substantially higher gold price. The Colomac mine produced about 4.5 t of gold during its 1.5 years of operation.

Saskatchewan

The Jolu mine of Corona Corporation (30%) and International Mahogany Corp. (70%) closed in October 1991 due to exhaustion of reserves. An underground drilling program failed to delineate any new reserves.

Claude Resources Inc. started production at the Seabee gold mine. However, cost overruns and start-up delays substantially increased the cost of the $23 million project. The 400-t/d operation is targeted to produce 1.5 t/y of gold. Proven and probable reserves are estimated at 1 Mt grading 13.7 g/t gold.

The Jasper mine of joint-venture partners Cameco Corporation (80%) and Shore Gold Fund Inc. (20%) is the only other operating gold mine in Saskatchewan. Mineable reserves of the deposit are 163 300 t containing 16.1 g/t of gold. The mine is expected to yield 2.6 t of gold during its anticipated two-year operation.

The Contact Lake property of Cameco, Uranerz Exploration and Mining Limited and Westward Explorations Ltd. has undergone a feasibility study for a planned 635-t/d operation. The project's estimated capital costs of $38 million are for a mine producing 2.0 t/y of gold.

Manitoba

Following the closure of several gold mines in the last few years, the entire gold production of Manitoba has become a by-product of base-metal mines.

Ontario

Ontario's gold production in 1991 totalled 77 t, a decrease of nearly 4% over the 1990 total. Production at the three mines in the Hemlo area account for over 50% of Ontario's production. Only one mine opened in 1991; the Cheminis gold operation of Northfield Minerals Inc. (78.5%) and Towerland Properties Inc. (21.5%), near Virginiatown, was brought on stream in July at a cost of $13 million. The Cheminis mine hosts proven and probable reserves of 300 Mt averaging 5 g/t gold and is expected to produce between 10 000 and 15 000 oz per month at a cost of $300/oz.

A total of four mines, employing 330, closed in 1991. Corona Corporation (55%) and American Barrick Resources Corp. (45%) closed their Renabie mine in September due to declining reserves, lower grades, rising costs and weak gold prices. The Renabie mine has been reactivated four times since the operation was opened in 1941 and has produced a total of 35 t of gold.

Canamax Resources Inc. announced in October that it would close its Bell Creek mine near Timmins due to high operating costs. Shortly after closing the mine, Falconbridge Gold Corporation announced that they had signed a letter of intent to purchase the Bell Creek gold mine and mill from Canamax Resources Inc. for $5 million. Falconbridge Gold plans to re-open the mill in 1992 to process ore from its nearby Hoyle Pond mine.

Two other mine closures also took place in the Timmins area. Eastmaque Gold Mines closed its Eastmaque mine, and Goldpost and St. Andrew Goldfields closed their Goldpost mine.

Quebec

In 1991, Quebec's gold production increased by 28%, from 40.7 t to 51.9 t, and four new mines opened. Despite low gold prices, the substantial rise in production was caused by production increases by TVX Gold Inc. in Casa Berardi and by Lac Minerals Ltd.'s Bousquet No. 2 mine.

A total of four mines started production in 1991. Cambior Inc. commissioned the Mouska mine in Bousquet Township. For Cambior, it was the company's third new mine in the past three years. It had previously opened the Pierre Beauchemin mine near Rouyn-Noranda and the Lucien C. Béliveau mine (formerly the Pascalis project) near Val-d'Or.

Agnico-Eagle Mines Limited started production at its Eagle West mine, 800 metres (m) west of the company's Eagle shaft in the Joutel area. The new mine will provide additional reserves to extend the life of the existing Eagle-Telbel mine.

Two other small mines also started in 1991: the Norlartic mine of Aur Resources Inc. (70%) and Ressources Nova Cogesco Inc. (30%), and the Simkar mine jointly owned by Explorations Ronrico Inc. and Mines d'or Louvicourt Inc.

Aur Resources and Société Minière Louvem jointly announced the development of the Louvicourt deposit. The $325 million project is expected to yield $2 billion in revenues over the 14-year life of the mine. The Louvicourt deposit has mineable reserves of 22.8 Mt grading 4% copper, 2% zinc, 1.3 g/t gold and 34.0 g/t silver.

Aurizon Mines Ltd. closed the Sleeping Giant mine because of low gold prices. However, Cambior Inc. is undertaking a three-year $12 million exploration program to delineate new reserves. After completing the exploration program, Cambior will earn a 50% interest in the property.

The 500-t/d Estrades polymetallic mine of Breakwater Resources (70%), Golden Group Explorations Inc. (18%) and Golden Hope Resources Inc. (12%) closed in June due to low metal prices and high operating costs. Estrades produced over 50 000 t of ore grading 4.38 g/t gold, 10.25% zinc and 1% copper in 1991.

Some mines could close within the next one or two years unless new reserves are found, including the Camflo mine of American Barrick Resources Corporation, which has reserves for only one more year of operation.

New Brunswick

The Murray Brook mine of NovaGold Resources Inc. is the only operating gold mine in New Brunswick. The mine, which uses an indoor vat leaching process, produces 1300 t/d of ore grading 2 g/t gold and 39.5 g/t silver.

Newfoundland

Hope Brook Gold Inc., a subsidiary of BP Resources Canada Inc., announced in May the temporary closure of its Hope Brook mine near Port-aux-Basques. The mine has experienced a number of difficulties in meeting its original production plans. Even though a new system for treatment of effluents was installed in January 1991, contaminated effluents from the previous system had to be retreated; therefore, the entire operation had to be shut down.

In December, Royal Oak Mines Inc. entered into an agreement with BP Canada Inc. to purchase the Hope Brook mine. Under the terms of the agreement, Royal Oak will issue 5.5 million shares plus provide a five-year operating royalty to BP Minerals should the price of gold be above US$380/oz. Completion of the acquisition is subject to regulatory approval, a definitive agreement and due-diligence review, receipt of environmental permits, and the satisfaction of other labour- and government-related issues. The Hope Brook mine is scheduled to re-open in July 1992.

WORLD DEVELOPMENTS

South Africa

South Africa remains the world's largest gold producer with output of 605 t in 1990 and an estimated 600 t in 1991. Its share of Western World production, however, has fallen from 70% in 1980 to 35% in 1990, and further in 1991, due to increased production in several other countries. With a cumulative output approaching 44 000 t since mining commenced in the early 1870s through to the end of 1991, South Africa has dominated the world's gold supply. Some 98% of the gold currently produced in South Africa comes from mines in the Witwatersrand trial in the Johannesburg area. In 1990, by-product gold produced by the platinum, copper and antimony industry totalled 3 t, while retreatment of tailings accounted for approximately 23 t.

South Africa has moved from being the lowest cost gold producer in 1985 to among the highest cost producers in 1990. Cash costs in South Africa in 1985 were approximately US$147/oz, while costs at other major Western World producers averaged about $200/oz. However, in 1991, South Africa was considered to be the highest cost producer with a cash cost of $294/oz, compared to the average Western World cost of $259/oz. At a price of US$350/oz, about 30% of South African gold mine production is unprofitable. In order to maintain a high level of production in 1991 despite low gold prices, companies had to mine high-grade ore zones. South African gold producers also obtained some major changes in their collective bargaining agreements with the unions. As well, further devaluations in the rand (R) helped gold producers remain competitive. Fiscal measures, such as the replacement of the Goods and Services Tax (GST) by the Value Added Tax (VAT) and the reduction in the import surcharge on capital goods from 10% to 5%, are also helping improve South Africa's competitive position.

Following the removal of various economic and political sanctions by the majority of its trading partners, South Africa is contemplating relaunching the Krugerand gold coin. Prior to the sanctions in 1984, the Krugerand coin accounted for between 40% and 60% of the Western World coin market.

Gold production, valued at US$6.5 billion per year, accounts for over 35% of South Africa's export earnings. According to the Chamber of Mines, a total of about 360 000 persons are employed in the gold mining industry in South Africa. Throughout its history, the Chamber of Mines has assumed responsibility for overall policy coordination, research, recruitment of labour and, until recently, marketing and promotion of the Krugerand through its former subsidiary, the International Gold Corporation.

The South African Department of Minerals and Energy Affairs estimates that the effective exchange rate of the rand in comparison to a basket of currencies has been declining at a rate of 10%/y during the 1980s. The Department also indicated that the producer price index rose by an annual average of 14.1% in the 1980s.

Despite a large reserve base, South Africa's mine production faces major difficulties due to declining ore grades, deep gold reserves, high domestic inflation and low productivity. Since most gold mines have been in operation for over 30 years, they have generally mined their best ore. The South African Department of Minerals and Energy Affairs indicated that 15 new mines could be developed if its mining industry could solve current financial and technical problems. These mines would require investments of up to $20 billion in capital expenditures. Most new major gold mines in the Witwatersrand Basin would also be operating at depths in excess of 2000 m.

Due to low gold prices during 1991, several projects were put on hold and only a few new projects were announced. Genmin's Stilfontein mine shut down in early 1991 primarily because of low prices. Weltevreden Mines Ltd. curtailed its R$210 million first-phase operation which was intended to produce 30 000 t/m of gold-bearing ore. In addition, Winkelhaak Mines Ltd. announced that it will stop work at the R$700 million sub-vertical shaft because of low gold prices. This project would have provided access to 20 Mt of ore grading 5.7 g/t gold, representing 120 t of gold. In September, Anglovaal's Lorraine gold mine announced some production cutbacks. GoldFields also scaled back underground operations at both Venterpost and Doorfontein, and operations at Vlakfontein had to be closed.

Anglo American Corporation of South Africa Ltd. started production at the R$2.5 billion Moab mine in 1991.

United States

U.S. gold production increased from 44 t in 1981 to an estimated 300 t in 1991. For the second time in nearly five decades, U.S. gold production will exceed that estimated for the Commonwealth of Independent States (C.I.S.), thereby making the United States the second largest producer behind the Republic of South Africa. Nevada accounted for about two thirds of U.S. production with an estimated production of 200 t. Growth in gold production in Nevada was made possible by the application of a new low-cost method of treating low-grade ores, the heap leach process. This technique, combined with financing by gold loans and forward sales, considerably shortened the time between the discovery of low-grade gold reserves and the beginning of commercial production. Newmont Gold Company, the largest U.S. gold producer, produced 50 t of gold in 1991, with the bulk coming from its Gold Quarry mine. Production at Gold Quarry is estimated at 30 t, which makes it the largest gold mine in North America. A few kilometres away, American Barrick Resources operates the Goldstrike mine which produced 16.8 t in 1991 and, in 1992, is expected to almost double its production.

American Barrick and Newmont signed an agreement in principle in early 1992 for joint cooperation in the development of the Deep and Lower Post orebodies which are adjacent to the Goldstrike mine. Both companies also agreed to jointly finance exploration and development along the common property boundaries and to share Newmont's bioleach technology. The agreement also permits Newmont to process all of American Barrick's refractory sub-economic ore which grades below 2.2 g/t gold.

Newmont will construct and operate bioleach facilities on its land holdings with Barrick receiving 50% of the profits after recovery of capital. In early 1992, American Barrick announced the development of the Meikle deposit 2 km north of the Goldstrike deposit. The Meikle deposit contains 6.5 Mt of ore grading 21.6 g/t gold. The Meikle underground mine is expected to produce 11 t/y for 11 years.

Other major producing states are California, South Dakota and Montana.

Australia

Australian gold production has also shown a spectacular increase over the past few years, having risen from 39 t in 1984 to an estimated 230 t in 1991. In 1988, Australia displaced Canada as the Western World's third largest gold-producing country. However, the 1991 production level of 230 t is lower than the 1990 total of 241.3 t. This decline stems largely from the government's decision in January 1991 to end the tax-exempt status of income generated from gold mine operations.

Enterprise Metals, a wholly owned subsidiary of CRA Limited, announced that it will proceed with the development of the Peak Gold mine, near Cobar, in central New South Wales. The mine will start to produce by the fall of 1992 at a rate of 3 t/y of gold.

Production capacity at Australia's largest gold mine, the Boddington operation jointly owned by Reynolds Metals (40%), Billiton Australia (30%), Newcrest Mining (20%), and Kobe Alumina Associates (10%), increased by 8% following the $15 million addition of a second extraction process. Production in 1991 was about 12.5 t.

Placer Dome Inc. indicated that development of an underground mine at its 50%-owned Big Bell mine in Western Australia could not proceed at this time. The mine, which is jointly owned by ACM Gold, is expected to have a gold output of around 15 t/y in 1992 and 1993. The production level has been reduced by 3 t/y from earlier forecasts because of dilution difficulties. The company also indicated that Big Bell mine costs were at US$433/oz.

With an expected production of 23 t in 1991, Newcrest is Australia's third largest gold producer. The Government of Australia has decided to ban a proposed gold, platinum and palladium project at Coronation Hill in the northern territory of Kakadu National Park. The Coronation Hill property, which is jointly owned by Newcrest Mining Ltd. (45%), Plutonic Resources Ltd. (45%) and North Broken Hill Peko (10%), did not receive governmental approval because of aboriginal protests that sacred ground would be defiled.

According to the Australian Mint, the Australian nugget became the largest selling gold coin in the world in 1991, surpassing the maple leaf of the Royal Canadian Mint. The new series of Australian nugget coins issued in 1991 came in denominations of two ounces, ten ounces, and one kilogram, while previously, the maximum size had been one ounce.

Papua New Guinea

Gold production in Papua New Guinea (PNG) has been stable during the last four years at around 35 t; however, major developments could boost production to 70 t/y within the next two years.

The huge Porgera gold mine in the Enga province is owned by Placer Pacific (30%) and the operators, Highlands Gold (a 65% subsidiary of Australia's MIM Holdings) and Renison Goldfields Consolidated, each with 30%; the PNG government holds the remaining 10% stake. The PNG government is also expected to earn US$600 million in royalties over the 20-year life span of the project. The Porgera mine is considered to have the lowest cash operating costs of any mine in the world at US$77/oz. The mine, which was officially opened on October 20, 1990, had a 1991 production of 50 t, or 43% more than anticipated.

Production is expected to increase further in 1992 with the mining of high-grade underground ore and the processing of stored residue material containing refractory gold. Finally, the construction of increased milling capacity to 4500 t/y from 1500 t/y is expected to be completed in late 1992. The operation is based upon 60 Mt of mineable reserves grading 6.6 g/t gold. Placer Dome Inc., through its PNG subsidiary, will manage the US$1 billion Porgera project.

Gold production at Placer Dome's 60.6%-owned Missina mine reached a level of 16.6 t. The production increase was realized as increased mill throughput offset lower head grades.

Mining at the Mount Kara alluvial/colluvial gold deposit in the Hidden Valley region started in December 1990. The project is 51% owned by CRA Minerals and 49% owned by Kare Puga Development, which in turn is owned by 6000 land owners. In early January 1992, the Mount Kare mine had to be temporarily closed after being firebombed by a group of armed men. Following this incident, the PNG government established a rapid-deployment police unit of 300 men to provide 24-hour protection for the country's resource projects. The formation of a rapid-deployment unit is necessary because the special services division is currently involved with riots such as the one in Bougainville. The Mount Kara deposit could produce up to 4.5 t/y.

A production decision on the Lihir gold project, owned by RTZ Corporation PLC (80%) and Niugini Mining (20%), a Battle Mountain Gold Co. subsidiary, is expected by the middle of 1992 with a possible initial production by 1993. The development plan was delayed twice because RTZ, which has a stake in Bougainville Copper Ltd. through its 49% ownership in CRA Ltd., has been hesitant to proceed. Failure to submit the feasibility study before the March 31, 1992, deadline would have meant losing the prospecting licence. CRA's ownership of the project could be reduced from 80% to 64% should the PNG government decide to be a partner in the project. Lihir is considered to be one of the world's largest undeveloped deposits outside South Africa with mineable reserves of 188 Mt at an average grade of 3.25 g/t gold, representing over 600 t of gold. The operators plan to produce 18 t/y in the first five years of the project.

Commonwealth of Independent States

The Commonwealth of Independent States (C.I.S.) is now the world's third largest gold producer, behind the Republic of South Africa and the United States, with production estimated to be between 260 t and 300 t in 1991.

Before the break-up of the U.S.S.R., the various producing republics decided to market their gold assets through their own local agencies. About 50% of the C.I.S.'s gold production comes from placer deposits; however, these deposits account for only 20% of the total proven reserve base. Gold reserves are generally concentrated in large low-grade deposits. About 20% of the C.I.S.'s annual gold production is believed to originate as by-product from base-metal operations with the copper industry accounting for 15% of gold production and the lead and zinc industry accounting for about 5%. Russia accounts for approximately 60% of total C.I.S. production, Uzbekistan for about

25%, and Kazakhstan for 5%, with the remainder of gold production coming from Tadjikistan, Kirgizia and Armenia. It is reported that the largest areas of gold production are in western Siberia near the Ural Mountains and in northwest Siberia placers near Magadan, and also from the Muruntau mine. The Muruntau low-grade open-pit mine in Uzbekistan was commissioned in 1969 and is reported to have a production of 60 t/y. The Government of Uzbeksitan signed an agreement in early 1992 with Newmont Mining Corp. to create a joint venture to process gold tailings from the Muruntau mine. Newmont expects that the leaching of the stockpile will yield 87 t of gold. The project's capital cost has been estimated at US$75 million with a life of 15 years; start-up is expected in 1993. Another major mine in the C.I.S. is the Zod mine, located in Armenia, which produces some 10 t/y.

About one third of the C.I.S.'s production is consumed in the domestic jewellery and electronics industries, while approximately 50% has historically gone into Union reserves. The large inflation levels of the past couple of years have prompted consumers to buy gold jewellery instead of holding rubles. There is also substantial usage of gold in dentistry.

Gold is produced by both state-owned enterprises and cooperatives known as artels. The artels generally operate small placer deposits and account for approximately 30% of total gold production. Many of the Artel members are also part of the prospector union, which has a membership of 50 000. Gold production from these individual prospectors has apparently increased by 50% over the last six years.

C.I.S. gold exports in 1991 totalled 200 t compared to 425 t in 1990, according to Gold Field Minerals Services Ltd. However, with its declining state reserves, exports from the C.I.S. should continue to decrease in the future. However, the C.I.S.'s US$70 billion foreign debt will continue to exert pressure to sell gold as a means of obtaining hard currency. Reserves, which were previously estimated at 2000 t, have been reduced significantly following the announcement by the former Soviet authorities that reserves were 240 t in Russia and 150 t of gold held abroad as part of swap transactions.

Following political reforms, the states are reported to handle gold trading directly. In the state of Russia, gold-trading rights have been transferred from Vneshekonombank to Vneshtorgbank. Glavalmazzoloto, which controlled all gold-mining enterprises, including ore and metallurgical plants, secondary processing factories, finished goods and jewellery-making facilities, and scientific research, has also been replaced by state companies. The major state companies are: for the state of Russia, Almazzoloto; for Uzbekistan, Uzbekzoloto; and for Kazakstan, Kazzoloto.

China

China's gold export policy remains unchanged as it needs additional foreign currencies to offset payments on imports and the repayment of the foreign debt. China's external debt exceeded US$43 billion at the end of 1990 and repayment requirements are expected to reach an annual US$10 billion by 1992. China's gold production was estimated at 100 t in 1991. Under the 1991-95 economic plan, the country intends to invest between US$1.3 billion and $1.5 billion for developing new gold mines and improving mining technology. Production between 1991 and 1995 is expected to rise by some

40%. The investment figure is nearly double the amount invested under the 1986-90 plan. China will focus primarily on large-scale operations. Currently, small- and medium-sized gold mines account for 80% of the country's gold production. The small mines are reported to be high-cost operations and also to be producing at lower than capacity. The State Gold Mining Bureau has stated that seven new mines will be brought into production in 1992. The Shandonc province is reported to be the largest producer with about 25% of China's gold production.

The State Administration of Exchange Control (SAEC) indicated that China's gold reserves stood at nearly 400 t.

China is minting gold and silver panda coins which are 99.9% pure. The gold coins are available in five sizes ranging from one ounce to one twentieth of an ounce. The Chinese normally mint between 6 t/y and 9 t/y of the panda gold coins.

Japan

The Hishikari gold-silver mine of Sumitomo Metal Mining Co., Ltd., located on the Kyushu Island, accounts for more than 70% of Japan's gold production. The 370-t/d mine, which has been in operation since 1985, annually produces between 6 t and 7 t of gold. It is reported to be the richest gold mine in the world with average grades of 70 g/t gold and 35 g/t silver.

In 1991, production increased to 10 t following Sumitomo's decision to start up production at the Yamada zone, which contains reserves of about 50 t of gold. The company also started the development of the Sanjin deposit, which hosts gold reserves of 50 t, bringing the Hishikari mine's total gold reserves to some 250 t.

Japan consumes around 200 t/y of gold, mainly in the jewellery and electronics industries. After completing the sale of 220 t of 20-g gold commemorative coins of former Emperor Hirohito in 1990, the Japanese Mint produced some 60 t of 30-g gold commemorative coins for the new Emperor Hakihito. Hakihito gold coins were sold in 1991 for 100 000 yen each.

Ghana

Ghana's gold production, which has grown steadily in the past five years, approached 25 t in 1991. Further production increases are also envisaged primarily because of the good mineral potential and the recent liberalization of the country's mining laws.

In May 1991, Canadian Bogosu Resources Ltd. (CBRL), a subsidiary of Billiton Metals, and its joint-venture partners International Finance Corporation (16%) and the Ghana government (10%), commissioned the Bogosu mine. The $100 million Bogosu mine has reserves of 10.4 Mt grading 3.7 g/t gold. Gold production at the open-pit mine is expected to peak at 5 t in 1992.

Gold production at the Ashanti gold mine in Ghana increased by 30% in 1991 to 16.2 t, and is expected to rise even further to 19 t in 1992. The mine is owned by Goldfields Corp. (55%) and Lonrho (45%).

Other projects currently under way include the Iduapreium gold deposit of Shamrock of Australia (70%), the International Finance Corporation (20%) and the Ghanaian government (10%). The

Iduapreium deposit has gold reserves for 10 years at a production rate of 3 t/y.

Goldenrae Mining completed the construction of a US$6 million alluvial mining complex which is expected to produce about 1 t/y of gold.

Latin America

Major changes in investment and mining laws and relatively unexplored land have made Latin America a very active area for gold mining exploration and development. Currently, there are more than 130 Canadian companies with mining interests in South and Central America, Mexico and the Caribbean. Mexico, Chile, Costa Rica, Bolivia, Guyana and Brazil account for about 80% of property interests in the region, with Mexico alone representing one quarter.

Brazil

Brazil's gold production was expected to have declined to 80 t in 1991 compared to 84 t in 1990. Gold output, which peaked at 112 t in 1988, is expected to decline further due to anticipated production decreases from wildcat miners called "garimpeiros." The garimpeiros' share of production decreased from 80% in 1988 to an estimated 55% in 1991. The sharp decline was due to depletion of easily accessible alluvial gold deposits, more stringent environmental regulations, a lower purchase price offered by the Central Bank of Brazil, and a commitment by government authorities to favour conventional mining companies who provide a guaranteed tax base. However, according to Brazilian authorities, gold smuggling has recently decreased to 5% from up to 60% of production. With high inflation and major currency fluctuations, Brazilians have preferred to hold gold rather than cruzeiros.

There are estimated to be around 800 000 garimpeiros in Brazil. Some are expected to move gradually from their placer mines at Serra Pelada, Tapajos, Rio Madeira in Romaina, and Minas Gerais States to hard-rock mining where they will be at a disadvantage with conventional mining companies due to their lack of equipment. Some states have prohibited gold prospecting by the garimpeiros mainly because of pollution problems and the fact that their presence usually dissuades conventional mining companies to invest.

At the request of Indian bands, Brazilian government authorities attempted to evict garimpeiros from certain areas. A few hundred tonnes of mercury have already been released into the rivers of the Amazon because, in filtering out gold from silt, the garimpeiros use mercury in the process, some of which is released into the water. Several organizations are pressuring Brazilean authorities to ensure that each miner uses a device, called a retort, which recovers almost all of the mercury.

Brazil's major conventional gold producer, Mineracao Morro Velho S.A. (a joint venture between Anglo American Corporation and the Bozzano Simonson group), produced over 12 t/y from its Raposos, Jacobina, Crixas and Cuiaba mines. Also, Rio Paracatu Mineracao S.A., an association between a Brazilean investor and Rio Tinto Zinc Corp. (RTZ), produced over 5 t/y. Through its participation in the Crixas Goias (50%), Brasilia (23%), and Novo Astro (50%) mines, TVX Gold was expected to produce over 4 t of the total 10 t of gold production of the three mines in 1991.

High inflation remained a problem, which sustained a strong domestic gold demand. Brazil is the world's sixth largest gold producer. The Central Bank does not release gold reserve figures, but it is estimated that Brazil's reserves totalled 130 t at the end of 1989.

Chile

Construction of the 16 500-t/d processing plant at La Coipa mine, to replace the original 1100-t/d mine, was commissioned in the third quarter of 1991. The project was completed at a cost of US$218 million and, according to the joint-venture partners Placer Dome Inc. and TVX Gold Inc., it will increase 1992 production to 6 t, along with silver revenues representing 4.5 t of gold. The mine, which is at an altitude of 4000 m in the Andes, should have a life span of 12 years.

Placer Dome was awarded the evaluation and development rights of the Andalco mineral property from Minera Carmen de Andacollo. The property is estimated to have 395 Mt of ore containing 2 billion kg of copper and 1.6 million oz of gold.

Lac Minerals Ltd.'s El Indio mine produced around 7 t of gold in 1991. Approximately $20 million was spent in 1990 and 1991 to build a third roaster and to expand the mill capacity to 3300 t/d.

Amax Gold Inc. has signed a letter of intent to acquire a 50% interest in the El Refugio property of Bema Gold Inc. The US$130 million heap leach gold mine would be operated and owned jointly by both partners. Mine production would be at a rate of 6 t/y. Total reserves are estimated at 100 t of gold.

The Chilean government has approved the La Candeleria copper gold mine of Phelps Dodge Corp. and Sumitomo Metal Mining Company Ltd. The US$1.5 billion project has reserves of 90 t of gold.

Codelco, with private joint-venture partners, has decided to proceed with the exploitation of the Pajonales Occidental and Silica Roja deposits in the Copiaco region which have reserves of 2 Mt grading 1.4 g/t gold. These deposits are adjacent to the El Hueso deposits of Homestake Mining.

Cia Minera Tres Cruces, which is controlled by Anglo American Corporation of South Africa Ltd., closed the Tres Cruces mine as of September 1, 1991. The mine became uneconomic due to low gold prices and lower-than-expected output. Should conditions improve, the company would consider re-opening the mine.

Guyana

Cambior Inc. announced in September 1991 its intention to proceed with the US$160 million Omai gold project in Guyana. The new company, Omai Gold, is owned by Cambior (60%), Golden Star Resources Ltd. (35%) and the Guyana government (5%). Production start-up is expected in the fourth quarter of 1992 at a rate of 250 000 oz/y.

CONSUMPTION AND USES

The industrial consumption of gold, sometimes referred to as fabrication demand, includes gold consumed in jewellery, electronics, dentistry, and both fake and official coins, even though the latter type of coin is often used for investment purposes. Table 4 provides an historical perspective to world gold consumption in these uses.

In Canada, the largest use of gold is for official coins. The Royal Canadian Mint produces two official coins that contain gold: a numismatic gold coin containing one quarter of an ounce of gold, and the gold maple leaf bullion coin family. Prior to 1987, the numismatic coin contained half an ounce of gold.

The gold maple leaf bullion coin, with its very high purity, is world-renowned. In 1988, Canada regained its position as the world's top user of gold for coinage after losing the lead to the United States in 1986 and 1987 when the United States launched the American eagle coin. However, in 1991, Canada lost its leading position to Australia.

The maple leaf coin plays an important role in the Canadian gold industry. Since its introduction in 1979, the program has consumed some 455 t of gold, or 34.2% of total Canadian production during that period.

The domestic carat jewellery industry has two main components: smaller manufacturers producing jewellery pieces in Canada, and larger sales companies importing stock jewellery pieces for direct sale. On average, Canadian gold consumption for jewellery is about 10 t/y.

Most other gold products used in Canada are imported either in end-use form or in semi-manufactured alloy form. Canadian consumption of gold in electronics, dentistry and other industrial uses totalled just above one tonne in 1990 and was not expected to show any dramatic change in 1991.

MARKETS, PRICES AND STOCKS

In the last 15 years, gold-trading practices have changed drastically in response to liberalized trading laws and the development of electronic markets in major financial centres. The price of gold used to be controlled by the intervention of central banks on terminal physical markets. Now the physical market represents only a fraction of the gold equivalent traded on the gold futures and options contracts on the New York Commodity Exchange (COMEX), the London Gold Market and the Tokyo Gold Exchange. While the price of gold is linked to supply-demand conditions, daily fluctuations motivated by speculation, computerized program trading and arbitrage are other key factors.

Another recent innovation on the gold market is the gold loan transaction in which gold holders lend their gold for a fee. These loan transactions are used primarily by gold producers who earn instant cash flow by selling the borrowed gold and repaying the loan at some point in the future out of their gold mine production. The market usually reacts negatively to news of large loan agreements because more gold is added to the market. As we are now entering a period of repayment of these loans, new gold loans and repayments of old loans should largely offset each other and have minimal impacts on the market. In addition, recent low gold prices have diminished the incentive to use gold loans.

OUTLOOK

Canadian gold production is expected to be stable over the next two to three years, assuming prices remain close to current levels. With an average cash production cost of about US$250/oz, Canada generally has a strong competitive position; however, about 10% of Canadian mines have costs near or above US$350/oz and are vulnerable to closure should prices weaken. There are many promising properties across the country which could come on stream with a strengthening in the price.

In spite of a reduction in the growth of Western World gold supply, coupled with a decline in exports from C.I.S. countries and a small recovery from jewellery sales, the price of gold is expected to be somewhat lower than in 1991. Several countries, such as China, the C.I.S. and Brazil, will need to sell important quantities of gold in light of their balance-of-payment difficulties and large external debts.

A factor that should be favourable to the price of gold is strong demand in the jewellery sector, particularly in Taiwan, Thailand and China. Barring very unusual events, such as a major world conflict or spiralling inflation, gold prices in the next five years are expected to fluctuate between US$330 and $400/oz in constant 1991 dollars, with periodic swings outside this range. This forecast is based upon the assumption that inflation in the Western World will remain low, and that Western World gold production will continue to grow at about 1%/y.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
71.08	Gold (including gold plated with platinum) unwrought or in semi-manufactured forms, or in powder form						
	Non-monetary						
7108.11.00	Powder	11%	7%	Free	Free	4.1%	Free
7108.12.00	Other unwrought forms containing by weight not less than 99.95% of gold	Free	Free	Free	Free-3.2%	Free	Free
7108.13	Other semi-manufactured forms						
7108.13.10	Of a purity of 10 carats or more	Free	Free	Free	1.2%-3.2%	0.5%-1.8%	Free
7108.13.20	Of a purity of less than 10 carats	10.3%	6.5%	Free	1.2%-3.2%	0.5%-1.8%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Custom Tariff Schedules of Japan, 1991.

[1] GATT rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, GOLD PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(kilograms)		(kilograms)	
PRODUCTION					
	Newfoundland	x		x	
	Prince Edward Island	–		–	
	Nova Scotia	x		–	
	New Brunswick	x		x	
	Quebec	40 675		51 949	
	Ontario	79 968		76 953	
	Manitoba	2 680		2 498	
	Saskatchewan	3 374		2 885	
	Alberta	32		34	
	British Columbia	16 105		18 660	
	Yukon	4 639		5 034	
	Northwest Territories	15 557		16 562	
	Total	167 373		176 720	
	Total Value ($000)	2 407 654		2 355 325	
	Mine output (kg)	169 412		178 712	
EXPORTS				(Jan.-Sept.)	
		(kilograms)	($000)	(kilograms)	($000)
2600.00	Gold in ores and concentrates	10 817	137 727	5 651	64 952
7108.11	Gold powder				
	United States	351	4 924	218	2 967
	Total	351	4 924	218	2 967
7108.12	Other unwrought forms				
	Switzerland	46 377	679 969	13 915	189 532
	Japan	13 454	214 439	2 290	30 841
	United States	33 200	479 709	73 175	995 886
	Hong Kong	19 252	249 895	27 791	366 238
	United Kingdom	9 802	143 368	4 025	52 838
	People's Republic of China	3 690	51 727	411	5 464
	Other countries	17 834	254 394	6 383	89 831
	Total	143 609	2 073 501	127 990	1 730 630
7108.13	Other semi-manufactured forms				
	Belgium	714	6 518	–	–
	Other countries	218	1 783	6	102
	Total	932	8 301	6	102
	Total refined gold exports	144 892	2 086 726	128 214	1 733 699
IMPORTS					
2600.00	Gold in ores and concentrates	626	7 232	666	6 911
7108.11	Gold powder				
	United States	13	153	4	92
	Other countries	...	1	...	1
	Total	13	154	4	93
7108.12	Other unwrought forms				
	United States	41 209	388 832	16 939	182 040
	Uruguay	1 835	28 909	–	–
	Nicaragua	2 556	17 213	1 233	11 858
	Guyana	1 303	17 973	1 311	17 657
	Other countries	486	5 815	298	3 850
	Total	47 389	458 742	19 781	215 405
7108.13	Other semi-manufactured forms				
	United States	370	3 645	1 307	4 325
	Germany[1]	140	1 595	30	343
	Switzerland	135	1 260	71	595
	Other countries	52	340	16	215
	Total	697	6 840	1 424	5 478
	Total refined gold imports	48 099	465 736	21 209	220 976

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Where applicable, data for East and West Germany have been combined.
– Nil; . . . Amount too small to be expressed; p Preliminary; x Confidential.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, GOLD PRODUCTION BY SOURCE, 1975, 1980 AND 1985-91

	Auriferrous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
1975	37 530	73.0	335	0.6	13 569	26.4	51 433	100.0
1980	31 929	63.1	2 060	4.0	16 632	32.9	50 620	100.0
1985	67 241	76.8	3 464	4.0	16 857	19.2	87 562	100.0
1986	83 197	80.9	2 802	2.7	16 900	16.4	102 899	100.0
1987	94 723	81.8	4 009	3.5	17 086	14.8	115 818	100.0
1988	112 404	83.4	4 879	3.6	17 530	13.0	134 813	100.0
1989	138 211	86.6	5 354	3.4	15 930	10.0	159 494	100.0
1990	147 355	88.0	3 993	2.4	16 025	9.6	167 373	100.0
1991p	153 483	86.8	5 426	3.1	17 811	10.1	176 720	100.0

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary.
Note: Numbers may not add to totals due to rounding.

TABLE 3. CANADA, GOLD PRODUCTION, AVERAGE VALUE AND PERCENT OF TOTAL MINERAL PRODUCTION, 1975, 1980, AND 1985-91

	Total Production	Total Value	Average Value[1]	Gold as a Percent of Total Mineral Production
	(kg)	($000)	($/g)	(%)
1975	51 433	270 830	5.27	2.0
1980	50 620	1 165 416	23.02	3.7
1985	87 562	1 219 653	13.93	2.7
1986	102 899	1 689 292	16.42	5.2
1987	115 818	2 204 472	19.03	6.1
1988	134 813	2 331 989	17.30	6.3
1989	159 494	2 315 860	14.52	5.9
1990	167 373	2 407 654	14.38	5.9
1991p	176 720	2 355 325	13.33	6.8

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary.
[1] Value is based on average reported sales.

TABLE 4. GOLD FABRICATION IN DEVELOPED AND DEVELOPING COUNTRIES, 1980 AND 1987-90

Fabricated Gold	1980	1987	1988	1989	1990
			(tonnes)		
DEVELOPED COUNTRIES					
Carat jewellery	315	585	672	815	864
Electronics	94	118	126	129	134
Dentistry	63	46	48	48	48
Other uses	58	52	54	57	57
Medals and fake coins	18	7	8	8	8
Official coins	170	170	98	98	99
Total	718	978	1 006	1 155	1 210
DEVELOPING COUNTRIES					
Carat jewellery	196	612	843	1 059	1 121
Electronics	2	6	7	8	8
Dentistry	2	2	3	3	4
Other uses	4	5	6	7	8
Medals and fake coins	3	9	11	11	11
Official coins	21	32	31	37	19
Total	228	666	901	1 125	1 171
TOTAL					
Carat jewellery	511	1 197	1 515	1 874	1 985
Electronics	96	124	133	137	142
Dentistry	65	48	51	51	52
Other uses	62	57	60	64	65
Medals and fake coins	21	16	19	19	19
Official coins	191	202	129	135	118
Total	946	1 644	1 907	2 280	2 381

Source: Consolidated Gold Fields PLC, "Gold 1991."

TABLE 5. GOLD MINE PRODUCTION IN THE NON-COMMUNIST WORLD, 1980 AND 1987-90

	1980	1987	1988	1989	1990
			(tonnes)		
South Africa	675.1	607.0	621.0	607.5	605.4
Canada[1]	50.6	115.8	134.8	159.5	167.4
United States	30.2	154.9	201.0	265.5	295.0
Other Africa					
Ghana	10.8	11.7	12.1	15.3	17.3
Zimbabwe	11.4	14.7	14.8	16.0	17.0
Zaire	3.0	12.0	12.5	12.1	12.0
Other	8.0	25.0	27.5	25.2	25.0
Total other Africa	33.2	63.4	66.9	68.6	71.3
Latin America					
Brazil	35.0	84.8	102.2	101.2	78.0
Colombia	17.0	32.5	33.4	31.7	32.5
Chile	6.5	21.4	24.9	27.1	31.6
Peru	5.0	10.8	10.0	12.6	14.6
Venezuela	1.0	16.0	20.0	17.1	14.2
Bolivia	2.0	6.0	9.0	11.5	10.4
Mexico	5.9	9.0	10.7	11.5	9.6
Ecuador	.7	8.0	9.0	11.3	9.3
Dominican Republic	11.5	7.9	6.7	5.5	4.0
Other	4.1	7.0	7.1	7.5	7.7
Total Latin America	88.7	203.4	233.0	237.0	211.9
Asia					
Philippines	22.0	39.5	39.2	38.0	37.2
Indonesia	2.1	12.2	12.3	10.8	13.3
Japan	3.4	13.6	14.4	11.0	11.9
Other	5.0	8.1	11.1	14.1	11.7
Total Asia	32.5	73.4	77.0	73.9	74.1
Europe	11.8	19.9	21.2	24.0	26.2
Oceania					
Australia	17.0	110.7	157.0	203.6	241.3
Papua New Guinea	14.3	33.9	36.6	33.8	33.6
Other	1.0	4.0	6.6	9.4	10.1
Total Oceania	32.3	148.6	200.2	246.8	285.0
Total	954.4	1 388.5	1 555.1	1 682.8	1 736.3

Source: Consolidated Gold Fields PLC, "Gold 1991."
[1] Production figures for Canada were obtained from Energy, Mines and Resources Canada.

TABLE 6. AVERAGE ANNUAL GOLD PRICES, 1970-91, AND MONTHLY, 1989-91

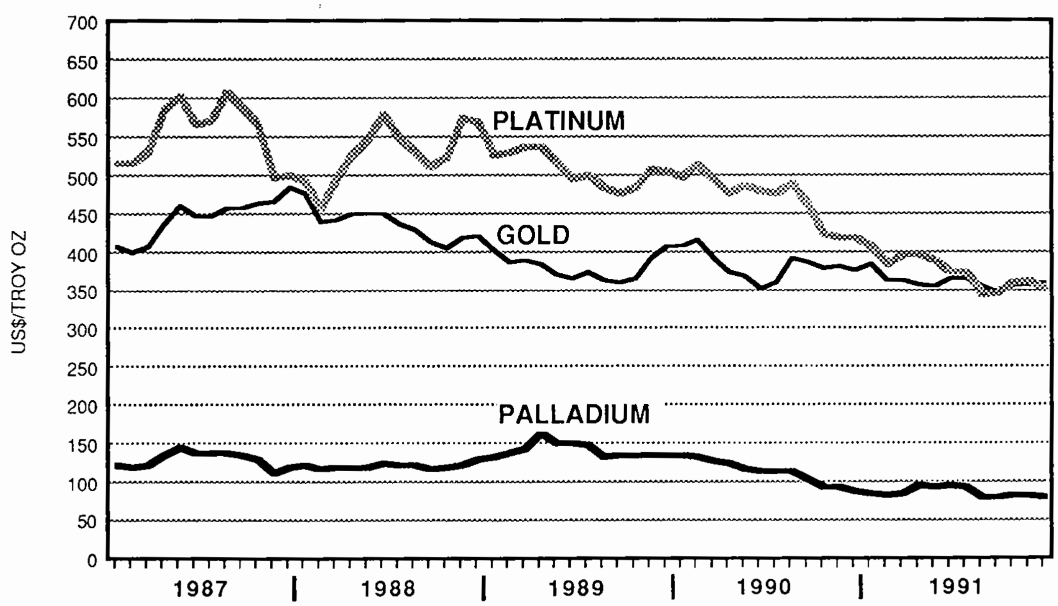
	US$/oz	C$/oz	Year	US$/oz	C$/oz
1970	35.97	37.54	1981	459.22	550.57
1971	40.87	41.27	1982	375.52	463.51
1972	58.22	57.66	1983	423.52	521.82
1973	97.22	97.24	1984	360.63	466.99
1974	158.80	155.36	1985	367.58	510.73
1975	160.96	163.76	1986	367.58	510.73
1976	124.78	123.01	1987	446.66	592.18
1977	147.80	157.10	1988	436.45	554.76
1978	193.51	220.74	1989	381.27	451.33
1979	305.69	358.12	1990	383.72	447.79
1980	614.38	719.08	1991	362.34	415.09

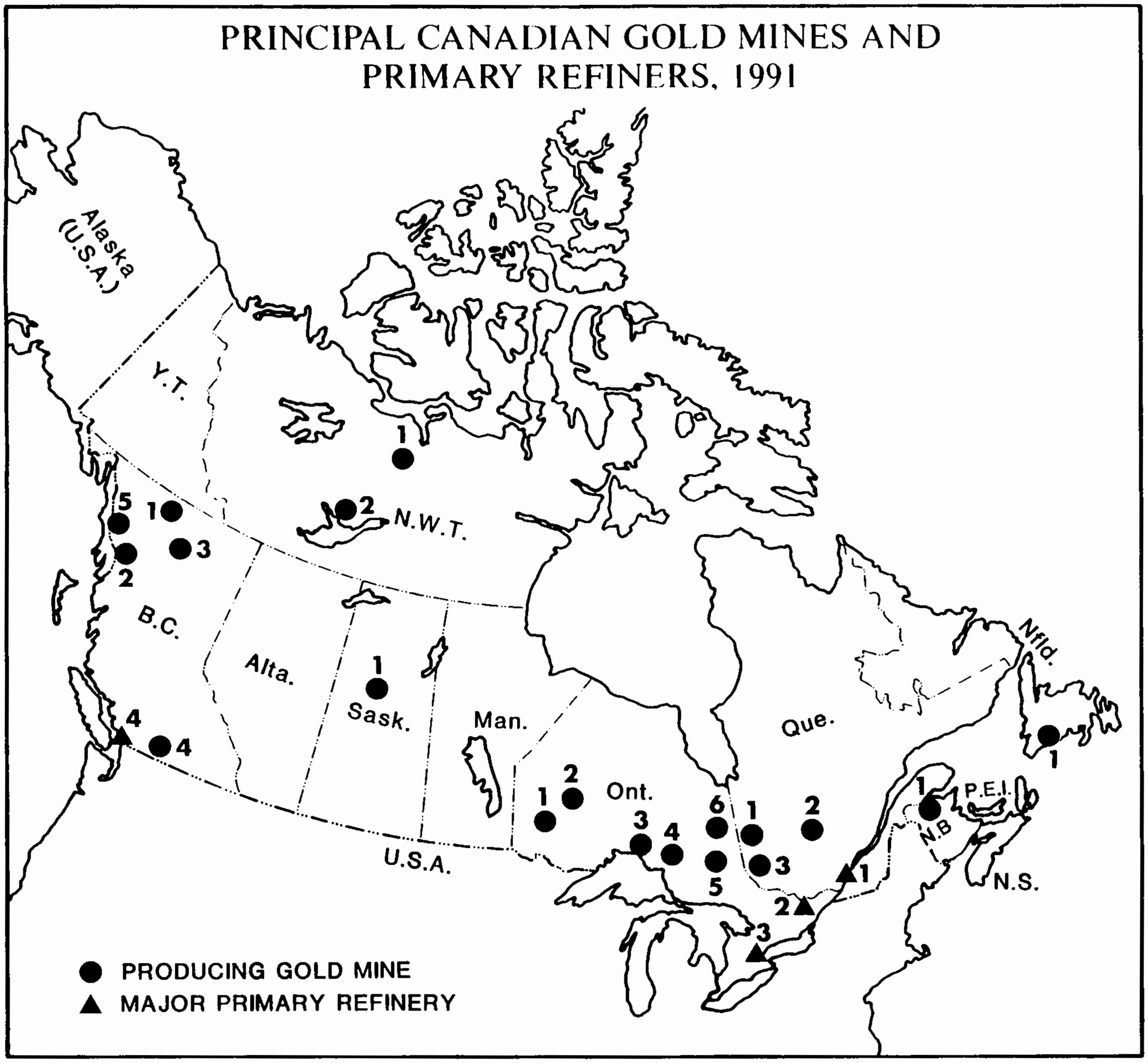
	1989		1990		1991	
	(US$/oz)	(C$/oz)	(US$/oz)	(C$/oz)	(US$/oz)	(C$/oz)
January	404.45	481.70	410.12	480.32	384.59	444.35
February	387.97	461.21	416.54	498.35	363.75	420.08
March	390.28	466.31	393.67	464.76	363.39	420.37
April	384.72	457.23	374.93	436.49	358.05	412.85
May	371.35	442.65	368.85	433.20	357.12	410.54
June	367.73	440.64	352.66	413.69	366.45	419.08
July	375.21	446.15	361.83	418.71	367.98	422.65
August	365.53	429.54	394.86	452.18	356.31	408.00
September	361.80	427.70	389.56	451.05	348.50	396.19
October	366.80	430.78	381.33	442.08	358.82	404.88
November	394.36	461.21	381.71	444.11	359.96	406.78
December	409.71	475.94	378.16	438.76	361.88	414.40

Source: London Gold Market. Compiled by Energy, Mines and Resources Canada.

Figure 1

LONDON PRECIOUS METAL PRICES, 1987-91
(MONTHLY AVERAGES)




PRINCIPAL CANADIAN GOLD MINES AND
PRIMARY REFINERS, 1991
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B
N.S.
U.S.A.
1
2
3
4
5
6
PRODUCING GOLD MINE
MAJOR PRIMARY REFINERY

MAJOR PRIMARY GOLD MINES IN CANADA, 1991

Northwest Territories:

1. Echo Bay Mines Ltd. - Lupin mine
2. Royal Oak Mines Inc. - Giant mine
   NERCO Minerals Company - Con mine
   Treminco Resources Ltd. - Ptarmingan and Tom mines

British Columbia:

1. Golden Bear Operating Company Limited - Golden Bear mine
2. Westmin Resources Limited - Premier mine
   Westmin Resources Limited - SB Project
3. Cheni Gold Mines Inc. - Lawyers mine
4. Corona Corporation - Nickel Plate mine
5. Cominco Limited - Snip mine

Saskatchewan:

1. La Ronge Area
   - Cameco Corporation - Star Lake mine, Jasper mine
   - Claude Resources - Seabee mine

Ontario:

1. Red Lake Area
   - Placer Dome Inc. - Campbell mine
   - Dickenson Mines Limited - Arthur W. White mine
2. Pickle Lake Area
   - LAC Minerals Ltd. - Golden Patricia mine
   - Placer Dome Inc. - Dona Lake mine
3. Hemlo Area
   - Corona Corporation/Teck Corporation - Williams mine
   - Hemlo Gold Mines Inc. - Golden Giant mine
   - Teck-Corona Operating Corporation - David Bell mine
4. Wawa Area
   - Muscocho Explorations Ltd. - Magino mine
5. Timmins - Kirkland Lake Area
   - Placer Dome Inc. - Dome mine
   - Royal Oak Mines Inc. - Pamour #1, #3, #5 and Hoyle mines
   - Falconbridge Gold Corporation - Hoyle Pond mine
   - LAC Minerals Ltd. - Macassa and Lake Shore tailings project
   - American Barrick Resources Corporation - Holt-McDermott mine
   - Deak Resources Corporation - Kerr mine
   - St. Andrew Goldfields Ltd. - Stock Township mine
   - Northfield Minerals Inc. - Cheminis mine

6. Placer Dome Inc. - Detour Lake mine

Quebec:

1. Northwestern Area
   Agnico-Eagle Mines Limited - Agnico-Eagle and Telbel mines
   Inco Gold Company - Golden Pond East and West mines
2. Desmaraisville - Chibougamau Area
   Minnova Inc. - Lac Shortt mine
   Campbell Resources Inc. - Joe Mann mine
3. Rouyn Noranda - Val-d'Or Area
   LAC Minerals Ltd. - Doyon and Bousquet 1 and 2 mines
   Agnico-Eagle Mines Limited - LaRonde mine
   American Barrick Resources Corporation - Camflo mine
   Placer Dome Inc. - Sigma and Kiena mines
   Aur Resources Inc. - Ferderber, Dumont, Kierens and Norlartic mines
   Cambior Inc. - Pierre Beauchemin, Lucien C. Beliveau, Chimo and Mouska mines
   Noranda Minerals Inc. - Silidor mine
   Explorations Ronrico-Simkar mine
   Mines Richmont Inc. - Francoeur mine
   Republic Goldfields Inc. - Malartic-Hygrade mine

New Brunswick:

1. NovaGold Resources Inc. - Murray Brook mine

Newfoundland:

1. Royal Oak Mines Inc. - Hope Brook mine

PRIMARY GOLD REFINERS

1. Noranda Minerals Inc. Canadian Copper Refiners

2. Royal Canadian Mint

3. Johnson Matthey Limited

4. Nesmont Precious Metals Corporation

Graphite

Michel Boucher

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-3074

SUMMARY

Stratmin Inc. remained Canada's only commercial producer of natural graphite in 1991. During the year, the development of graphite deposits was active, mainly in Labrador. Efforts continued to be made by companies in Canada to produce very high-purity graphite for specialty applications, and exfoliated graphite for the manufacture of graphite foil in uses such as gasketing material and pipe-joint packing.

Consumption of graphite in Canada in 1990, the latest year for which statistics were available, was 12 155 tonnes (t), compared with 13 407 t in 1989. About 35% of graphite consumption is natural graphite, of which 90% is flake. Most graphite is used as foundry facing, and in the metallurgical and refractory industries.

Imports of natural graphite for the first nine months of 1991 were 1074 t valued at $1.023 million. Imports for twelve months in 1990 were 2148 t valued at $2.030 million. Exports for the first nine months of 1991 were 4803 t valued at $5.164 million. Exports for twelve months in 1990 were 9841 t valued at $11.564 million. World demand for natural graphite declined in 1991 as a result of the recession.

NATURAL GRAPHITE

Graphite is a natural form of carbon. Natural graphite is a lustrous black carbon mineral, crystallized in the hexagonal system with rhombohedral symmetry. Flake graphite is opaque, flexible and sectile, and exhibits perfect basal cleavage. Natural graphite is unctuous and relatively soft with a hardness of 1-2 on the Mohs scale. It has a black colour and a black streak on glazed porcelain. Its specific gravity is 2.26 g/cm^3. Graphite is an excellent conductor of heat and electricity, and has a high melting temperature of 3500°C. It is extremely resistant to acid, chemically inert, and highly refractory.

Natural graphite is widely distributed throughout the world and is of common occurrence in metamorphic rocks produced by regional or contact metamorphism. Commercially, natural graphite is classified as amorphous, crystalline lump (or vein) and flake. Amorphous graphite is a microcrystalline graphite formed by crystallization of the carbon from organic sediments. The graphite occurs as distorted seams of minute microcrystalline particles intermixed with ungraphitized materials. The graphite content may vary from 15% to 98%, depending on the degree of metamorphism and the original carbon content in the sediments. Crystalline lump occurs in the form of massive vein or circular accumulation formed probably from hydrothermal origin. Deposits are found in fissures or other cavities in igneous or metamorphic rocks. The size of the particles varies from fine grains to large lumps. The vein deposits vary widely in width from 2 mm to more than 2 m. Flake graphite is found disseminated in metamorphosed siliceous or calcareous sediments such as marble, gneiss and schist.

Flake is defined as thin flakes which are classified from coarse to fine, and which are graded according to their graphitic carbon content.

OCCURRENCES

Graphite deposits of potentially commercial interest in Canada occur principally in rocks of the Grenville series of eastern Canada. The mineral is found in disseminated crystalline flake and vein forms. Most Canadian graphite deposits are associated with graphite gneiss and crystalline limestones which have been subjected to contact metamorphism associated with tectonic features such as folding, compression and fracturing, and with pegmatitic intrusions. The richest ore zones occur as a succession of veins or lenticular bodies that gradually merge into the adjacent non-graphitic host rock and that are bordered by lenses of lower grade ore.

Fine to coarse flake graphite deposits have been reported mainly in Quebec and Ontario, but also in New Brunswick, Nova Scotia, Saskatchewan, Labrador, and British Columbia.

In Quebec, graphite deposits are located mainly along the Grenville series in several townships of western Quebec: Buckingham, Argenteuil and Pontiac. The disseminated flake graphite variety is dominant in biotite gneiss and crystalline limestone associated with biotite quartzite, but the vein variety is also reported along the contact of intrusive rocks and crystalline limestone. Occurrences of graphite are associated with metasedimentary rocks which have been subjected to several deformations and where metamorphism has reached amphibolitic or granulitic phases.

Graphite also occurs in Esmanville Township, south of Fermont. Several graphite-rich schist zones, measuring 1-25 m in thickness, are found interlayered with quartz-feldspar gneiss. Some graphite zones locally contain more than 15% graphite in the form of fine and well-crystallized flakes.

In Ontario, graphite deposits are found in several townships of eastern Ontario in rocks of the Grenville Geological Province. Flake graphite occurs disseminated in marbles and gneiss. The occurrences of major interest are in semipelitic and pelitic gneiss units within paragneiss sequences. Graphite is present in amounts up to 10%. Accessory minerals consist of biotite, garnet and pyrite; trace elements in these graphitic rocks are nickel, cobalt, boron and vanadium.

CANADIAN PRODUCTION AND DEVELOPMENT

In 1991, Canada's only commercial production of graphite came from Stratmin Inc. with a mine and concentrator at Lac-des-Îles, Quebec, and a concentrator at Notre-Dame-du-Laus, also in Quebec.

The year 1991 was marked by a decline in exploration and development activity in both Ontario and Quebec. The only company involved in major exploration work was Mart Mining & Exploration Ltd. of Labrador City, Labrador. Mart Mining completed a 600-m diamond drilling program in 1991 on its graphite deposit, which is located 14 km south of Labrador City. The host rock is a micaceous quartz feldspar graphite schist with inclusions of garnet crystals and sulphides, dipping at 40° east and striking north at 20° east. Five holes with a maximum hole depth of 154 m were drilled along a 600-m strike distance. The property's reserves are estimated at 6 Mt grading 17.3% graphitic carbon. The company plans to continue with a diamond drilling program in 1992.

Cal Graphite Corporation of Lively, Ontario, holds a 100% interest in mining claims in the Township of Butt near Huntsville, where crystalline flake graphite occurs in mafic gneiss and paragneiss. Since 1985, Cal Graphite Corporation has undertaken exploration work and, in 1988, the company reported that it had outlined some 60 Mt of proven and probable reserves grading almost 3% graphitic carbon. An open-pit mine and a processing plant with an initial milling capacity of 3000 t/d of ore, which could be expanded to 5000 t/d of ore, is currently producing +94% carbon graphite. Higher grade concentrates for specialty applications are expected to be produced in 1993 from the company's refining facility at Huntsville.

No new developments were reported by Stewart Lake Resources Inc. of Oakville, Ontario, in 1991. The feasibility study on its Kirkham, Ontario, flake graphite project, completed in 1990, concluded that the project could be successfully developed and placed into production at an estimated cost of $9.8 million. Graphite ore would be mined by open-cast method at the beginning, moving to an underground operation eventually. Approximately 8000 t of graphite concentrate would be produced annually.

Victoria Graphite Inc. is seeking financing to start production on its 400-ha property at Portland, half way between Ottawa and Kingston. On the surface, the ore extends about 1700 m by 75 m. Based on 25 trenches and 74 drill holes totalling 8000 m, the company reported possible ore reserves of 750 000 t averaging 7% with a cut-off grade of 3%. The mill has a design capacity of 300 t/d of ore. For a good ore-waste ratio, the mine design is an open pit to 20 m, followed by an incline along the ore. Research has indicated that the graphite would be suitable for the production of exfoliated graphite used in the manufacture of graphite foil.

North Coast Industries Ltd. of Vancouver, British Columbia, after a share consolidation during the year, is now called Consolidated North Coast Industries Ltd. The company is seeking financing to develop its flake graphite project in Bissett Creek, Ontario. North Coast is proposing an annual production of 17 000 t of marketable flake graphite grading 90%-92% carbon. The company has an agreement with Possehl of Germany for the marketing of its production. The deposit has established reserves of 20 Mt of proven and probable flake graphite ore with an average grade of 3.2% carbon.

In 1991, Stratmin Graphite Inc. completed the tune-up of its new mill at Lac-des-Îles, bringing it to its designed capacity of 950 t/d of ore, or about 20 000 t/y of graphite concentrates. With the leased mill at Notre-Dame-du-Laus, which has a rated capacity of 400 t/d of ore, the combined capacity of Stratmin is 28 000 t/y of graphite concentrates. Stratmin is currently exporting its graphite concentrates to 14 countries in North America, South America, Europe, the Far East, and Asia. Due to depressed markets in 1991, the Notre-Dame-du-Laus mill was temporarily shut down in January 1991. From April to December 1991, the Lac-des-Îles mill was operated on a reduced schedule of four days per week. Full production is scheduled to resume early in 1992. Total production of concentrates by the company in 1991 was 10 323 t.

Mazarin, of Quebec City, Quebec, is seeking financing to develop its Fermont, Quebec, flake graphite deposit. A feasibility study on putting the property into production was prepared a couple of years ago. The study proposed an open-pit mining operation for six months of the year, which would supply enough ore to feed a 400-t/d concentrator on a year-round basis for an annual production of 23 000 t of concentrates. A second feasibility study was prepared in early 1991 by Cambior inc., which is a prospective partner in Mazarin. The total capital cost of the project is estimated by Cambior at $30.6 million. Geological reserves are 8.1 Mt averaging 16.7% carbon. The 20-year mining reserves amount to 2.5 Mt grading 17.4% carbon after dilution, and they are mineable by open pit with a waste-ore ratio of 1.0/1.0. The graphite is suitable for all major applications without chemical upgrading. The project is ready for construction and reportedly could be in production within 13 months.

In 1991, Graphicor Resources Inc. added primary milling capacity to its concentrator at Lac-des-Îles, Quebec. Starting in May, the facility was operated in various trial configurations designed to optimize both grade and recovery of flake graphite. However, mill results did not meet expectations, and mining problems at the Diotte mine also developed. Consequently, mining operations were terminated in November with test milling of stockpiled ore continuing until closure in mid-December. The company is pursuing acquisition of the mining and environmental permits required to develop ore reserves at lac la Rouge (formerly lac Carmin), which is held in partnership with SOQUEM, and at Mousseau Township in the municipality of Sainte-Véronique. Results of bulk tests to be performed on the ores from these two locations will be used to determine the cost of any further concentrator retrofit deemed necessary to ensure consistent production at design specifications. Given the reduced demand and sharply reduced prices for graphite, Graphicor will subject any decision to resume full operation to a complete review of all economic factors.

CONSUMPTION AND TRADE

Reported Canadian consumption of graphite in 1990, the latest year for which data are available, amounted to 12 155 t; it was used mainly in foundries, metallurgy and refractories.

In 1991, imports of crude graphite for the first nine months were 1074 t and exports were 4803 t. Some 90% of Canada's trade is with the United States. Crude graphite is used mainly in Ontario (70%) and Quebec (15%).

USES AND SPECIFICATIONS

The uses of natural graphite flow from its physical and chemical properties. The strength of graphite increases as its temperature rises. It has a high thermal conductivity and a low absorption coefficient for X rays and electrons.

Flake graphite is used in the manufacture of crucibles for the steel, nonferrous and precious metals industries. It is preferred to microcrystalline graphite because it burns more slowly, has a high attrition resistance, and imparts structural strength through the orientation of the flakes.

Carbon refractories consist of more than 7% carbon in a blend with either microcrystalline or flake graphite, and are known as magnesia carbon brick. Mag-carbon brick is used in high-temperature and corrosion-prone applications such as steel furnace lining, ladles, slag-lines, hotpots, nozzles and blast furnaces.

Graphite is used because of its thermal conductivity and thermal and chemical resistances. Flake graphite must have a carbon content between 90% and 97% and sizes ranging from 75 to 180 microns.

The use of graphite in brake linings reduces the wear rate. High-carbon, fine crystalline graphite below 75 microns is used with a minimum carbon content of 98%, although a concentrate of 90% can be used if abrasive impurities such as silica are at a low level.

Graphite has traditionally been used in dry-cell zinc-carbon batteries because of its electrical conductivity. Fine-grain carbon below 75 microns, or microcrystalline graphite with a minimum carbon content of between 85% and 90%, is required. Alkaline batteries require a purer natural graphite with a carbon content of at least 98% or a synthetic grade. Carbon material should be free of metallic impurities such as copper, cobalt or antimony.

Electric motor components use a wide variety of graphite, natural or synthetic. Powdered graphite, 150 microns, with a minimum carbon content of 95%-99% is required. Lump graphite, low-silica microcrystalline graphite and synthetic graphite are usually suitable.

In powder metallurgy where steel is reinforced by the absorption of carbon, high-purity graphite is required for the sintering. It also acts as a lubricant and as a source of carbon. Dry powder graphite should be of an average particle size of five microns and must have a carbon content of between 96% and 99%.

Lubricants for industrial usage are also made from graphite because of its softness, low friction, inertness and heat resistance. High-carbon, fine crystalline graphite below one micron is specified with a carbon content of between 96% and 99%.

In paint manufacture, graphite is used to protect metal surfaces exposed to a corrosive environment and to eliminate the accumulation of static electricity in floor coatings. Microcrystalline graphite of low carbon content, 50%-55%, is usually required.

In the manufacture of lead pencils, natural graphite is used because of its marking properties. The degree of hardness of a pencil is determined by the clay-to-graphite ratio of its lead. Microcrystalline graphite, 80%-82%, is used in the cheaper grades of leads. However, a finely ground graphite with a higher carbon content, over 90%, is usually required.

For foundry applications such as mould coating, graphite prevents the adhesion of metals. Foundry facings are usually made of lump graphite or microcrystalline graphite, between 53 and 75 microns, with a low carbon content of 40%-70%.

Iron foundries use microcrystalline graphite as a recarburizer for raising the carbon content of iron melted in electrical furnaces from charges containing large proportions of scrap. A wide variety of material, such as synthetic graphite and coke, may serve as a substitute.

Other uses for natural graphite include engineering components, polishes, rubber products and explosives.

Growth Areas

Growing markets include exfoliated flake graphite rolled into sheet for the manufacture of gaskets and seals used in the automotive industry, heat exchangers, and other products; high alumina and magnesia graphite bricks for the refractory industry; zirconia-graphite; alumina-SiC-graphite refractories; and friction materials. Other growing markets are very high-purity graphite for specialty applications, metal powders and motor brushes.

Flexible Graphite

According to Polycarbon Inc., a manufacturer of flake graphite in the United States, the world market for flexible graphite products is estimated at between 5500 and 6000 t/y in 1990. This amount requires between 8000 and 8600 t/y of flake graphite raw material due to losses in the manufacturing process. To date, the natural graphite flake normally widely used to manufacture flexible graphite has come from mines located in Madagascar, China, Brazil, Canada, India, Zimbabwe, Sri Lanka, Mexico and Norway. The flake quality and price are dependent upon the flake size distribution, fines content, carbon content, and ash content and distribution. Ash is defined as those elements present other than graphite. The size of ash particles as well as the content has an effect on the quality of the finished flexible graphite product. The ash normally consists of varying amounts of trace elements plus larger quantities of silica, sulphur, iron, aluminum and magnesium. The quality of the graphite raw material is also dependent on the quality and process control of the benefication process at the mine site, and must be closely monitored by the flexible graphite manufacturer.

The following table shows the markets for flexible graphite by use and geographic regions.

FLEXIBLE GRAPHITE MARKETS (1990)

Region	Industrial	Automotive
	(t/y)	
North America	400	2 600
Japan	100	1 900
Europe	300	50
Other	100	50
Total	900	4 600

Source: Polycarbon Inc.

Prices for graphite foil averaged US$12/kg in 1990. Major producers of flexible graphite include Polycarbon, Union Carbide Corporation and Flexitallic in the United States; SIGRI GmbH in Germany; Le Carbone Lorraine in France; and Nippon Carbon, Hitachi Chemical and Toyo Tanso in Japan.

WORLD PRODUCTION, TRADE AND CONSUMPTION

Estimated figures for 1990 indicated that world production of natural graphite was 660 600 t. Some 35%-40% was flake graphite. China was the largest producer of graphite with an estimated 200 000 t, followed by South Korea (100 000 t), the former U.S.S.R. (80 000 t), Mexico (37 000 t), and Brazil (32 000 t).

The major world producer countries, by type of graphite and by decreasing order of importance, are as follows:

- **Flakes:** China, the Commonwealth of Independent States (C.I.S.), Brazil, India, Madagascar, Germany, Canada, and Norway.
- **Microcrystalline:** China, South Korea, Mexico, Czechoslovakia, Austria, North Korea, the C.I.S., and Zimbabwe.
- **Lump:** Sri Lanka.

A summary of the largest exporter and importer countries of graphite in recent years is as follows:

MAJOR EXPORTER AND IMPORTER COUNTRIES OF GRAPHITE IN RECENT YEARS

Country	Exports	Country	Imports
	(000 t/y)		(000 t/y)
China	70-80	Japan	70-90
South Korea	35-45	United States	40-47
Mexico	20	Germany	30-35
Madagascar	15	United Kingdom	20-22
Zimbabwe	13		
Canada[1]	6-10	Taiwan	8
Austria	10	Italy	6
Germany	10	France	5
Brazil	9	Austria	4
Norway	5-7		

[1] Exports are expected to increase during the next five years as production capacity increases.

The largest consumers of graphite are the large producers of iron and steel, base metals and precious metals. Together they consume about 50% of all graphite and are the largest users of flake graphite. The largest consumer countries are the C.I.S., Japan, the United States, China, Germany, the United Kingdom, Italy, France, and Brazil.

PRICE

Published prices for natural graphite provide only a range and are not representative of market prices which are contracted prices negotiated between suppliers or distributors and consumers. The prices of flake graphite and lump graphite are higher than those for microcrystalline (amorphous) graphite because of the nature of mining and processing operations. Prices for flake graphite concentrate vary depending on the carbon content, the size of the flakes and their distribution, and the ash content. In Europe, published prices of flake graphite decreased considerably during the year. In the United States, all graphite prices remained the same.

OUTLOOK

Graphite has excellent physical and chemical properties; its resource base is large and it is readily available from several countries. For these reasons, growth should continue. Canadian deposits are of the flake type, relatively easy to upgrade to +90% carbon, and many contain graphite that is expandable. These products command high prices and the outlook for growth is good. World supply will continue to be abundant as many deposits await development.

Note: Information in this review was current as of January 31, 1992.

PRICES

"Industrial Minerals"[1] pricing quotation, c.i.f., United Kingdom port, US$ per tonne

		1988		1989	1990	1991
		Nov.	Dec.	Dec.	Dec.	Dec.
Crystalline lump	92%-95% C	550 – 1 100	750 – 1 500	750 – 1 500	750 – 1 500	750 – 1 500
Crystalline large flake	85%-90% C	630 – 1 000	820 – 1 300	820 – 1 300	820 – 1 300	650 – 1 200
Crystalline medium flake	85%-90% C	490 – 860	770 – 1 120	770 – 1 120	770 – 1 120	450 – 1 000
Crystalline small flake	80%-95% C	300 – 800	540 – 900	540 – 900	540 – 900	400 – 600
Powder (200 mesh)	80%-85% C	250 – 275	325 – 360	325 – 360	325 – 360	325 – 360
	90%-92% C	410 – 460	520 – 600	520 – 600	520 – 600	520 – 600
	95%-97% C	550 – 750	770 – 1 000	770 – 1 000	770 – 1 000	770 – 1 000
	97%-99% C	750 – 1000	1 000 – 1 300	1 000 – 1 300	1 000 – 1 300	1 000 – 1 300
Amorphous powder	80%-85% C	175 – 350	220 – 440	220 – 440	220 – 440	220 – 440

"Chemical Marketing Reporter"[2] pricing quotation, New York, U.S. basis, bags, drums, ex. warehouse, US$ per pound

			1989	1990	1991
Crystalline, powder		88%-90%	.30 – .60	.30 – .60	.30 – .60
		90%-92%	.40 – .75	.40 – .75	.40 – .75
		95%-96%	.60 – .90	.60 – .90	.60 – .90
		97% and up	.80 – 1.20	.80 – 1.20	.80 – 1.20
Flake	No. 1 (large)	90%-95%	.65 – .75	.80 – .95	.80 – .95
	No. 2 (medium)	90%-95%	.65 – .75	.80 – .95	.80 – .95
	No. 3 (small)	90%-95%	.65 – .75	.80 – .95	.80 – .95
Amorphous	powder		.16 – .40	.16 – .40	.16 – .40
	powder	97% and up	.80 – 1.20	.80 – 1.20	.80 – 1.20

c.i.f. Cost, insurance and freight.
1 "Industrial Minerals," November and December 1988, December 1989, December 1990, and December 1991. 2 "Chemical Marketing Reporter," December 1989, December 1990, and December 1991.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
25.04	Natural graphite				
2504.10.10	in powder	9.2%	6%	Free	Free
2504.10.20	in flakes	4%	2.5%	Free	Free
69.02	Refractory bricks, blocks, tiles and similar refractory ceramic constructural goods, other than those of siliceous fossil meals or similar siliceous earths				
6902.90.10	Other, containing by weight 85% or more of carbon or graphite	6.8%	4.5%	4.0%	Free
6902.90.90	Other	Free	Free	Free	4.0%
69.03	Other refractory ceramic goods, other than those of siliceous fossil meals or of other similar siliceous earths				
6903.10	containing by weight more than 50% of graphite or other forms of carbon or of a mixture of these products	6.8%	Free	4.0%	3.4%
6903.10.10	crucibles and covers therefor				
8545.20	Carbon or graphite brushes	10.2%	6.5%	6.1%	2.5%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

Graphite

TABLE 1. IMPORTS OF CRUDE GRAPHITE AND GRAPHITE-RELATED PRODUCTS, 1990 AND 1991

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
2504.10	Natural graphite in powder or flake				
	United States	1 967	1 813	990	913
	Other countries	180	216	84	107
	Total	2 148	2 030	1 074	1 023
6902.90	Refractory bricks, etc., n.e.s. (containing by weight more than 50% carbon or graphite)				
	United States	26 600	20 487	15 451	11 431
	France	279	335	1 019	2 536
	Italy	179	384	631	1 523
	Germany[1]	1 610	2 190	617	1 444
	United Kingdom	1 850	1 779	897	865
	Japan	1 293	2 149	222	682
	Other countries	707	1 279	504	414
	Total	32 518	28 603	19 345	18 900
6903.10	Refractory ceramic goods, n.e.s. more than 50% of graphite or other forms of carbon, etc. (including crucibles)				
	United States	..	1 518	..	1 037
	United Kingdom	..	400	..	513
	Japan	..	360	..	328
	Other countries	..	563	..	414
	Total	..	2 841	..	2 295
8545.20	Carbon or graphite brushes				
	United States	147	4 159	124	3 123
	Other countries	14	535	14	523
	Total	161	4 694	138	3 646

Sources: Energy, Mines and Resources Canada; Statistics Canada.
.. Not available; n.e.s. Not elsewhere specified; p Preliminary.
[1] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. EXPORTS OF NATURAL GRAPHITE, 1990 and 1991

		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
2504.10	Natural graphite, powder or flake	9 841	11 564	4 803	5 164
2504.90	Natural graphite, n.e.s.	689	496	421	178

Source: Statistics Canada.
n.e.s. Not elsewhere specified; p Preliminary.

TABLE 3. GRAPHITE WORLD PRODUCTION, BY COUNTRY[1]

Country	1986	1987	1988	1989	1990e
			(tonnes)		
Argentina	40	216	24	100r	100
Austria	36 167	39 391	7 577	15 307r	17 500
Brazil (marketable)[2]	28 586	31 404	34 520r	31 700r	32 000
Burma[3]	722	–	–	–	–
Canada	w	w	w	w	w
Chinae	185 000	185 000	200 000	200 000	200 000
Czechoslovakiae	25 254a	25 000r	25 000	25 000	25 000
Germany, Federal Republic of	13 233	9 891	9 666r	7 000	8 000
India (mine)[4]	38 412	42 589	57 325r	47 731r	50 000
Korea, Northe	25 000	25 000	25 000	35 000r	35 000
Korea, Republic of					
Amorphous	96 577	106 507	107 767	100 282r	100 000
Crystalline flake	641	838	678	1 186r	1 000
Madagascar	16 187	13 169	14 106	15 863r	16 000
Mexico					
Amorphous	36 018r	36 674	47 871r	38 304r	35 000
Crystalline flake	1 838	1 787	1 735	1 942r	2 000
Norway	–	–	–	1 800r	5 000
Romaniae	12 000	12 000	12 000	10 000	20 000
Sri Lanka	7 453	9 400	8 547	4 163	4 000
Turkey (mine)	3 586	11 760	12 911r	11 302r	12 000
U.S.S.R.e	83 000	84 000	84 000	84 000	80 000
United States	–	–	w	w	w
Zimbabwe	15 004	13 530	11 441	18 147r	18 000
Total	624 718	648 156	660 168r	648 827r	660 600

Source: U.S. Bureau of Mines.
– Nil; e Estimated; r Revised; w Withheld to avoid disclosing company proprietary data.
a Reported figure.
[1] Table includes data available through May 9, 1991. [2] Does not include the following quantities sold directly without beneficiation: 1986–19 074 t; 1987–10 505 t; 1988–18 269 t; and 1989–20 000 t.e
[3] Data are for fiscal year beginning April 1 of that stated. [4] Indian marketable production is 10%-20% of mine production.

TABLE 4. REPORTED CONSUMPTION OF GRAPHITE IN CANADA, 1985-90

	1985	1986	1987	1988[a]	1989[r]	1990[p]
			(tonnes)			
Reported consumption[1] of graphite						
Natural graphite						
Foundry facing	3 994	2 703	3 030	2 722	1 723	1 892
Refractories	472	757	740	673	643	415
Other uses[2]	650	1 050	1 499	1 450	1 625	2 881
Synthetic graphite						
Foundry facing	2 138	7 591	7 003	3 928	3 790	2 680
Other uses[3]	1 083	1 656	2 131	7 002	5 626	4 287
Total	8 337	13 757	14 403	15 775	13 407	12 155

Source: Energy, Mines and Resources Canada.
[p] Preliminary; [r] Revised.
[a] Increase in number of companies being surveyed.
[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants.
[2] Includes brake linings, chemicals, abrasives, primary steel and other end uses. [3] Includes abrasives, batteries, bearings and brake linings, cement, chemicals, primary steel and other uses.

Gypsum and Anhydrite

Oliver Vagt

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-2667

Gypsum

Continued weakness in the construction sector in 1991 resulted in lower demand for all gypsum products. Total shipments of crude gypsum were 7 304 570 tonnes (t) valued at $74.3 million in 1991, compared to 7 977 685 t valued at $80.1 million in 1990. Shipments from Nova Scotia, mainly dependent on captive markets for gypsum wallboard in the United States, were about 4% lower, according to preliminary figures. In Ontario, the second most important producing province, shipments of gypsum were more than 25% lower. All of this latter output was essentially for local captive use.

THE CANADIAN INDUSTRY

Most deposits of gypsum being mined in the Atlantic provinces are characterized by high quality, amenability to inexpensive mining methods, and close access to coastal bulk-shipping facilities. Nova Scotia accounts for more than 75% of Canada's output and nearly all of its exports. Ontario production is used on site, except in the case of Westroc Industries Limited at Drumbo, which ships to the company's Mississauga wallboard plant. Production from Manitoba and from Windermere, Canal Flats (Lussier River), and Falkland, British Columbia, serve the Prairie region and a portion of the B.C. market not served by imports. Domtar Inc. meets most of the requirements of its wallboard plant in Surrey, British Columbia, with gypsum provided under a long-term contract by a 49% Domtar-owned Mexican affiliate, which supplies other company-owned plants further south along the U.S. west coast. About 60% of Canadian shipments of crude gypsum of domestic origin are moved by rail, according to the National Transportation Agency.

Canadian operations are mainly subsidiaries of U.S. gypsum product manufacturers. In Nova Scotia, National Gypsum (Canada) Ltd. is owned by the National Gypsum Company, and both Fundy Gypsum Company Limited and Little Narrows Gypsum Company Limited are owned by USG Corporation, the leading manufacturer of gypsum products in the United States.

Gypsum mining and related manufacturing plants are listed in Table 2. During the past few years, there has been a trend toward closing smaller, less efficient plants and improving the distribution systems associated with larger, more efficient plants.

Domtar Inc. of Caledonia, Ontario, completed a major underground development at the No. 3 mine to supply the company's adjacent board complex (the new east plant) at Caledonia, Ontario. This allowed the phasing out of the No. 2 mine and the introduction of continuous mining technology. Domtar's long-established mine at Flat Bay, Newfoundland, continued to supply the company's new US$35 million board plant in Newington, New Hampshire. This mine also supplies the wallboard manufacturing plant owned by Atlantic Gypsum Limited, a subsidiary of Lundrigans-Comstock Ltd.

CGC Inc., owned 75% by USG, continued its six-year project that began in 1989 to develop ore reserves at Hagersville, Ontario. Production from the new eastern reserves will be phased in gradually as present reserves are depleted. Early in 1991, as a result of weak demand, the company mothballed its wallboard plant in St-Jerome, Quebec.

Louisiana-Pacific Corp., a major Oregon-based wood products manufacturer, operated its new $65 million fibre-gypsum board plant at Port Hawkesbury, Nova Scotia, at a reduced level. Gypsum is purchased locally, perlite is imported, and large quantities of recycled paper are back-hauled, mainly from the United States. This project marks the first time that a local gypsum board product has been produced for both regional and export markets.

Eastern Gypsum Inc. of McAdam, New Brunswick, which operated a gypsum wallboard plant for only a few months, fell into receivership in February 1991. Weak demand for board products in the U.S. market is believed to have been the main reason for the closure.

Several companies now use recycled gypsum wallboard in the manufacturing process; Domtar's Surrey, British Columbia, wallboard plant was the first in North America to use large quantities. This was possible through arrangements with a reclaimer, New West Gypsum, of Vancouver, which operates a plant with a capacity of about 40 000 t/y. The source of the material is about 75% scrap from new construction sites and 25% waste from wallboard plants. In Ontario, CGC Inc., Domtar and Westroc Industries Limited developed programs for accepting scrap wallboard from construction sites. This initiative was taken mainly because the City of Toronto banned the tipping of wallboard scrap in landfill sites reaching capacity levels.

Occurrences of gypsum, other than reserves being mined, are known to exist 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, at Loos, and at O'Connor River in British Columbia; on the shores of Great Slave Lake, the Mackenzie River, Great Bear River and Slave River in the Northwest Territories; and on several Arctic islands. Of recent interest, Industrial Mineral Background Paper No. 12 entitled "Gypsum in Northern Ontario" describes the resources and market potential for high-purity gypsum in the Moose River Basin. This paper was published in 1990 by the Ontario Ministry of Northern Development and Mines.

WORLD DEVELOPMENTS AND TRADE

Gypsum-related projects are generally limited to the industrialized countries because of dependence on the building construction sector. However, world reserves are widespread and are conservatively estimated to be more than 2.3 billion t.

World production of gypsum in 1991 was an estimated 98 Mt, according to the U.S. Bureau of Mines. The United States ranked number one with 13.9 Mt, followed by China (8.1 Mt) and Canada (7.3 Mt).

International trade has become more important in North American markets in recent years as a result of low production costs and competitive shipping rates. In particular, U.S. imports of gypsum from Spain continue to increase and now amount to several hundred thousand tonnes per year. Relatively low east-to-west back-haul freight rates are the main factors at work. Canada's imports of gypsum from Mexico, as described earlier, as well as those from the United States, are used by both wallboard and cement manufacturers. Imports from Spain, however, are used only by certain cement manufacturers.

Trade in gypsum products, particularly wallboard, is generally limited because of high unit weight, susceptibility to damage, high transportation costs and relatively low unit values. These factors generally dictate that markets are served by the nearest producer; however, imports of wallboard into Canada have increased since 1986 and now amount to more than 9% of domestic consumption.

Gypsum wallboard capacity in the United States increased in 1991 to nearly 2.3 billion m^2, an amount much more than sufficient to meet current demand. In fact, weak demand in the United States is placing more pressure on some producers to export more finished products to Canada.

PROCESSING AND MARKETS

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 hemi-hydrate 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. This is particularly suited to products including wallboard, lath and tile. Anhydrite, an anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum but is not a suitable substitute for most uses.

The type of processing necessary depends upon end-use requirements. Crude gypsum is crushed, pulverized and calcined to make a stucco mainly for the manufacture of wallboard, lath and sheathing, which together account for more than 75% of end uses in North American markets. These products are formed by introducing a slurry of stucco, foam, pulp and starch between two unwinding rolls of absorbent paper, resulting in a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to pre-determined lengths, dried, bundled and stacked for shipment. These products may also be manufactured with asphalt-impregnated paper and with asphalt added to the gypsum core to improve water resistance. Stucco may also be adapted for other construction uses after mixing with water and aggregate (sand, vermiculite or expanded perlite) for application over wood, metal or gypsum lath to form interior wall finishes.

In general, the wallboard industry serves the residential, institutional and commercial building sectors. Housing starts have become a less reliable indicator of the demand for gypsum wallboard because improved fire-retardant qualities, along with more renovation work, has encouraged broader use.

The Portland cement industry accounts for about 15% of the gypsum used in North America. Crushed, uncalcined gypsum, acting as a set regulator, and in a proportion up to 5% by total weight, is ground with the primary stage clinker to produce the final cement product. Based on this proportion of gypsum, crushed to about -13 mm, the total amount required by cement producers in Canada is estimated to be about 500 000 t/y.

For agricultural purposes, specifications mainly relate to the degree of fineness. Gypsum combines with potassium aluminum silicates in the soil resulting in the release of potassium for use as a nutrient. Also, gypsum serves to reduce sub-soil acidity, which is particularly beneficial in aluminum-rich lateritic soils. In addition, it provides a source of calcium and sulphur trioxide and helps break up hard soils, allowing better aeration and water penetration and retention.

For filler uses, gypsum is dried and finely ground to a range of particle sizes for use in joint compounds (mainly with gypsum wallboard), plastics, paint and paper.

Relatively pure uncalcined gypsum, depending on glass batch chemistry, may also substitute for salt cake (sodium sulphate) in glass manufacturing. Special high-purity gypsum may be used in foods and pharmaceutical products.

At the "Second International Conference on FGD and Chemical Gypsum" sponsored by Ortech International, held in Toronto, a wide range of issues were discussed concerning by-product gypsum produced from flue-gas desulphurization systems of coal-fired power stations. In Europe and Japan, by-product gypsum of this type is used by gypsum product manufacturers and cement manufacturers, and also in agriculture for soil stabilization. In North America, use to date has been minimal because natural gypsum is much more readily available. It is expected that in the future, however, there will be more encouragement to include by-product gypsum in finished products.

By-product gypsum produced by the acidulation of phosphate rock in manufacturing phosphate fertilizer has not been utilized in Canada. In the case of phosphogypsum produced from sedimentary phosphate rock, which can contain significant quantities of uranium and radium, studies have indicated that a potential radiation hazard exists. In the United States, interest is increasing in flue-gas derived (FGD) gypsum. At least partial substitution of this by-product for natural gypsum has been accomplished at several wallboard plants.

Canadian Standards Association (CSA) Standards A 91.20 and A 91.31 relate to gypsum and gypsum products.

PRICES

Prices for gypsum in non-captive markets are negotiated, the only published figure being an approximate minimum price for crude material, ex-mine or c.i.f. United Kingdom, published in *Industrial Minerals*. In the United States, prices for crude material, f.o.b. mine, have fallen from US$7.55/t in 1987 to US$6.80/t in 1991, according to preliminary information from the U.S. Bureau of Mines.

OUTLOOK

Shipments of gypsum in 1992 are expected to be in the range of 7.4-7.7 Mt, which is considerably lower than the average of

8.3 Mt shipped during the three-year period from 1988 to 1990. Canadian housing starts were 215 000 in 1989, 182 000 in 1990, and then fell to about 156 000 in 1991. Some forecasts predict housing starts will recover to about 180 000 in 1992. However, non-residential building construction is not expected to recover given the relatively high office and industrial vacancy rates.

The construction sector in the United States is projected to improve in 1992 based on an increase in housing starts early in the year and expectations that more relaxed credit conditions will prevail.

Although new construction materials are being introduced, the demand for gypsum wallboard is expected to remain popular because of its low price, ease of installation and well-recognized fire-retarding properties. The present structure of the industry in Canada is not expected to change greatly, although future availability of by-product gypsum based on satisfying stricter environmental controls will likely influence developments in some areas. The recycling of scrap and waste gypsum from construction sites and wallboard manufacturing lines is expected to become more important in both Canada and the United States.

Anhydrite

Production and trade statistics for anhydrite are included with gypsum. Anhydrite–the anhydrous form of gypsum, about twice as hard and also heavier than gypsum–is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia.

Production of anhydrite in 1990 was 151 000 t based on final figures, and in 1991 was an estimated 133 000 t, according to the Nova Scotia Department of Natural Resources. Shipments were mainly to the United States for use in manufacturing Portland cement and as a peanut crop fertilizer. Also, minor quantities were shipped to Quebec and Ontario for the manufacture of cement.

On-site testing began in Nova Scotia for using anhydrite (in combination with water and special chemicals) as a mine "pack" construction material to improve underground support in coal mines. This work is based on an earlier cooperative program involving the Canada Centre for Mineral and Energy Technology (CANMET) of Energy, Mines and Resources Canada and the Technical University of Nova Scotia. Results of this phase of the work are described in a Canada-Nova Scotia Cooperation Agreement on Mineral Development report released in 1989 entitled "Investigations to Determine Potential Applications for Anhydrite Resources Indigenous to Nova Scotia."

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2520.10	Gypsum; anhydrite	Free	Free	Free	Free
68.09	Articles of plaster or of compositions based on plaster: Boards, sheets, panels, tiles and similar articles, not ornamented				
6809.11	Faced or reinforced with paper or paperboard only				
6809.11.10	Gypsum wallboard	9.4%	Free	5.6%	1.6%
6809.11.90	Other	9.2%	Free	5.5%	1.6%
6809.19.00	Other	10.2%	6%	6.1%	4.2%
6809.90	Other articles				
6809.90.10	Models and casts, of a kind used in the manufacture of dental prosthesis	Free	Free	Free	3%
6809.90.90	Other	10.2%	6.5%	6.1%	3%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, GYPSUM PRODUCTION AND TRADE, 1989-91

Item No.		1989		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION (SHIPMENTS)							
	Crude gypsum						
	Nova Scotia	5 926 449	53 847	5 971 222	52 818	5 717 105	52 342
	Ontario	1 344 561	20 347	1 123 719	17 090	835 000	13 900
	British Columbia	357 742	x	410 616	x	277 680	x
	Manitoba	x	x	x	x	x	x
	Newfoundland	x	x	x	x	x	x
	Total[1]	8 179 588r	85 713r	7 977 685	80 080	7 304 570	74 315
IMPORTS						**(Jan.-Sept.)**	
2520.10	Gypsum, anhydrite						
	Mexico	98 673	3 496	105 133	3 352	91 985	2 855
	United States	94 823	1 481	126 442	1 962	29 977	953
	Spain	97 224	943	85 997	985	42 448	341
	Other countries	653	27	542	27	248	14
	Total	291 373	5 953	318 114	6 326	164 658	4 163
		(square metres)		**(square metres)**		**(square metres)**	
6809.11	Plasterboards, etc., not ornamental; faced or reinforced with paper or paperboard						
	United States	18 983 801r	21 862r	18 665 502	20 336	14 364 544	15 466
	United Kingdom	. .	169r	. .	191	. .	55
	Total	18 983 801r	22 033r	18 665 502	20 528	14 364 544	15 521
6809.19	Plasterboards, etc., not ornamental; faced or reinforced n.e.s.						
	United States	. .	1 723r	. .	1 751	. .	901
	France	–	–	–	–	. .	42
	Other countries	–	–	. .	103	. .	10
	Total	. .	1 723r	. .	1 854	. .	954
6809.90	Articles of plaster or compositions based on plaster, n.e.s.						
	United States	. .	761	. .	1 469	. .	1 212
	United Kingdom	. .	533	. .	788	. .	671
	Italy	. .	216	. .	257	. .	75
	Other countries	. .	170	. .	396	. .	120
	Total	. .	1 685	. .	2 910	. .	2 078
	Total imports of gypsum and gypsum products	. .	31 394r	. .	31 618	. .	22 716

TABLE 1 (cont'd)

Item No.		1988		1989		1990p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS							
2520.10	Gypsum, anhydrite						
	United States	5 356 932r	52 797	5 756 919	52 554	3 622 522	32 710
	Other countries	123	145	408	179	11 158	118
	Total	5 357 055r	52 943	5 757 327	52 735	3 633 679	32 829
		(square metres)		(square metres)		(square metres)	
6809.11	Plasterboards, etc., not ornamental; faced or reinforced with paper or paperboard						
	United States	34 975 291	32 787	27 996 949	28 914	7 442 172	7 394
	Other countries	452 483	36	41 867	89	41 935	90
	Total	35 427 774	32 825	28 073 332	29 006	7 484 107	7 487
6809.19	Plasterboards, etc., not ornamental; faced or reinforced n.e.s.						
	United States	..	8 086	..	3 150	..	4 442
	Other countries	..	373	..	197	..	323
	Total	..	8 460	..	3 354	..	4 766
6809.90	Articles of plaster or compositions based on plaster						
	United States	..	756	..	3 561	..	705
	Other countries	..	50	..	121	..	51
	Total	..	807	..	3 685	..	757
	Total exports of gypsum and gypsum products	..	95 035	..	88 780	..	45 839

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; n.e.s. Not elsewhere specified; p Preliminary; r Revised; x Confidential.
1 Totals do not include gypsum produced by or shipped for use by Canadian Portland cement producers.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, GYPSUM MINING AND GYPSUM PRODUCTS MANUFACTURING OPERATIONS, 1991

Company	Location	Operation
NEWFOUNDLAND		
Domtar Inc.	Flat Bay	Open-pit mining
Atlantic Gypsum Limited	Corner Brook	Wallboard manufacture
NOVA SCOTIA		
Domtar Inc.	McKay Settlement	Open-pit mining
	Windsor	Plaster and "Gypcrete" manufacture
Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corporation	River Denys, Sugar Camp	Open-pit mining of gypsum
Little Narrows Gypsum Company Limited	Little Narrows	Open pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
QUEBEC		
CGC Inc.	Montreal	Wallboard manufacture
	St-Jerome	Wallboard plant mothballed
Domtar Inc.	Montreal	Distribution terminal only
Westroc Industries Limited	Ste. Catherine d'Alexandre	Wallboard manufacture
ONTARIO		
CGC Inc.	Hagersville	Underground mining and wallboard manufacture
Domtar Inc.	Caledonia	Underground mining and wallboard manufacture
Westroc Industries Limited	Drumbo	Underground mining
	Clarkson	Wallboard manufacture
MANITOBA		
Domtar Inc.	Gypsumville	Open-pit mining
	Winnipeg	Wallboard manufacture
Westroc Industries Limited	Amaranth	Open-pit mining
	Winnipeg	Wallboard manufacture
SASKATCHEWAN		
Domtar Inc.	Saskatoon	Closed wallboard manufacturing plant in 1988
ALBERTA		
Domtar Inc.	Edmonton	Wallboard manufacture
Westroc Industries Limited	Calgary	Wallboard manufacture
BRITISH COLUMBIA		
Domtar Inc.	Canal Flats	Open-pit mining
	Vancouver	Gypsum products manufacture
Westroc Industries Limited	Vancouver	Gypsum products manufacture
	Windermere	Open-pit mining

TABLE 3. CANADA, GYPSUM PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1980-91

	Production[1]	Imports[2]	Exports	Apparent Consumption[3]
		(tonnes)		
1975	5 719 451	553 338	3 691 676	2 083 113
1980	7 336 000	154 717	4 960 240	2 530 477
1981	7 025 000	143 500	5 094 873	2 073 627
1982	5 987 000	93 843	4 775 755	1 305 088
1983	7 507 000	100 939	5 187 032	2 420 907
1984	7 775 082	131 809	6 224 574	1 682 317
1985	7 760 783	121 802	5 879 664	2 002 921
1986	8 802 805	221 644	5 921 982	3 102 467
1987	9 093 926	217 625	5 704 853	3 606 698
1988[4]	8 813 760[r]	274 917	5 651 286	3 437 391[r]
1989	8 179 588[r]	291 373	5 357 055[r]	3 113 906[r]
1990	7 977 685	318 114	5 757 327	2 538 472
1991[p]	7 304 570	255 538	4 940 614	2 619 494

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[p] Preliminary; [r] Revised.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production plus imports minus exports. [4] Beginning in 1988 imports and exports are based on the new Harmonized System and may not be in complete accordance with previous method of reporting. Imports and exports include H.S. class 2520.10.00 gypsum; anhydrite.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1990 AND 1991

	Starts			Completions			Under Construction		
	1990	1991	% Diff.	1990	1991	% Diff.	1990	1991	% Diff.
Newfoundland	3 245	2 836	–13	3 127	3 219	+3	3 201	2 867	–10
Prince Edward Island	762	553	–17	683	722	+6	463	281	–39
Nova Scotia	5 560	5 173	–7	5 477	4 905	–10	3 376	3 567	+6
New Brunswick	2 683	2 872	+7	2 959	2 858	–3	1 359	1 366	+1
Subtotal (Atlantic provinces)	12 250	11 434	–7	12 246	11 704	0	8 402	8 081	–4
Quebec	48 070	44 654	–7	52 630	42 720	–19	14 719	15 662	+6
Ontario	62 649	52 794	–16	80 562	59 622	–26	47 808	40 599	–15
Manitoba	3 297	1 950	–41	4 028	2 190	–46	1 316	1 029	–22
Saskatchewan	1 417	998	–30	1 575	1 241	–21	809	509	–27
Alberta	17 227	12 492	–17	17 467	12 959	–26	5 973	5 497	–8
Subtotal (Prairie provinces)	21 941	15 440	–30	23 070	16 390	–29	8 098	7 035	–13
British Columbia	36 720	31 875	–13	37 655	29 578	–21	21 645	23 658	+9
Total Canada	181 630	156 197	–14	206 163	160 014	–22	100 672	95 035	–6

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION BY TYPE,[1] 1989-91

	1989	1990	1991
		($ millions)	
BUILDING CONSTRUCTION[2]			
Residential	42 729	41 767	39 687
Industrial	4 487	4 205	3 787
Commercial	16 193	15 987	14 927
Institutional	5 111	5 680	6 220
Other building	2 718	2 535	2 568
Subtotal	71 238	70 174	67 189
ENGINEERING CONSTRUCTION[2]			
Marine	614	629	736
Highways, airport runways	6 199	6 814	7 523
Waterworks, sewage systems	2 569	2 911	3 263
Dams, irrigation	470	523	542
Electric power	5 153	6 137	7 678
Railway, telephones	3 511	3 295	3 274
Gas and oil facilities	7 403	8 185	10 200
Other engineering	3 255	3 190	3 393
Subtotal	29 174	31 684	36 609
Total construction	100 412	101 858	103 798

Source: Statistics Canada.
[1] Actual expenditures 1989; preliminary 1990; intentions 1991. [2] Includes total value of new and repair work purchased.

TABLE 6. WORLD PRODUCTION OF GYPSUM, 1990 AND 1991

	1990	1991[e]
	(000 tonnes)	
United States	14 883	13 900
People's Republic of China	7 983	8 100
Iran	7 983	8 000
Canada	7 978	7 300
Japan	6 350	6 400
Mexico	6 001	6 000
Thailand	5 753	5 800
France	5 625	5 700
Spain	4 990	5 000
U.S.S.R.	4 717	4 800
United Kingdom	3 992	4 000
Germany, Federal Republic of	2 096	2 100
Australia	1 796	1 800
Other countries	17 307	18 200
Total world	97 454	97 100

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines Mineral Commodity Summaries, January 1992.
[e] Estimated.

Iron Ore

Bruce Boyd

The author is with the Mineral Policy Sector, EMR Canada.
Telephone (613) 992-8179

World iron ore production in 1991 declined slightly for the second year in a row in response to lower demand by steel producers. However, at 960 million tonnes (Mt), it was within 4% of the record established in 1989, and world trade remained steady at 400 Mt.

The prices for internationally traded iron ore had risen in 1990 and 1991 in response to tight markets coincident with the supply contract negotiations. With a weaker market at the end of the year, prices negotiated for 1992 delivery were lower by 4%-7%.

Canadian iron ore producers benefitted from the higher prices last year, but were unable to increase shipments significantly. Pellet shipments fell to their lowest level since 1983. The total value of shipments increased by 4% to $1.3 billion.

CANADIAN DEVELOPMENTS

After a difficult year in 1990, the Canadian steel industry did not fully recover in 1991. At best, only eight blast furnaces were operating during the year, compared to ten as recently as October 1989. As a result, domestic consumption of iron ore remained at 2 Mt below the historical level. With the permanent closure of two domestic mines in 1990, imports of iron ore from the United States remained high at 5 Mt, accounting for 40% of Canadian steel plant consumption of iron ore.

The export market for Canadian iron ore was affected by a 4.5% decline in world steel production in 1991 relative to 1990. The greatest effect came from the 11.3% drop in crude steel production in the United States. As a result, Canadian iron ore pellet shipments to the United States fell an estimated 19%.

The four Canadian iron ore mines and ancillary plants produced 37 Mt of concentrate, pellets and sinter from hematite and siderite ores in 1991. The production of concentrate that was not further processed to pellets or sinter increased to 16.2 Mt in 1991 from 12.8 Mt in 1990 in response to demand for fines and concentrate in Europe. Acid pellet production fell by 2 Mt to 13.8 Mt, and fluxed pellet production decreased to 6.2 Mt. Sinter produced at the mine site recovered to 1 195 000 t after production of only 769 000 t in 1990.

Employment at Canadian iron ore mines, concentrators, agglomerating plants and support services fell to 5900 by the end of 1991, the second year of declining employment since 1989 when the level was 6900.

There are three mines in the Labrador Trough area of northern Quebec and Labrador, and these account for over 96% of Canadian iron ore production. The mines belong to Quebec Cartier Mining Company (QCM), Iron Ore Company of Canada (IOC) and Wabush Mines. There is also one mine in Ontario. Other iron ore mines, which were operating in various provinces over the last 20 years, have closed due to high operating costs and depleted reserves. In British Columbia, by-product iron concentrate production is less than 100 000 t/y. Although not an iron ore producer, QIT-Fer et Titane Inc. makes pig iron from ilmenite mined near Havre St. Pierre, Quebec.

QCM produced 16.2 Mt of ore in 1991, having recovered from the difficulties encountered the previous year when it had changed its mine plan. QCM shipped 15.3 Mt of ore, of which 7.7 Mt was concentrate destined mainly for Europe. The remainder was acid and fluxed pellets.

QCM is pursuing two avenues of research on improving iron recovery by treating tailings from the concentrate circuit. A decision on modifications to the circuit is expected in 1992.

IOC shipped 15.2 Mt of iron ore in 1991, about 1.3 Mt more than in 1990. However, almost all of the increase was attributable to concentrate for sale in Europe. Sales of the highest value product, fluxed pellets, were down by 0.9 Mt. IOC and the Canada Centre for Mineral and Energy Technology (CANMET) continued research on the production of low silica pellets to meet client demands. IOC is the first mine in North America to be certified under the International Standards Organization (ISO) standard 9002. This means that IOC meets the ISO specifications for process control relative to quality assurance and technical standards in iron ore production.

IOC inaugurated a long-term (25-year) mine plan in 1991. The plan calls for average annual production of more crude ore than in either 1989 or 1990. IOC also announced that employee cutbacks and increased productivity would be necessary in 1992 to reduce production costs. Cuts of some 240 jobs, both unionized and staff, were included in the announcement. In the face of an expected glut in the iron ore market over the short term, a 38-day shutdown has been scheduled for the summer of 1992.

Mitsubishi Corporation announced its intention to purchase 20% of IOC, taking most of the shares that had belonged to M.A. Hanna Company. Final arrangements for closing the transaction were being completed at year-end. Under the new structure, the ownership would be: Bethlehem Steel, 34.52%; National Steel, 19.96%; Labrador Mining & Exploration, 11%; Mitsubishi Corporation, 20%; M.A. Hanna, 8.14%; and Dofasco Inc., 6.38%.

Wabush Mines shipped 4.7 Mt of pellets in 1991. The mine, mill and pellet plant closed for 71 days over the summer to bring inventories down and to keep production at the same low level as sales. In a move to exploit new markets, Wabush made its first shipment of concentrate, supplying over 100 000 t to European steel mills. However, since the market for pellets appears to be depressed, Wabush announced that it would reduce production capacity from 6.1 Mt/y to 4.6 Mt/y in 1992. As a result, the workforce will be reduced by some 200 people.

Wabush completed its stack emission control system during the year and brought it on line in September.

The Algoma Ore Division (AOD) of The Algoma Steel Corporation, Limited returned to its 1990 level of production. Some 1.2 Mt of superfluxed sinter was produced at Algoma's sinter plant at Wawa, Ontario. The plant used siderite ore from the adjacent mine, but over 40% of the feed was recycled material from steel mills. Algoma is examining the possibility of closing the mine and sinter plant as part of a restructuring of operations.

Hollinger North Shore Exploration Inc., owned by the La Fosse Platinum Group Inc., continued its efforts to re-open one or more of the direct-shipping iron ore mines in the Schefferville area. La Fosse is also attempting to develop the manganese deposits in the region.

WORLD DEVELOPMENTS

World trade in iron ore reached 199 Mt for the first six months of 1991, and may exceed 400 Mt for the year, a small increase from the 395 Mt traded in 1990. Brazil again led the world in iron ore exports, establishing a record of close to 120 Mt. Australia was second (110 Mt), and the next largest exporters were India (37 Mt), Canada (29 Mt) and the U.S.S.R. (26 Mt). Japan took 30% of world imports and the European Economic Community took 34%.

In 1991, Canada exported about 80% of its iron ore and, although the largest single customer was the United States, European destinations accounted for 63% of the total. The Canadian industry is, therefore, very sensitive to competition from U.S. mines in the North American market and to competition from the countries that ship to the European market.

In the United States, the decline in steel production was matched by a 14% drop in iron ore consumption that affected both the domestic iron mining industry and imports. Consumption of U.S. ore fell from 55.9 Mt in 1990 to 48.6 Mt in 1991. Consumption of ore imported from Canada fell from 8.3 Mt to 7.2 Mt.

In September 1991, LTV Steel Co. closed the McKinley Extension mine, the last "natural ore" mine in Minnesota. High-grade deposits of iron ore have been depleted in Canada and the United States but are mined extensively in Brazil, Australia and India.

With the restructuring of the republics of the former U.S.S.R., the Ukraine has emerged as the world's largest producer of iron ore. This country is also a major source of iron ore pellets, ranking third in the world behind Brazil and Canada for pellet exports. Overall, the changes in the former U.S.S.R. have resulted in a forecasted short-term decrease in production and exports for the region. Pig iron production, which had averaged 112 Mt/y prior to 1991, fell by 18 Mt in 1991, and is forecast to reach only 92 Mt for 1992. Similarly, iron ore production may fall below 200 Mt, of which pellets would account for 66-68 Mt. Exports of iron ore, which totalled 46 Mt in 1986, declined to 36 Mt in 1990 and to 26 Mt in 1991, and may reach only 25 Mt in 1992.

Brazil's largest iron ore producer, Companhia Vale do Rio Doce (CVRD), has stopped increasing its production capacity for the time being in response to the soft world market. On the other hand, Brazil's second largest iron ore company, Minerações Brasileiras Reunidas SA, increased production by 4 Mt in 1991, with most of the increase being bound for export. The net effect for the country's totals was a small decrease in production, but record exports.

Australia benefitted from continued growth in the economies of Southeast Asia, its major market area, and reached record levels for iron ore production and exports in 1991. Major expansions and new mines, with a potential production capacity of 27 Mt/y, are planned in the Pilbara region of Western Australia before the end of the decade. Mine closures in Australia, over the same period, will reduce capacity by 6.5 Mt/y. With a net increase in production capacity of some 20 Mt/y, Australia will replace Brazil as the fastest growing producer of iron ore over the next eight years.

The civil unrest in Liberia continued to prevent internal shipments of iron ore in that country. A few shipments from stockpiles at the ports accounted for Liberian sales in 1991.

In 1989, several countries, including Canada, cooperated in setting up a trust fund under the United Nations Conference on Trade and Development (UNCTAD) to collect and publish statistics on iron ore for all the major producing, consuming and trading countries. The trust fund project produced two statistical reports in 1991. Supporting countries, including Canada, provided sufficient funds to continue the arrangement until 1993.

UNCTAD DIALOGUE ON IRON ORE

The Intergovernmental Group of Experts on Iron Ore (IGE), under UNCTAD, met in Geneva October 21-23, 1991. There was representation from 32 countries and several international agencies. Japan participated as a member for the first time. There were also significant presentations from companies based in Peru, Chile, Venezuela and Australia. In addition, new information was made available by the delegates of the countries of Eastern Europe whose economies are currently undergoing dramatic transitions. The group worked toward improving market transparency through improved quality and comparability of published statistics as well as through dialogue among producing and consuming countries on supply/demand issues and related problems. Previously released statistics were updated at the meeting, and a market review prepared by the secretariat was discussed.

The level of response to the secretariat's questionnaires on iron ore statistics improved during the year and now comes directly from 85 countries, including all major producers and consumers. Notable new additions were the People's Republic of China and the Republic of the Ukraine. The secretariat, under the direction of the IGE, will be producing preliminary 1991 statistics in early 1992.

PRICE

Iron ore exporters were able to negotiate moderate price increases for deliveries in 1991. In Europe, the price increased by an average 8% for fines and concentrate used as sinter feed, and by 1% for pellets. The Japanese steel mills settled on an increase of 7.9% for fines and concentrate and 5.9% for lump ore.

The price difference between pellets and fines narrowed to 18.4¢ on the basis of US¢/Fe unit.[1] The pellet producers had regarded the previous year's premium of 21¢ for pellets as reasonable given the higher costs of production relative to concentrate and fines.

Negotiations for 1992 deliveries led to price cuts in both the European and Japanese markets. In Europe, prices were cut by 1.19%-4.9% for fines and concentrate, and by around 7% for pellets, thereby reducing

[1] Price is reported in cents, U.S. currency, for each percentage point of iron in a tonne of ore; e.g., at 30¢/Fe unit, ore grading 65% iron would bear a price of 65 x 30¢ = US$19.50/t.

further the premium for pellets. Japanese steel-makers made similar price cuts in negotiations with their suppliers.

OUTLOOK

World iron ore production in 1991 did not increase as expected, but declined for the second year in a row, due mainly to changes in the former U.S.S.R. Prospects for 1992 are similarly constrained by the restructuring of the economies of Eastern Europe. In the longer term, the economies in those areas have potential to grow rapidly to catch up with other European countries. Consequently, toward the end of this decade, world iron ore, iron and steel production may grow significantly.

Steel production in North America and Europe has been forecast to grow over the next two to three years, and this should translate into higher iron ore sales for Canadian producers. Recovery of the steel industry in Canada and the United States would be especially important for pellet sales, and could mark a reversal of the trend of the past two years. The three mines in the Labrador Trough are scheduled to operate at 70%-80% of capacity in 1992, but they would be able to return to near-capacity production at the end of the year should the market recover by then. The last remaining mine in Ontario does not have a long-term future, but it may operate for a few more years.

Prices for deliveries to Europe in 1992, already determined through the annual negotiation process, are lower by 4.9% for concentrate and by 7% for pellets in U.S. dollar terms. As a result, Canadian mines will be facing a drop in revenue per tonne for the year. In the longer term, producers in Brazil and Australia will require higher prices to finance new mines to replace exhausted deposits. The steel-makers are familiar with this requirement and, based on experience, will allow iron ore prices to rise rather than face a tight market or dependence on a small number of suppliers.

Note: Information in this review was current as of January 31, 1992.

Iron Ore

TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)1	($000)	(tonnes)1	($000)
PRODUCTION	(mine shipments)				
	Newfoundland	18 969 449	708 367	19 200 000	737 704
	Quebec	15 305 907	x	15 500 000	x
	Ontario	1 294 195	x	1 195 279	x
	British Columbia	100 457	3 676	65 800	3 095
	Total2	35 670 008	1 258 792	35 961 079	1 307 888
IMPORTS		1990p		(Jan.-Sept.)	
2601.11	Iron ore concentrates, non-agglomerated				
	United States	23 644	843	12 076	426
	Total	23 644	843	12 076	426
2601.12	Iron ore, agglomerated				
	United States	3 684 660	154 359	2 792 327	111 899
	Brazil	404 666	15 753	–	–
	Total	4 089 327	170 113	2 792 327	111 899
EXPORTS					
2601.11	Iron ore concentrates, non-agglomerated				
	Germany3	2 740 144	63 301	2 237 420	54 601
	United Kingdom	1 438 287	29 938	1 805 266	41 274
	Netherlands	1 791 936	29 527	1 943 684	35 407
	France	1 528 360	32 356	1 053 911	23 660
	Japan	1 797 293	28 186	1 043 022	16 743
	South Korea	664 822	11 548	872 992	16 274
	Italy	567 196	12 954	265 738	6 657
	Philippines	489 184	7 582	422 933	6 527
	Belgium	215 990	4 876	239 466	6 296
	Sweden	225 531	5 001	225 264	5 379
	Spain	138 383	3 140	194 992	4 734
	United States	526 733	19 197	141 729	3 476
	Israel	–	–	154 868	2 826
	Portugal	88 752	2 165	78 585	2 004
	Yugoslavia	180 845	2 983	30 836	562
	Venezuela	–	–	217	30
	Total	12 393 456	252 761	10 710 923	226 457
2601.12	Iron ore, agglomerated				
	United States	8 638 131	365 995	4 395 412	186 264
	Germany3	1 309 065	50 017	1 303 818	49 859
	United Kingdom	1 816 007	64 167	967 905	34 115
	Netherlands	864 290	27 660	964 103	32 792
	Belgium	253 116	8 099	753 122	28 574
	Italy	622 470	28 299	333 725	15 930
	Spain	411 237	17 481	328 991	12 868
	France	536 623	19 730	307 335	11 222
	Yugoslavia	–	–	120 006	4 121
	Portugal	196 310	7 148	111 704	4 060
	Poland	–	–	56 483	2 696
	Turkey	–	–	54 121	2 583
	Venezuela	34	3	–	–
	Total	14 647 283	588 603	9 696 725	385 089
Total exports, all classes					
United States		9 164 864	385 192	4 537 141	189 740
Germany3		4 049 209	113 318	3 541 238	104 460
United Kingdom		3 254 294	94 105	2 773 171	75 389
Netherlands		2 656 226	57 187	2 907 787	68 199
France		2 064 983	52 086	1 361 246	34 882
Belgium		469 106	12 975	992 588	34 870
Italy		1 189 666	41 253	599 463	22 587
Spain		549 620	20 621	523 983	17 602
Japan		1 797 293	28 186	1 043 022	16 743
South Korea		664 822	11 548	872 992	16 274
Philippines		489 184	7 582	422 933	6 527
Portugal		285 062	9 313	190 289	6 064
Sweden		225 531	5 001	225 264	5 379
Yugoslavia		180 845	2 983	150 842	4 683
Israel		–	–	154 868	2 826
Poland		–	–	56 483	2 696
Turkey		–	–	54 121	2 583
Venezuela		34	3	217	30
Total		27 040 739	841 364	20 407 648	611 546
Consumption of iron ore at Canadian iron and steel plants		11 219 000	..	12 505 944	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.
– Nil; .. Not available; p Preliminary; x Confidential.
1 Dry tonnes for production (shipments) by province; natural weight for imports and exports. 2 Total iron ore shipments include shipments of by-product iron ore. 3 Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, IRON ORE SHIPMENTS, 1988-91

Company and Location	Ore Mined	Product Shipped	1988	1989	1990	1991p
			(000 tonnes, natural or wet)			
Adams Mine Kirkland Lake, Ont.	Magnetite	Fluxed pellets	1 017	1 078	244	–
Algoma Ore Division The Algoma Steel Corporation, Limited Wawa, Ont.	Siderite	Sinter	1 066	1 243	735	1 195
Iron Ore Company of Canada Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	788	177	38	–
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	4 127	5 130	5 543	7 300
		Acid pellets	7 899	8 106	5 473	5 900
		Fluxed pellets	1 954	1 732	2 797	1 900
		Chips	–	–	147	100
Quebec Cartier Mining Company Mount Wright, Que.	Specular hematite	Concentrate	8 506	7 734	7 573	7 700
		Acid pellets	7 749	6 031	4 781	5 300
		Fluxed pellets	582	2 033	2 952	2 300
Sherman Mine Temagami, Ont.	Magnetite	Fluxed pellets	865	1 023	281	–
Wabush Mines Wabush, Lab. and Pointe-Noire, Que.	Specular hematite and magnetite	Acid pellets	6 035	5 953	3 921	2 997
		Fluxed pellets			1 771	1 687
		Concentrate				108
British Columbia producers	Magnetite	Concentrate	59	73	100	66
Other Ontario	Magnetite	Concentrate	2	1	–	–
Total			40 649	40 314	36 357	36 552

– Nil; p Preliminary.

TABLE 3. RECEIPTS, CONSUMPTION AND INVENTORIES OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, 1990 AND 1991

	1990	1991
	(000 tonnes)	
Receipts imported	3 910	5 225
Receipts from domestic sources	7 484	6 885
Total receipts at iron and steel plants	11 393	12 112
Consumption of iron ore	11 219	12 506
Inventory at docks, plants, mines and furnace yards, December 31	7 460	7 864
Inventory change	717	403

Source: American Iron Ore Association.

TABLE 4. WORLD IRON ORE PRODUCTION, 1989-91

	1989	1990	1991e
		(000 tonnes)	
U.S.S.R.	241 000	236 200	215 000
People's Republic of China	162 160	169 360	167 600
Brazil	153 740	154 370	152 000
Australia	108 680	112 320	115 600
India	51 430	53 700	56 000
United States	59 030	56 410	55 060
Canada	41 142	36 033	37 055
Republic of South Africa	29 960	30 290	30 340
Venezuela	19 030	20 120	23 000
Sweden	21 760	19 880	19 500
Mauritania	12 110	11 420	10 600
Liberia	12 300	4 000	200
Other countries	79 450	75 850	77 005
Total	991 792	979 953	958 960

Source: Trust Fund Project on Iron Ore Information.
e Estimated by EMR.

TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1990

Material Consumed	Consumed In: Sinter Plants at Steel Mill	Direct Reduction Plants	Iron and Steel Furnaces: Production of Pig Iron	Steel Furnaces	Total in Furnaces
	(tonnes)				
Iron ore					
Crude and concentrate	98 357	200 863	26 689	–	26 689
Pellets	30 992	880 525	9 190 160	10 066	9 200 226
Sinter	43 181	–	670 586	–	670 586
Sinter produced at steel plant	–	–	343 655	–	343 655
Direct reduced iron	–	–	–	725 226	725 226
Other iron-bearing materials including flue dust, mill scale, cinder, slag, etc.	196 348	–	209 502	85 623	295 125
Total	368 878	1 081 389	10 440 592	820 916	11 261 508

Source: Company data.
– Nil.
[1] Dofasco Inc.; Sidbec-Dosco Inc.; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; Stelco Inc.

TABLE 6. NORTH AMERICAN PRICES OF SELECTED ORES AT YEAR-END 1975, 1980, 1985, 1990 AND 1991

	1975	1980	1985	1990	1991
			(US$/t)		
Mesabi non-bessemer[1]	17.92	27.61	29.557-31.03	29.557-31.03	29.557-31.03
Old range non-bessemer and manganiferous	18.16	27.85	32.264	32.264	32.264
			(US¢/t iron unit)[2]		
Pellets					
Lake Erie base price[3]	45.7	71.36	85.53	71.31-73.47	71.31-73.47
USX Corporation[4]	–	–	–	36.756	36.756
Upper Lakes[5]	–	–	58.46	46.10-58.46	46.10-58.46
Wabush[6]	–	62.5	62.5	62.5	62.5
Cyprus Northshore[7]	–	–	–	47.99	47.99
			(US$/t)		
Direct reduced iron	–	–	115-135	115-135	115-135

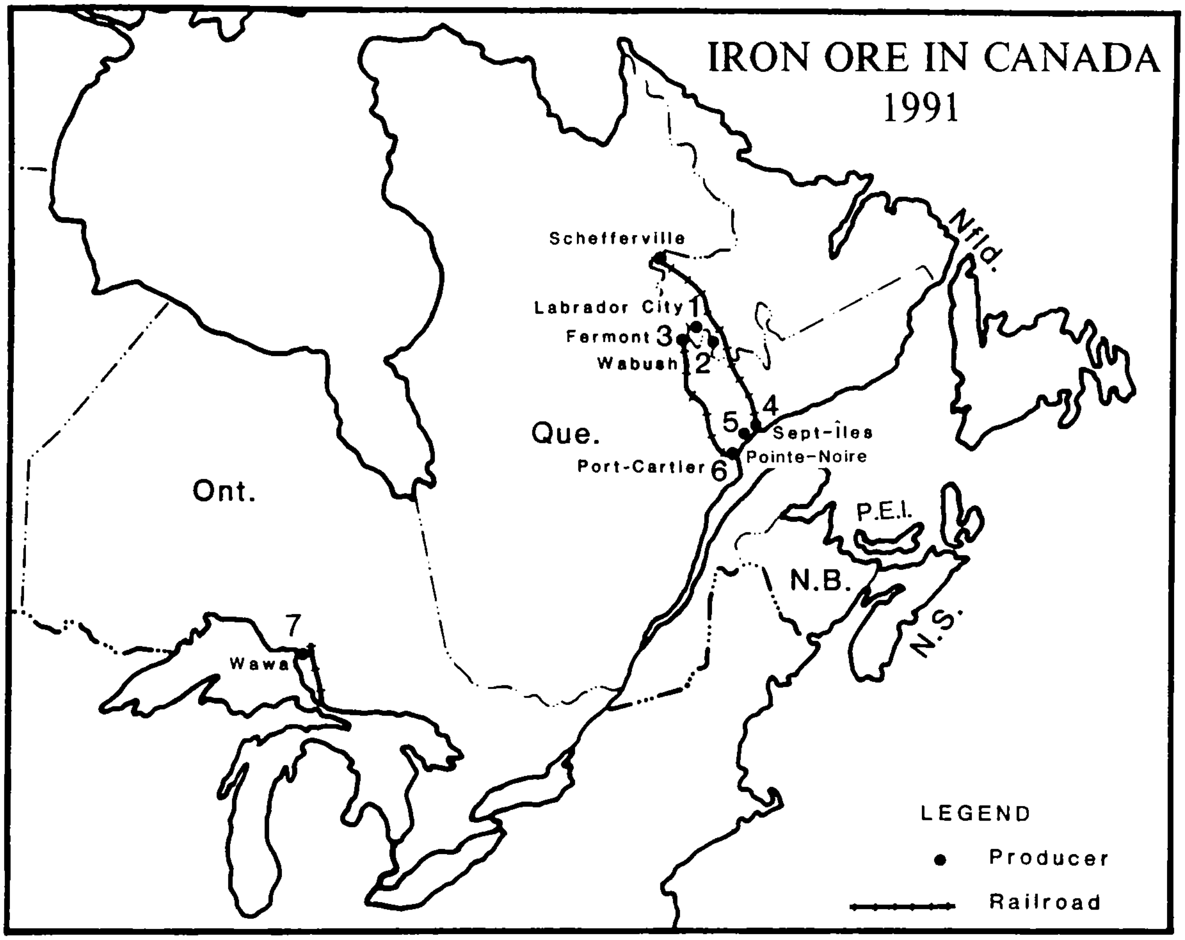
Sources: Skillings Mining Review; Iron Age.
– Nil.
[1] US$/t, 51.5% of iron natural, at rail of vessel, lower lake port. [2] One iron unit equals one percentage point of iron content in a tonne of ore; therefore, an ore containing 60% iron has 60 iron units. [3] Cleveland-Cliffs Inc., M.A. Hanna Company, Oglebay Norton Company at rail of vessel, lower lake port. [4] At mine. [5] Pickands-Mather & Co. and Inland Steel Mining Co. in hold of vessel, upper lake port. [6] F.o.b. Pointe-Noire. [7] F.o.b. Silver Bay.

TABLE 7. SELECTED PRICES OF IRON ORE BOUND FOR JAPAN AND EUROPE, 1985-91

Ore	Market	Source	1985	1986	1987	1988	1989	1990	1991
			(US¢/Fe Unit Dmt, f.o.b.)						
Fines (including concentrate)	Europe	CVRD	26.56	26.26	24.50	23.50	26.56	30.80	33.25
		Iscor	23.50	22.70	. .	20.55	20.70	24.75	. .
		Kiruna	28.50	27.90	25.25	26.00	30.00	35.70	37.10
		Carol Lake	26.80	26.50	24.03	23.69	27.00	31.78	34.60
		Mt. Wright	26.80	26.50	24.03	23.69	27.00	31.78	34.60
	Japan	CVRD	24.26	23.29	21.89	20.90	23.61	27.38	30.05
		Iscor	21.91	20.23	18.85	17.75	20.05	23.25	25.09
		Hamersley[2]	26.62	25.56	24.28	23.31	26.34	30.54	32.96
		Carol Lake	23.00	22.09	20.93	19.93	22.52	26.11	28.18
Lump	Europe	Iscor	29.00	26.70	23.50	22.34	. .	. .	. .
		Hamersley[1]	38.48	36.20	33.15	36.00	43.00	49.97	50.25
	Japan	CVRD	24.26	23.29	21.89	21.89	25.20	29.22	30.96
		Iscor	25.45	23.53	21.99	21.86	25.64	29.73	31.51
		Hamersley[2]	31.05	29.81	28.33	27.88	33.23	38.53	40.83
Pellets	Europe	CVRD	36.00	35.60	36.70	40.35	47.33	51.60	52.15
		Kiruna	38.60	38.15	41.15	46.35	53.50	59.00	57.50
		Carol Lake	36.50	36.50	37.15	39.95	48.35	52.58	53.00
		Mt. Wright	36.50	36.50	37.15	39.95	48.35	52.58	53.00
	Japan	CVRD (Nibrasco)	35.68	34.73	35.04	37.93	44.49	48.50	. .
		Savage River	36.52	35.45	34.17	35.89	42.10	34.17	46.39

Source: The Tex Report.
. . Not available; Dmt Dry metric tonne; f.o.b. Free on board.
[1] C.i.f. Rotterdam; [2] F.o.b. Dampier.

Iron Ore



PRODUCERS (numbers refer to numbers on map above)

1. Iron Ore Company of Canada, Carol Division (mine/concentrator/pellet plant)
2. Wabush Mines (mine/concentrator)
3. Quebec Cartier Mining Company (mine/concentrator)
4. Iron Ore Company of Canada (port)
5. Wabush Mines (pellet plant/port)
6. Quebec Cartier Mining Company (pellet plant/port)
7. Algoma Ore division of The Algoma Steel Corporation, Limited (mine/concentrator/ sinter plant)

Lead

John Keating

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4409

Western World lead consumption was estimated at 4.39 million tonnes (Mt) in 1991, a decrease of 1.2% from 1990. Metal production, including both primary and secondary material, decreased by 0.4% in 1991 to 4.34 Mt. Total metal stocks at year-end were estimated at 464 000 t, an increase of 26% from the previous year.

The increase in stock levels had a depressing effect on prices, which averaged US25¢/lb on the London Metal Exchange (LME) compared to 37¢/lb in 1990.

CANADIAN DEVELOPMENTS

Canadian lead mine output in 1991 rose for the first time in four years despite some mine closures. The increased output to 240 000 t from 233 000 t in 1990 was primarily the result of the return to more normal production levels caused by the settlement of labour disputes.

Lead metal output also rose to more normal levels in 1991: by 20% to 105 000 t from primary sources, and by 7% to 104 000 t, from the processing of recycled material.

Nova Scotia

The Gays River mine, which re-opened in January 1990, closed in May 1991 after production difficulties were encountered due to poor ground conditions and water problems. Later in the year, Westminer Canada Limited placed the mine and 800-t/d mill up for sale.

New Brunswick

Production at Brunswick Mining and Smelting Corporation Limited's Brunswick mine and Belledune smelter resumed in May when contract settlements were reached with the 1100 miners and 470 smelter workers, ending a ten-month strike. The company subsequently proceeded with cost reduction measures which included a 10% reduction in the workforce and the introduction of open-stope mining methods, as opposed to the previous cut-and-fill techniques. In 1990, the Brunswick mine produced 94 000 t of lead in concentrate containing 39.8% lead and 557 grams per tonne (g/t) silver.

Brunswick also initiated a waste recovery project during 1991. In June, the company announced that it would process 15 000 t of lead-contaminated soil through the Belledune smelter. The soil, transported by rail from an industrial site near Halifax, Nova Scotia, was reported to be composed of up to 1% lead and 50% silica flux.

The Heath Steele mine and 2600-t/d mill completed its second full year of production in 1991. Heath Steele Mines Ltd. also commenced development of its C-zone which was partially developed in the 1970s. The zone is expected to produce ore in 1992 and add two years to the operation's life.

Stratabound Minerals Corp. started shipping ore from its Captain North Extension open-pit mine to the Heath Steele mill during 1991. Mine life was reported at two years with reserves of approximately 210 000 t averaging 2.8% lead, 7.4% zinc and 83 g/t silver, based on a cut-off of 8% combined lead and zinc.

Quebec

In June, Breakwater Resources Ltd. temporarily suspended production at its Estrades mine and placed the operation on care and maintenance until metal prices improve. The mine had a rated capacity of 1000 t/y of lead in bulk concentrate.

Ontario

Noranda Minerals Inc. closed the Lyon Lake mine and Mattabi mill in May due to the depletion of ore reserves. The mine had a rated capacity of 2000 t/y of lead in concentrate.

British Columbia

Cominco Ltd.'s new 160 000-t/y QSL lead smelter, which was commissioned in December 1989 but closed in early 1990, remained idle throughout 1991. Although tests at Metallgesellschaft AG's 100 000-t/y QSL smelter in Germany indicated that natural gas could be used as a reductant, it was reported that modifications remained on hold pending further examination of the gas injectors and refractory stabilizing systems. The company is considering alternate technology and has shipped residues from the Trail zinc operation to a Kivcet pilot plant in the former U.S.S.R. for testing. All tests were to be completed by the end of 1991 with a decision on acceptable smelter technology expected by May 1992.

In June, Cominco announced that 266 Trail employees, approximately 10% of the workforce, would be laid off by the end of 1991 as a five-year modernization project comes to an end and additional methods to improve efficiency are implemented.

Delineation drilling at the Samatosum mine during the first half of 1991 outlined 80 300 t of mineable underground reserves grading 1022 g/t silver, 1.7 g/t gold, 1.2% copper, 2.9% zinc and 1.7% lead. The 450-t/d mill began processing ore from underground in September. The mine is scheduled to close in October 1992 after both open-pit and underground reserves are depleted. The mine was opened in 1989 by the current owners, Minnova Inc. (70%) and Rea Gold Corporation (30%), and had produced approximately 295 000 g of silver, 536 g of gold, 3700 t of copper, 4300 t of lead, and 900 t of zinc to the end of 1991.

Curragh Resources Inc. received a mine development certificate from the Government of British Columbia for the Stronsay (formerly Cirque) deposit, owned 70% by Curragh and 30% by Asturiana de Zinc S.A. It was reported that mine and mill construction could commence in 1992, pending the approval of environmental permits, and be completed within 18 months at an estimated cost of $140 million. The operation is expected to produce 28 000 t/y of lead in concentrate at full production and operate for almost 20 years with reserves of 52 Mt averaging 2% lead, 8% zinc and 42 g/t silver.

Exploration by Cominco at the J&L property, near Revelstoke, outlined a new lead-zinc zone called the Yellowjacket. The resource is estimated to be 910 000 t grading 2.6% lead, 7.4% zinc and 55 g/t silver.

Yukon Territory

A ten-week strike at Curragh Resources' Faro operation ended June 15 with the ratification of a three-year labour contract. It was reported that non-unionized staff produced about 50 000 t of concentrate during the strike. Nearly exhausted reserves at the Faro mine are to be replaced by ore from the Vangorda open pit, which opened in 1991, and from the Grum deposit where development is on hold pending resolution of discussions with possible contributors of financing for stripping. The Faro operation produced 189 040 t of lead and 359 444 t of zinc concentrates in 1990.

In September, Curragh Resources brought the Sa Dena Hes mine (formerly Mt. Hundere) deposit on stream at an estimated capital cost of $70 million. The open-pit and underground operation, owned 80% by Curragh and 20% by Hillsborough Resources Limited, is 45 km north of Watson Lake and is expected to produce about 30 000 t/y of lead and 52 000 t/y of zinc in concentrate over an estimated nine-year mine life. Preliminary reserves are 4.8 Mt averaging 4% lead, 12.7% zinc and 59 g/t silver with minor cadmium.

Northwest Territories

Cominco's Pine Point mine, which closed in 1988, shipped the last of its stockpiled high-grade lead concentrates to the 42 000-t/y Naoshima smelter in Japan. Mitsubishi Metal Corporation became the sole owner of the Naoshima smelter after acquiring Cominco's 45% interest in June.

WORLD DEVELOPMENTS

The International Lead and Zinc Study Group (ILZSG) indicated that Western World lead mine production increased marginally to 2.327 Mt in 1991 from 2.326 Mt in 1990. Canada, Peru and Australia recorded the largest increases in output while the United States and Europe posted the greatest declines in production.

In Australia, concentrate and metal shipments from Mount Isa Mines Ltd.'s (MIM) operations were disrupted during the first and third quarters by flooding and by a cooling tower accident at the lead smelter in Queensland. In December, the company's new 60 000-t/y Isasmelt lead smelter officially opened; however, production was temporarily halted on December 30 after an explosion occurred when a refractory failure allowed molten slag to mix with water. The new smelter is expected to boost lead bullion production to 200 000 t/y at Mount Isa.

MIM also announced plans to reduce costs and improve competitiveness at its Mount Isa and Hilton operations by 1993. The restructuring will include doubling the size of the grinding and flotation plant as well as installing a single reverse cleaning process to improve zinc recovery from lead concentrates. In 1990, the Mount Isa mine milled 4.4 Mt of ore grading 5.18% lead, 6.34% zinc, 0.05% copper and 126 g/t silver.

Pasminco Ltd. reduced output by 30 000 t/y of lead in concentrate at its Elura mine in early 1991. Production was also affected at the company's Broken Hill operations after damage to the haulage shaft resulted in a temporary suspension of output from the North mine. Also at Broken Hill, the Old South mine, with a rated capacity of 10 000 t/y of lead in concentrate, closed in early 1991.

In Tasmania, improved mill throughput and higher recovery rates increased output at Aberfoyle Limited's Hellyer mine.

As for new mineral potential, Australia has some of the most promising discoveries. MIM outlined a high-grade zone of 47 Mt grading 6.5% lead, 15.7% zinc and 66 g/t silver within its 227-Mt McArthur

River deposit. It was reported that the re-defined reserves may improve the economic feasibility of the remote deposit.

The Australian government also approved CRA Limited's purchase of 6900 km^2 of land for the planned Century mine site in northwest Queensland. The property reportedly contains 120 Mt of indicated resources grading 1.5% lead, 10.0% zinc and 30 g/t silver.

Also in Queensland, Plutonic Resources Ltd. carried out feasibility work on the Conjuboy/Balcooma deposit. It was estimated that an underground/open-pit operation could produce about 14 000 t/y of lead in concentrate.

In December, Broken Hill Pty Co. Ltd. announced the discovery of a new mineral resource 140 km south of Cloncurry in northern Queensland. The Cannington deposit is quoted at 20 Mt of mineralization grading 10.2% lead, 3.3% zinc and 470 g/t silver.

Asia

China's new 52 000-t/y QSL lead smelter at Baiyin, which came on stream in December 1990, closed in March for modifications to the oxygen plant.

In India, Hindustan Zinc Ltd.'s Rampura Agucha mine came on stream in March and is expected to produce 11 000 t/y of lead in concentrate. The concentrate is to be processed at the company's new ISF smelter in Rajasthan, which opened in October with a rated capacity of 35 000 t/y lead and 70 000 t/y zinc.

Mitsubishi Cominco Smelting Ltd.'s 3300-t/d electrolytic refinery at its Naoshima lead smelter is scheduled to come on stream in 1992. The smelter, which previously received high-grade lead concentrates from the Pine Point mine, is expected to process scrap, along with concentrates, from the Cadjebut, Hellyer and Red Dog mines.

With respect to future projects, the Padaeng Industry Co. received approval to construct an ISF smelter in Rayong, Thailand. It is anticipated that the 40 000-t/y lead and 100 000-t/y zinc operation, which will be owned 51% by Padaeng Industry and 49% by Metallgesellschaft AG, will come on stream by the end of 1994.

Americas

Bolivia, like several other Latin American countries, is restructuring its mining sector to attract foreign investment. In preparation to privatize the state-owned mining company (Corporacion Minera de Bolivia - COMIBOL), the government announced that it would lay off 2000 workers (25% of the company's workforce) from its Bolivar, San Jose, Catavi, Tasna, Chocaya, and Tatasi mines. COMIBOL is also considering recommissioning the Karachipampa lead smelter near Oruro. The 22 000-t/y Kivcet smelter was completed in 1984 but never operated.

Lead metal production in Peru increased by 6% in 1991 to a reported 199 100 t. The increase was partly attributed to the absence of labour unrest, with the exception of a three-week strike by Centromin Peru S.A.'s workers that ended on December 4. Contract violations and opposition to the government's privatization plan were cited as reasons for the dispute.

Production at Breakwater Resources' polymetallic El Mochito mine in Honduras was halted for five days due to a labour dispute in mid-October.

Also in October, the Mexican government began soliciting bids to develop the state-owned Tizapa property as part of a strategy to attract foreign investment. Reserves were reported to be 5.6 Mt grading 1.24% lead, 6% zinc, 0.68% copper, 1.65 g/t gold and 246 g/t silver.

Met-Mex Penoles SA de CV temporarily declared force majeure on shipments from its 180 000-t/y Torreon lead smelter after workers walked out over a wage dispute on February 14. It was also reported that capacity utilization was down during 1991 because of a sinter plant bottleneck.

In the United States, Bunker Hill Mining placed its Bunker Hill lead-zinc-silver mine on care and maintenance in January. The mine, located near Kellog, Idaho, has a rated capacity of 18 000 t/y of lead in concentrate.

Equinox Resources opened its Van Stone mine in Washington in April but ceased mining in September in response to low metal prices. The 1000-t/y mill produced 850 t of lead and 3000 t of zinc in concentrate before being placed on care and maintenance.

Also in Washington, it was reported that ASARCO Incorporated would demolish and dispose of all buildings and structures at its former Tacoma operations.

In Alaska, Cominco Ltd.'s Red Dog mine completed its second year of operation. The mine, which produces lead, zinc and bulk concentrates, made its last shipment in October, bringing the total for the 1991 shipping season to approximately 489 800 t containing 46 500 t of lead and 231 900 t of zinc in concentrate.

Europe

In Spain, the life of Andaluza de Piritas S.A.'s Aznalcollar mine was extended past the end of 1992 after additional ore reserves were discovered. It was reported that approximately 19 000 t of lead in concentrate were produced in 1991.

Also in Spain, output resumed in January at Sociedad Minera y Metalurgica de Penarroya-Espana S.A.'s 90 000-t/y lead smelter at Cartegena. Production had been temporarily suspended in December 1990 for environmental reasons.

In Portugal, Pirites Alentejanos (EDM) brought the Aljustrel mine on stream in July. The underground operation has a rated capacity of 6000 t/y of lead in concentrate.

It was announced in November that Anglesey Mining PLC had arranged financing for its Parys Mountain mine in North Wales. Additional underground development and construction of a 350 000-t/y mill are expected to commence in 1992. Reserves were estimated at 6.45 Mt grading 2.6% lead, 5.35% zinc, 2.34% copper, 39 g/t silver and 0.32 g/t gold.

Definition drilling increased ore reserves at the Lisheen deposit of Ireland. The property is reported to contain 13.5 Mt grading 2.1% lead and 12.4% zinc.

Production at Poland's Olkusz, Pormorzany, and Boleslaw lead-zinc mines was disrupted by a three-day strike in July. Production of lead in concentrate from the three mines was reported to be about 17 000 t in 1990.

The Bulgarian government phased out production at the 65 000-t/y Dimitur Blagoev lead plant and reduced output at the 60 000-t/y Georgi Dimitrov lead smelter for environmental reasons. It was also reported that output would continue from a secondary lead smelter at Kurdjali in southern Bulgaria.

RECYCLING

Almost 50% of Canada's production of lead metal came from recycled material in 1991. Although world statistics are not yet available, it is expected that Western World secondary lead output will have surpassed primary production in 1991 for the second year in a row.

British Columbia implemented a lead acid battery recycling system in 1991. The government provides a cash incentive to offset the transportation costs of retrieving batteries. Revenue is generated by the government to pay for the program through a $5.00 green tax that consumers pay when they purchase a new battery. Foreign recycling facilities are also reimbursed for the B.C. portion of their transportation costs.

In the United States, a Battery Council International (BCI) study indicated that, in 1989, the U.S. recycling rate for SLI (Starting, Lighting, Ignition) batteries had reached 95.3%, an increase of 4.3% from the previous year. The increase is, in part, attributed to recycling legislation that has been enacted in 37 states. Twenty-two states have adopted plans similar to the BCI's recycling model which prohibits the disposal of used batteries in landfills or incinerators and requires wholesalers and retailers to take back old batteries. Other states have instituted a tax or cash deposit in lieu of trade when purchasing a new battery.

In February, ASARCO and MIM announced an interest in jointly developing a lead- recycling facility in the United States.

Also in the United States, The Doe Run Company officially opened its new 54 000-t/y secondary lead smelter at Buick, Missouri, at an estimated capital cost of US$38 million.

In the United Kingdom, Cookson Industrial Materials Ltd. closed its 50 000-t/y secondary lead smelter at Newcastle in March, but production continued at its refinery.

In September, Britannia Refined Metals Ltd. commissioned its new 30 000-t/y Isasmelt lead smelter and CX battery breaking plant at Northfleet. The CX battery breaking system has also been installed at a number of lead facilities located in Canada, the United States, Germany and Italy.

In Saudi Arabia, a 12 000-t/y secondary lead smelter near Riyadh is expected to come on stream in late 1992 or early 1993. Feed availability is not anticipated to be a problem as it was reported that Saudi authorities have instituted a ban on scrap battery exports.

On December 30, Hollandse Metallurgische Industrie Billiton BV closed its 35 000-t/y Arnhem lead-tin smelter in response to low metal prices and rising environmental costs.

In an effort to curb air pollution, the Government of Taiwan announced in December that it will ban imports of scrap metal commencing January 1993. Scrap metal imports were reported to be 234 094 t in 1990.

CONSUMPTION AND USES

On the basis of preliminary statistics from the International Lead and Zinc Study Group (ILZSG), lead consumption decreased by 1.2% in 1991 to 4.39 Mt.

Lead is a dense, bluish-white metal whose physical and chemical properties find application in a variety of uses in the manufacturing, construction and chemical industries.

Lead acid batteries constitute the largest market for lead, representing over 60% of total usage in the non-socialist world. In the United States, battery manufacturing constitutes almost 80% of total lead demand. The largest market for batteries, representing about 80% of lead used in the industry, is the automotive sector. The average automobile battery contains about 10 kg of lead. A potential growth area for the lead acid battery is in energy storage facilities for utilities. These are designed to supplement existing generators during the peak morning and evening hours without drawing on other sources or building new power plants.

In the future, electric cars may provide the greatest growth in demand for lead acid batteries and lead. In 1990, California approved stringent automobile emission standards which will require, by 1998, 2% of new cars sold in the state, estimated at about 40 000 vehicles, to be 0% emission or electric powered, with the figure increasing to 10% by the year 2003. Similar requirements were adopted by 10 eastern states in 1991. It was reported that the 11 states account for one third of the total U.S. vehicle market. General Motors Corp.'s lead acid battery-powered "Impact" electric car is expected to be available for this new market by the mid-1990s. However, the new demand for lead will also increase the incentive to develop a longer lasting, more efficient and cost-competitive substitute for the lead acid battery.

In this regard, Nissan is developing a future electric vehicle (FEV) to be powered by a nickel-cadmium battery that is expected to achieve full charge in 15 minutes. Isuzu Motors Ltd. and Fuji Electro-chemical Co., Ltd. expect to market, by 1993, a new revolutionary battery made of activated carbon and diluted sulphuric acid that recharges faster and produces more power than conventional batteries. Also competing are Kansai Electric Power Co., Inc. and Japan Storage Battery Co., Ltd., who are developing a new nickel-zinc battery. Due on the market in 1992, the nickel-zinc battery will reportedly provide double the mileage of fuel batteries in current use, with an expected price 5-10 times that of the lead acid battery. Other candidates include a zinc-based slurry developed by Luz International that generates energy when combined with oxygen and can be recharged in minutes by adding fresh slurry. There is also the Australian-designed vanadium redox battery that is reported to be recyclable, more efficient, longer lasting, and to require one eighth the time a lead acid cell takes to recharge.

The use of lead in chemicals and compounds constitutes the second largest use of the metal. The principal uses are in PVC stabilizers, which prevent degradation during processing or from ultraviolet radiation; in colour pigments; and in the manufacture of glass, including crystal, light bulbs, insulators, and television and computer screens. While lead is still used for some specific paint applications, its general use in this application has declined significantly due to the potential risk involved in exposure to weathered or flaked paint.

Until the mid-1970s, the production of lead additives for gasoline, including tetraethyl lead, constituted one of the most important markets for the metal. However, with the adoption of environmental regulations that have either prohibited or severely restricted the use of such additives, the demand for lead in this application has declined dramatically. In Canada, lead was eliminated, through legislation, as an additive in gasoline for general consumption at the end of 1990.

Lead is alloyed with tin in the production of solder used in both the electronics and plumbing sectors, although these markets have declined in recent years. In the plumbing industry, the demand for lead has fallen as a result of the increasing use of plastic piping. Where metal systems are still used for potable water systems, new regulations, which have been adopted or are being considered, will reduce the amount of lead in solder. In the electronics field, the move to miniaturization, combined with the replacement of printed circuit boards, has also reduced the demand for lead in solder.

Lead is also used with tin in foil for wine bottle capsules. However, this practice is being phased out because of perceived environmental and health concerns. In mid-1991, the European Community announced it would ban the use of tin-lead capsules as of January 1, 1993. Aluminum, plastics (PVC) and tin-based products have been used to replace lead foil.

Other important applications of both lead metal and lead alloys include the production of free machining steel and brass, rolled sheet and strip for roofing applications, power and communication cable sheathing, especially for underground or submarine environments, and as a sound barrier material in construction.

Lead's high resistance to gamma radiation and X rays makes it the preferred metal for shielding around X-ray equipment and at nuclear installations.

Potential new uses for lead include nuclear waste disposal applications; liquid metals (magnetohydrodynamics), a method of generating electricity by passing an electrically conducting fluid through a magnetic field; additives to extend the life of asphalt; barriers or shields against radon gas and electromagnetic fields; and as a damper to protect buildings from vibrations during earthquakes.

MARKETS, PRICES AND STOCKS

Lead prices on the London Metal Exchange (LME) fell to an average of US25¢/lb in 1991 from 37¢/lb in 1990. The U.S. domestic lead price also dropped to 39¢ from 47¢ in 1990. (Table 3 provides a detailed price history for both price quotations.)

LME prices declined steadily during 1991 as LME stocks rose because of weak demand, particularly in North America, combined with increased production primarily due to a resolution of labour disputes and increased Soviet exports.

Although LME stocks were high at the end of 1991, the market was relatively tight for high-grade material. To correct this discrepancy it was suggested that the LME list a high-grade (battery-grade) contract for lead similar to the SHG (Special High Grade) contract for zinc.

The LME also began receiving lead metal at its Baltimore warehouse in July. Other LME warehouses which may start storing lead are Long Beach, Louisville, Bridgeport or New Haven, and Chicago/Toledo.

As lead becomes more available at these locations, it is expected that more North American producers will move away from a producer pricing system for lead to an international pricing system based on the LME price plus a premium (reflecting transportation factors).

According to the latest statistics compiled by the ILZSG, lead stocks totalled 464 000 t at the end of 1991 compared with 438 000 t at the end of 1990. Producer and consumer stocks were down 26% and 18% to 170 000 t and 165 000 t respectively, while merchant and LME stocks rose by 1% and 69% to 3000 t and 126 000 t respectively.

INTERNATIONAL ORGANIZATIONS

The International Lead and Zinc Study Group was formed in 1959 to improve market information and to provide opportunities for regular intergovernmental consultations on lead and zinc markets. Particular attention is given to providing regular and frequent information on supply and demand and their probable development.

The Study Group is headquartered in London, England. Its membership includes most major lead- and zinc-producing and consuming countries. While it has an extensive information-gathering and dissemination role, the Group has no market intervention powers. Member countries' delegations generally include a number of industry representatives as advisors. Canada has been an active member since its inception and chaired the Group in 1988 and 1989.

In 1991, the International Council on Metals and the Environment (ICME) was formed to coordinate industry expertise and resources when addressing environmental and health-related concerns. Members of this Ottawa-based association include American Barrick Resource Corp., Cominco Ltd., Noranda Minerals Inc., Falconbridge Limited, Placer Dome Inc., Asarco Inc., The Doe Run Company, Freeport-McMoRan Inc., Magma Copper Corp., Minorco U.S.A., Phelps Dodge Corp., Industrias Penoles SA de CV, Corporacion Nacional del Cobre de Chile (Codelco), Boliden Mineral AB, ACEC Union Minière, Metaleurop S.A., RTZ Corp., MIM Holdings Ltd., Western Mining Corp. Ltd., Broken Hill Pty Co. Ltd., and two memberships to be represented initially by the Japanese Mining Industry Association.

HEALTH, SAFETY AND THE ENVIRONMENT

In response to concerns over the health effects of exposure to lead and lead compounds, and to an overall increase in environmental awareness, governments in the industrialized nations have moved to restrict or ban the use of lead additives in gasoline. In Canada, leaded gasoline was phased out during 1990, prior to the December 31 legislated deadline banning its use. In addition to the potential benefits associated with the removal of lead emissions, the use of unleaded fuel permits the removal of hydrocarbons, carbon monoxide and nitrous oxides from automobile exhaust gases.

In March 1989, the Basel Convention was signed by a number of countries, including Canada. This regulatory initiative, which will control the transboundary movement of hazardous waste, could adversely affect recycling, including lead acid batteries. Although Canada has not ratified the convention, it is expected that, in 1992, it will come into force after having been ratified by the required 20 countries. However, industrialized nations, through the Organization for Economic Co-operation and Development (OECD), are developing a parallel agreement that would facilitate trade in recyclable materials which are considered to be potentially hazardous.

During 1991, there were a large number of regulatory initiatives with regard to lead.

In Canada, Environment Canada's proposed Secondary Lead Smelter Release Regulations, pursuant to the *Canadian Environmental Protection Act* (CEPA), entered the Canada Gazette, Part II in February. Amendments to address concerns raised during the public review process (Canada Gazette, Part I) are expected to be finalized in the fall of 1993. These regulations, which govern the concentration of particulate lead matter emitted from a secondary smelter, will replace a 1989 interim order which was established as part of the process to roll over, into CEPA, similar regulations that existed under the *Clean Air Act* of 1976.

The United States continued to be the most active country in respect of legislative initiatives relating to lead. In September, the Senate Environment and Public Works Committee approved the *Lead Exposure Reduction Act of 1991*, sponsored in part by Senators Reid and Lieberman. There was general support for the bill, which intends to reduce or restrict the use of lead in certain applications, require mandatory recycling of lead acid batteries, and institute labelling programs for lead-bearing products and fund lead-related studies, educational efforts and blood-monitoring programs. Similar bills aimed at restricting the use of lead in various products or packaging were also introduced in the House of Representatives by Swift and Wolpe. Also tabled in the House by Waxman were lead abatement and remediation bills entitled the "Lead Control Act Amendments of 1991"; B. Cardin tabled the "Lead-Based Paint Hazard Abatement Act." The latter bill proposes a 75¢/lb tax on primary lead and a 37¢/lb tax on secondary lead to fund lead abatement programs.

As for battery recycling, House representative E. Torres and Senator T. Wirth sponsored similar bills aimed at increasing the rate of recycling by methods such as a mandatory recycled content requirement. In December 1990, the U.S. Environmental Protection Agency (EPA) established an industry-government advisory committee to develop rules that would also increase battery recycling. In September, the EPA disbanded the committee after its risk and cost benefit analysis indicated that there would be limited benefit from the proposed rules being considered, given the current high rate of recycling in the United States.

The OECD is preparing an international document of strategies on lead risk reduction. Initial drafts raised considerable concern as they focused on sunsetting and substitution at the expense of other risk management measures. In November, Canada, the United States, Germany and Australia were requested to jointly prepare a third revision in consultation with industry and labour. Energy, Mines and Resources Canada has been asked to coordinate Canada's contribution to the section on production, use, disposal and linkages to exposures. The next draft is scheduled to be available for review by mid-1992.

PRICES AND OUTLOOK

A supply surplus is forecast for 1992 as a modest recovery in demand is expected to be outstripped by a combination of increased metal production and the continued export of refined lead from Eastern Bloc countries. However, the market could tighten if secondary lead producers are forced to reduce output or close as a result of low profit margins caused by high scrap prices combined with low metal prices. The price of lead in 1992 is expected to average US24¢/lb.

In the longer term, it is predicted that a modest growth in demand, averaging 1.0%/y during the 1990s, may be outpaced by supply if: the former U.S.S.R. continues to be a net exporter, new mining and smelting capacity comes on stream in the Asia Pacific region, and increased recycling occurs in North America and Europe.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada[1]	EEC MFN	Japan[1] MFN
2607.00	Lead ores and concentrates	Free	Free	Free	1.1¢/kg on Pb	Free	Free
78.01	Unwrought lead						
7801.10	Refined lead						
7801.10.10	Pig and block	Free	Free	Free	2.1% on Pb	3.5%	8 yen/kg
7801.10.90	Other	10.2%	Free	6.1%	2.1% on Pb	3.5%	8 yen/kg
7801.91	Containing by weight antimony as the principal other element						
7801.91.10	Lead antimony - tin alloys	6.8%	Free	4%	2.1% on Pb	3.5%	6.5%
7801.91.90	Other	10.2%	Free	6.1%	2.1% on Pb	3.5%	6.5%
7801.99	Other						
7801.99.10	For refining, containing 0.02% or more by weight of silver (bullion lead)	10.2%	Free	6.1%	2.4% on Pb	Free	4.7%
7801.99.20	Lead alloys	10.2%	Free	6.1%	2.1% on Pb	3.5%	4.7%
7801.99.90	Other	10.2%	Free	6.1%	2.1% on Pb	3.5%	8 yen/kg
7802.00	Lead waste and scrap	Free	Free	Free	Free	Free	3.2%
7803.00	Lead bars, rods, profiles and wire						
7803.00.10	Bars and rods, not alloyed	4%	2.5%	2.4%	0.8%	8%	5.8%
7803.00.20	Bars and rods, of lead-antimony-tin alloys	6.8%	Free	4%	0.8%	8%	5.8%
7803.00.30	Bars and rods, of other alloys; profiles and wire	10.2%	Free	6.1%	0.8%	8%	5.8%
7804.20	Powders and flakes						
7804.20.10	Powders, not alloyed	4%	Free	2.4%	7.8%	2.2%	6.5%
7804.20.20	Alloyed powders; flakes	10.2%	Free	6.1%	7.8%	2.2%	6.5%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States,1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Customs Tariff Schedules of Japan, 1991.

[1] GATT rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, LEAD PRODUCTION AND TRADE, 1990 AND 1991, AND CONSUMPTION, 1989 AND 1990

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
SHIPMENTS					
	All forms[1]				
	Newfoundland	–	–	–	–
	Prince Edward Island	–	–	–	–
	Nova Scotia	x	x	x	x
	New Brunswick	56 244	67 324	59 019	50 225
	Quebec	–	–	–	–
	Ontario	x	x	x	x
	Manitoba	1 755	2 101	2 463	2 096
	Saskatchewan	–	–	–	–
	Alberta	–	–	–	–
	British Columbia	19 312	23 117	49 578	42 191
	Yukon	104 181	124 704	95 224	81 036
	Northwest Territories	46 588	55 766	31 403	26 724
	Total	233 372	279 346	239 558	203 864
	Mine output[2]	241 277	..	277 853	..
	Refined production				
	Primary	87 180	..	104 700	..
	Secondary	96 465	..	103 600	..
	Total	183 645	..	208 300	..
EXPORTS				(Jan.-Sept.)	
2607.00	Lead ores and concentrates				
	Japan	68 682	33 759	46 176	18 703
	United States	9 038	13 737	28 098	14 057
	Germany[3]	49 223	33 398	23 729	8 696
	South Korea	–	–	12 932	6 542
	Australia	9 233	6 383	9 481	4 788
	Italy	25 433	19 063	10 205	4 328
	Belgium	17 710	14 599	5 280	1 780
	Morocco	13 568	11 468	–	–
	Other countries	18 358	14 823	9 113	3 901
	Total	211 245	147 230	145 014	62 795
2607.00.20	Lead content of lead ores and concentrates	209 417	123 645	143 178	50 712
2603.00	Copper ores and concentrates				
2603.00.20	Lead content	2 317	715	335	167
2608.00	Zinc ores and concentrates				
2608.00.20	Lead content	9 831	4 093	7 769	1 697
78.01	Unwrought lead				
7801.10	Refined lead				
	United States	43 512	42 160	36 924	26 956
	Japan	8 262	7 810	4 457	3 101
	Belgium	3 055	2 885	3 106	2 266
	South Korea	1 290	1 236	2 788	1 758
	Italy	7 835	8 154	220	157
	United Kingdom	8 971	4 903	99	72
	Netherlands	3 545	3 355	–	–
	Other countries	6704	6 154	8 519	6 425
	Total	83 174	76 657	56 113	40 735
7801.91	Containing by weight antimony as the principal other element	5 321	5 323	6 569	4 871
7801.99	Other	27 625	27 331	10 968	8 349

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
7802.00	Lead waste and scrap				
	United States	8 730	2 872	1 446	753
	Ireland	–	–	750	464
	United Kingdom	1 265	918	179	115
	People's Republic of China	1 469	836	166	65
	Philippines	2 958	676	38	11
	Brazil	1 885	595	55	2
	Other countries	1 627	761	1 618	854
	Total	17 934	6 658	4 252	2 264
7803.00	Lead bars, rods, profiles and wire				
	United States	222	401	156	299
	Other countries	11	61	–	–
	Total	233	462	156	299
78.04	Lead plates, sheets, strip and foil; lead powders and flakes				
	Plates, sheets, strip and foil				
7804.11	Sheets, strip and foil of a thickness (excluding any backing) <0.2 mm	300	442	178	211
7804.19	Other	274	71	18	22
7804.20	Powders and flakes	26	71	2	10
7805.00	Lead tubes, pipes and tube or pipe fittings (i.e. couplings, elbows, sleeves)	24	34	12	47
7806.00	Other articles of lead				
	United States	. .	1 499	. .	1 043
	Other countries	. .	348	. .	335
	Total	. .	1 847	. .	1 378
IMPORTS					
2607.00	Lead ores and concentrates				
	United States	22 123	23 734	2 362	1 791
	Peru	13 382	23 776	861	5 606
	Australia	8 055	6 250	–	–
	Total	43 561	53 760	3 223	7 398
2607.00.00.20	Lead content of lead ores and concentrates	37 448	23 646	2 632	1 564
2608.00	Zinc ores and concentrates				
2608.00.00.20	Lead content	7 549	7 144	7 048	5 914
78.01	Unwrought lead				
7801.10	Refined lead				
7801.10.10.10	Pig and block	10 560	10 195	5 434	4 007
7801.10.90.00	Other	259	234	58	78
7801.91	Containing by weight antimony as the principal other element	340	366	410	539
7801.99	Other	523	561	555	443
7802.00	Lead waste and scrap				
	United States	34 787	12 460	42 758	8 143
	Other countries	44	38	13	1
	Total	34 831	12 498	42 771	8 144
7803.00	Lead bars, rods, profiles and wire				
	United States	145	211	69	94
	Other countries	77	152	18	28
	Total	222	363	87	123

TABLE 1 (cont'd)

Item No.		1990 (tonnes)	1990 ($000)	Jan.-Sept. 1991p (tonnes)	Jan.-Sept. 1991p ($000)
IMPORTS (cont'd)					
78.04	Lead plates, sheets, strip and foil; lead powders and flakes				
	Plates, sheets, strip and foil				
7804.11	Sheets, strip and foil of a thickness (excluding any backing) < 0.2 mm	146	242	108	202
7804.19	Other	372	528	199	256
7804.20	Powders and flakes	197	269	146	170
7805.00	Lead tubes, pipe and tube or pipe fittings (i.e. couplings, elbows, sleeves)	14	36	7	19
7806.00	Other articles of lead				
	United States	. .	2 469	. .	1 570
	Germany3	. .	69	. .	50
	Japan	. .	28	. .	11
	Other countries	. .	191	. .	31
	Total	. .	2 757	. .	1 662

	1989 Primary	1989 Secondary5	1989 Total	1990 Primary	1990 Secondary5	1990 Total
	(tonnes)					
CONSUMPTION4						
Lead used for, or in the production of:						
Antimonial lead	x	x	23 999r	x	x	20 450
Batteries and battery oxides	29 720r	10 134r	39 854r	22 350	5 467	27 817
Chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	x	x	10 289r	x	x	10 494
Copper alloys; brass, bronze, etc.	141	21	162	113	19	132
Lead alloys:						
solders	916	863	1 779	485	1 020	1 505
others (including babbitt, type metals, etc.)	412	3 568	3 980	380	3 230	3 610
Semi-finished products:						
pipe, sheet, traps, bends, blocks for caulking, ammunition, etc.	1 980	715	2 695	2 081	1 275	3 356
Other lead products	3 875	1 082	4 957	2 983	1 399	4 382
Total, all categories	49 001r	38 714r	87 715r	40 018	31 727	71 745

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; p Preliminary; r Revised; x Confidential.
1 Production includes recoverable lead in ores and concentrates shipped, valued at the average Montreal price for the year. 2 Lead content of domestic ores and concentrates exported. 3 Where applicable, data for East and West Germany have been combined. 4 Available data, as reported by consumers. 5 Includes all remelt scrap lead used to make antimonial lead.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, LEAD PRODUCTION, TRADE[1] AND CONSUMPTION, 1975, 1980, AND 1985-91

	Production				Exports[1]			Imports	Consumption[3]
		Refined							
	All Forms[2]	Primary	Secondary	Total	In Ores and Concentrates	Refined	Total	Refined	
	(tonnes)								
1975	349 133	171 516	..	171 516	211 909	110 882	322 791	1 962[a]	89 192
1980	251 627	162 463	72 117	234 580	147 008	126 539	273 547	2 602[a]	106 836
1985	268 291	173 220	66 791	240 011	93 657	113 993	207 650	5 675[a]	104 447
1986	334 342	169 934	87 746	257 680[r]	118 373	111 831	230 204	4 247[a]	94 680
1987	373 215	139 475	91 186	230 661	207 936	100 204	308 140	12 558[a]	97 281
1988	351 148	179 461	88 615	268 076	200 822	179 946	380 768[r]	15 132	88 041
1989	268 887	157 330	85 515	242 845	170 568	121 444	292 012[r]	11 708	87 715[r]
1990	233 372	87 180	96 465	183 645	221 565	84 007	305 572	11 756	71 745[p]
1991[p]	239 558	104 700	103 600	208 300	151 282[b]	56 467[b]	207 749	6 032	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
.. Not available; [p] Preliminary; [r] Revised.
[a] Lead in pigs, blocks and shot. [b] January to September 1991.
[1] Beginning in 1988, Exports and Imports are based on the new Harmonized System and may not be in complete accordance with previous method of reporting. Ores and concentrates include H.S. classes 2603.00.20, 2607.00.20 and 2608.00.20. Refined exports include H.S. classes 7801.10, 7803.00, 7804.11, 7804.19 and 7804.20. Refined imports include H.S. classes 7801.10.10.00, 7801.10.90.00, 7803.00, 7804.11, 7804.19 and 7804.20. [2] Recoverable lead in ores and concentrates shipped. [3] Consumption of lead, primary and secondary in origin, as measured by survey of consumers.

TABLE 3. AVERAGE ANNUAL LEAD PRICES, 1975-91

Year	London Metal Exchange Settlement (£/t)	Settlement (US¢/lb)	Three Months (£/t)	Three Months (US¢/lb)	U.S. Domestic (US¢/lb)
1975	185.63	18.755	186.78	18.821	21.529
1976	250.70	20.480	259.79	21.275	23.102
1977	354.11	28.022	359.12	28.433	30.703
1978	342.79	29.886	342.94	29.895	33.653
1979	567.66	54.574	542.66	52.161	52.642
1980	391.29	41.237	392.08	41.343	42.455
1981	363.37	33.327	370.93	34.025	36.531
1982	310.72	24.679	321.55	25.516	25.547
1083	279.97	19.290	290.62	19.983	21.377
1984	332.49	20.156	333.20	20.196	25.548
1985	304.01	17.876	304.03	17.877	19.067
1986	277.36	18.456	277.61	18.473	22.047
1987	363.66	27.098	346.40	25.736	35.943
1988	368.40	29.748	358.35	28.834	37.140
1989	412.39	30.669	406.41	29.908	39.350
1990	458.21	37.097	443.06	35.871	47.069
1991	315.23	25.303	325.84	25.805	38.800

Sources: London Metal Exchange; Metals Week; Reuters.

TABLE 4. AVERAGE MONTHLY LEAD PRICES, 1990 AND 1991

	London Metal Exchange Settlement (£/t)	Settlement (US¢/lb)	Three Months (£/t)	Three Months (US¢/lb)	U.S. Domestic (C¢/lb)	U.S. Domestic (US¢/lb)
1990						
January	428.66	32.1	422.52	31.1	47.1	40.2
February	459.77	35.4	423.70	32.1	49.9	41.7
March	653.91	48.2	501.18	36.3	63.0	53.4
April	510.68	37.9	495.01	36.2	57.2	49.2
May	492.21	37.4	488.20	36.6	55.8	47.5
June	489.93	38.0	492.86	37.6	55.7	47.5
July	483.71	39.7	486.69	39.3	58.4	50.5
August	460.80	39.7	465.61	39.5	58.4	51.0
September	446.13	38.0	452.59	38.0	58.3	50.4
October	391.10	34.5	391.36	34.0	55.0	47.4
November	356.96	31.8	361.97	31.8	50.2	43.1
December	325.06	28.3	334.96	28.8	48.8	42.0
1991						
January	309.99	27.2	324.20	28.0	45.5	39.3
February	301.89	26.9	312.61	27.4	44.4	38.5
March	330.69	27.3	342.94	27.9	44.5	38.5
April	343.02	27.2	351.78	27.5	44.4	38.5
May	321.72	25.2	333.34	25.7	44.3	38.5
June	332.72	24.9	339.03	25.0	44.0	38.5
July	331.64	24.8	340.42	25.2	44.3	38.5
August	320.54	24.5	332.49	25.1	44.1	38.5
September	312.41	24.5	322.98	25.0	43.9	38.7
October	302.88	23.7	313.70	24.2	44.5	39.5
November	284.24	22.9	295.51	23.5	44.8	39.7
December	290.98	24.1	301.07	24.6	45.3	39.5

Sources: Metals Week; Reuters.

TABLE 5. NON-SOCIALIST WORLD LEAD CONSUMPTION, 1987-90

	1987		1988		1989		1990	
	(000 t)	(%)	(000 t)	(%)	(000 t)	(%)	(000 t)	(%)
Batteries	2 312.3	60.5	2 395.8	61.1	2 490.9	61.5	2 529.2	63.3
Cable sheathing	193.1	5.1	183.6	4.7	196.3	4.8	177.9	4.5
Rolled and extruded products	289.0	7.6	313.4	8.0	323.3	7.9	303.7	7.6
Shot/ammunition	87.7	2.3	85.4	2.2	95.8	2.4	112.6	2.8
Alloys	148.4	3.9	146.9	3.7	139.7	3.6	130.8	3.3
Pigments and other compounds	517.4	13.5	526.2	13.4	555.4	13.7	505.6	12.6
Gasoline additives	106.4	2.8	95.9	2.4	94.5	2.3	84.2	2.1
Miscellaneous	169.1	4.3	174.7	4.5	155.1	3.8	153.6	3.8
Total	3 823.4	100.0	3 921.9	100.0	4 051.0	100.0	3 997.6	100.0

Source: International Lead and Zinc Study Group.
Statistics are for: Australia, Austria, Belgium, Brazil, Canada, Finland, France, Germany, India, Italy, Japan, Republic of Korea, Mexico, Netherlands, New Zealand, Scandinavia, South Africa, Southeast Asia, Spain and Switzerland.

TABLE 6. REFINED LEAD CONSUMPTION BY COUNTRY, 1987-91

	1987	1988	1989	1990	1991p
			(000 t)		
AMERICAS					
Canada	103	102	93	91	77
United States	1 217	1 236	1 262	1 312	1 247
Mexico	100	77	86	67	79
Brazil	93	95	100	75	66
Other Americas	95	83	64	62	72
Total Americas	1 608	1 593	1 605	1 607	1 541
EUROPE					
United Kingdom	288	303	301	302	268
Germany[1]	345	373	375	392	409
Italy	244	246	259	258	259
France	207	216	244	255	253
Spain	128	123	119	134	134
Other EEC	187	184	183	264	275
Other Europe	253	263	252	141	135
Total Europe	1 652	1 708	1 733	1 746	1 733
ASIA					
Japan	378	406	406	416	422
Republic of Korea	122	146	155	149	165
Taiwan	75	75	65	75	75
India	70	75	80	75	77
Other Asia	165	174	194	206	227
Total Asia	810	876	900	921	966
OCEANIA					
Australia	62	60	61	53	50
Other Oceania	8	9	9	7	7
Total Oceania	70	69	70	60	57
AFRICA					
South Africa	51	56	63	66	52
Egypt	16	10	11	11	12
Algeria	19	21	20	11	12
Other Africa	23	23	25	23	24
Total Africa	109	110	119	111	100
Total, non-socialist world	4 249	4 356	4 427	4 445	4 397

Source: International Lead and Zinc Study Group.
p Preliminary.
1 Data prior to 1991 include the former Federal Republic only.

TABLE 7. LEAD MINE PRODUCTION BY COUNTRY, 1987-91

	1987	1988	1989	1990	1991p
			(000 t)		
AMERICAS					
Canada	414	367	275	241	278
United States	318	394	419	495	475
Mexico	177	178	163	180	180
Peru	204	149	192	186	199
Other Americas	55	70	65	59	123
Total Americas	1 168	1 158	1 114	1 161	1 193
EUROPE					
Yugoslavia	94	95	86	83	71
Sweden	89	85	82	85	80
Spain	82	74	64	60	44
Ireland	34	32	32	35	40
Germany[1]	25	18	9	8	8
Other EEC	56	69	51	62	
Other Europe	10	7	21	5	
Total Europe	390	380	345	339	301
ASIA					
Japan	28	23	19	19	19
Iran	20	17	10	11	11
Thailand	34	29	24	22	20
India	29	23	25	25	26
Other Asia	28	31	35	33	32
Total Asia	139	123	113	110	108
Australia	455	457	499	556	574
AFRICA					
South Africa	96	90	78	70	72
Morocco	72	69	63	65	52
Zambia	15	14	12	12	10
Other Africa	36	34	30	23	22
Total Africa	219	207	183	170	156
Total, non-socialist world	2 371	2 325	2 254	2 336	2 332

Source: International Lead and Zinc Study Group.
p Preliminary.
[1] Data prior to 1991 include the former Federal Republic only.

TABLE 8. REFINED LEAD PRODUCTION BY COUNTRY, 1987-91

	1987	1988	1989	1990	1991p
			(000 t)		
AMERICAS					
Canada	231	268	243	184	208
United States	1 042	1 091	1 253	1 291	1 185
Mexico	185	179	174	173	173
Peru	88	98	74	69	76
Brazil	71	54	86	76	64
Other Americas	56	48	45	40	44
Total Americas	1 673	1 738	1 875	1 833	1 753
EUROPE					
United Kingdom	347	374	350	329	318
Germany[1]	341	345	350	349	373
Italy	168	177	181	171	208
France	245	256	268	260	283
Spain	126	122	122	130	110
Yugoslavia	128	131	119	94	95
Other EEC	150	179	165	164	177
Other Europe	116	109	93	90	88
Total Europe	1 621	1 693	1 652	1 587	1 652
ASIA					
Japan	339	340	333	327	334
Republic of Korea	83	90	87	75	68
Taiwan	66	67	58	27	30
India	32	32	37	41	43
Other Asia	64	73	84	82	88
Total Asia	584	602	599	552	563
OCEANIA					
Australia	217	204	210	224	221
Other Oceania	4	5	5	5	5
Total Oceania	221	209	215	229	226
AFRICA					
South Africa	35	36	37	31	31
Morocco	62	71	66	67	72
Namibia	41	45	44	35	33
Other Africa	20	17	16	18	16
Total Africa	158	169	163	151	152
Total, non-socialist world	4 257	4 411	4 504	4 352	4 346

Sources: Energy, Mines and Resources Canada; International Lead and Zinc Study Group.
p Preliminary.
[1] Data prior to 1991 include the former Federal Republic only.

TABLE 9. CANADA, PRIMARY LEAD REFINED METAL CAPACITY, 1990

Company and Location	Annual Rated Capacity
	(000 t of refined lead)
Brunswick Mining and Smelting Corporation Limited Belledune, New Brunswick	72
Cominco Ltd. Trail, British Columbia	135
Total Canada	207

Lime

Oliver Vagt

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-2667

"Lime" is a general term referring to burned or calcined limestone (burnt lime or quicklime) and its secondary products, including slaked lime and hydrated lime (or calcium hydroxide). In the calcining process, quicklime (CaO or CaO.MgO), begins to form when the dissociation temperature of the limestone occurs. (This occurs from 402°C for the $MgCO_3$ component and at up to 898°C for the $CaCO_3$ portion.) Temperatures are maintained until there is a complete breakdown of the limestone and the carbon dioxide content is released.

In 1991, shipments of lime were 2.3 Mt valued at $186.3 million. This was a decrease of 1% in terms of both volume and value compared to 1990. Shipments of quicklime, accounting for about 92% of the market, were 2.2 Mt, a 1% increase compared to 1990. Shipments in 1991 were 8% lower than in 1989. (Major strikes closed the Ontario steel industry for three months in 1990.) Production figures do not include some captive production from pulp and paper plants. This industry burns sludge to recover lime for re-use in the causticization process.

THE CANADIAN INDUSTRY

In 1991, the lime industry in Canada comprised 14 companies operating 20 plants, of which 13 were in eastern Canada. Employment in the industry was approximately 900. Calcining capacity to produce quicklime stabilized in 1991 following expansions during 1989/90. The capacity utilization was approximately 60% in 1991.

Lime is a high-bulk, comparatively low-cost commodity; however, it may be sold within a wide radius depending on transportation costs and supply and demand. Preferred locations are within close proximity to major lime markets and sources of high-quality raw material with convenient access to low-priced energy.

High-calcium quicklime is commercially available in six forms: lump, crushed, pebble, ground, pulverized lime, and as briquettes or pellets. Slaked lime is produced from mixing quicklime and water and may be purchased as a putty, dry powder or slurry. Hydrated lime is produced from slaked lime after drying and regrinding. The resulting hydrated lime products, which are characterized by their chemistry, include the following types: high-calcium lime, dolomitic lime, and magnesian or hydraulic lime. (The latter type contains siliceous, aluminous or ferrous impurities.) Aglime, or agricultural lime, refers to pulverized limestone used for soil neutralization, primarily during the fall and spring spreading seasons.

In **New Brunswick**, Havelock Lime, a division of Dickenson Mines Limited, completed its new kiln at Havelock. Its capacity to produce calcitic quicklime increased to 175 000 t/y in 1991, an increase of 105 000 t/y. In 1990, the company commissioned a new 10-t/h hydrator, increasing capacity to 129 000 t/y from about 40 000 t/y.

In **Quebec**, Graybec Inc. completed a second kiln at its Domlim plant in St-Adolphe-de-Dudswell. This project was part of a $13.2 million expansion announced in 1989, which effectively doubled capacity to 300 000 t/y of quicklime. Graybec is a member of the Graymont group of companies, a privately owned Vancouver-based group having diverse interests in Canada and the United States.

Dolo-Mine Inc. of St-Bruno-de-Guigues, in the Abitibi region, invested $2.5 million in 1990 in a new 40 000-t/y lime plant. Dolomitic quicklime is produced and sold mainly for controlling acidic waters at mine sites; however, output has been intermittent. The company has produced aglime and crushed stone for many years.

In **Ontario**, BeachviLime Limited modernized part of its quicklime facilities at Ingersoll. A new, more energy-efficient 230 000-t/y kiln replaced an older installation in 1991. The total capacity of 922 000 t/y was not changed. Other modernizations are planned in 1992.

Dymond Clay Products Limited of Haileybury continued to run its new lime plant near Lake Timiskaming, 5 km north of Cobalt. Its reported production capacity for calcitic quicklime is about 40 000 t/y from a gas-fueled vertical kiln. Sales are to the mining and paper sectors in northern Ontario and northwestern Quebec. Traditional markets include metallurgical limestone for smelters, crushed stone, and aglime.

Stelco Inc. and The Algoma Steel Corporation, Limited, two major steel companies affected by a three-month strike in 1990, resumed operations at reduced levels. Lime plants owned by the companies remained idle during most of the affected period.

In **western Canada**, Continental Lime Ltd. of Richmond, British Columbia, 100% owned by Graymont Inc., purchased Summit Lime Works of Coleman, Alberta, in 1991. Summit operates a 50 000-t/y lime plant and produces a range of limestone products at Hazell, Alberta. In 1991, Texada Lime increased its quicklime capacity from 65 000 t/y to 135 000 t/y by the addition of a new $9 million kiln at Fort Langley, British Columbia. Texada is a division of BP Resources Canada Limited. The incremental production will be sold mainly to the mining and pulp and paper industries in British Columbia and the northwestern United States.

CONSUMPTION

Consumption of lime produced in Canada consists of two basic categories: the captive market, which includes quicklime produced internally by chemical plants, sugar refineries and some steel producers; and the merchant market, which is served by the lime producers. In 1990, the captive market, estimated to be 780 000 t, accounted for about 40% of total domestic sales. (Domestic sales are defined as output for captive use, plus all sales in the merchant market.)

Consumption of quicklime, based on sales in the merchant market, amounted to 1 223 100 t in 1990. The major end uses were steelmaking (39%), environmental control (27%), pulp and paper (16%), chemicals (9%), and other industrial uses (9%). Hydrated lime shipments in the merchant market amounted to 170 000 t in 1990, and were mostly sold for environmental control (52%), industrial uses (35%), masonry (4%), metallurgy (1%), pulp and paper (2%), and other miscellaneous uses (6%). Eastern Canada, comprising Ontario eastward, accounted for about three quarters of total merchant sales of quicklime in 1990.

Lime is used widely in the metallurgical, industrial (including environment), agricultural and construction sectors. In the metallurgical industry, consumption is mainly as a basic flux in steel furnaces allowing impurities, including silica, alumina, phosphorus and sulphur, to form a slag. Other fluxing agents may include limestone, dolomite and fluorspar. Limestone and dolomite (or dolostone) are used mainly in blast furnaces for making pig iron and in sinter plants at steel mills; limestone, lime and dolime are used in both basic oxygen and electric-arc steel furnaces. Electric-arc furnaces account for one third of steel production capacity in Canada, with basic oxygen furnaces accounting for the remainder.

Industrial markets mainly include the pulp and paper industry, the mining industry, chemicals manufacturing, and environmental control. The pulp and paper industry is the second largest consumer of lime used mainly for the preparation of digesting liquor for manufacturing Kraft or sulphate paper and for pulp bleaching during a primary stage of production. Most of the input lime is recovered by calcining dewatered calcium carbonate sludges; however, an important volume of lime is required as "make-up." The increasing use of precipitated calcium carbonate (PCC) in coated and uncoated printing and writing papers in North America has led to major growth in the demand for lime.

In the mining sector, acidic effluents are treated with alkalis or related industrial products. These include lime, limestone, soda ash, and ammonium and magnesium hydroxide to raise pH levels (for neutralization) and to precipitate metals. In the uranium industry, lime controls hydrogen-ion concentration in the extraction process as well as in the recovery of sodium carbonate and neutralization of waste sludges. Lime is also used for cyanidation and neutralization in recovering gold and silver by flotation. Chemical manufacturers require lime to produce sodium carbonate (soda ash) and bicarbonate of soda, and also to produce chloralkali, calcium carbide and calcium cyanimide.

Lime is increasingly needed for environmental control with the introduction of more stringent regulations. Major uses concern the treatment of liquid wastes and industrial effluents; lime is also used in the clarification and softening of potable water. In addition, the neutralization of lakes has attracted much attention over the last two decades. In certain areas, these bodies of water have been acidified by precipitation of sulphur dioxide and nitrogen dioxide emissions. Effective interim actions include liming with limestone, calcite, quicklime, hydrated lime, dolomite, sodium bicarbonate, fly ash and industrial slags. However, research conducted mainly in Ontario has shown that pure limestone (or calcite) is the most cost-effective method.

Air pollution control is a major developing market for lime and limestone in North America. Major coal-fired power stations are taking measures to reduce emissions from the burning of high-sulphur coal, oil and lignite. Several methods apply, including the use of Flue Gas Desulphurization (FGD) units, or scrubbers. There are several options for scrubbing, including the following: wet scrubbing with limestone or lime; dry scrubbing with lime; dry injection using sodium reagents (sodium bicarbonate and sodium sesquicarbonate), trona, or nahcolite; dry injection with limestone integrated with calcium oxide activation; and dry injection of hydrated lime. Wet scrubbing processes using limestone or lime now appear to be gaining importance. The choice of processes depends on many factors such as resource availability, solid waste disposal programs, equipment costs, maintenance and operational costs, flue gas characteristics, utility type and size, and type of fuel consumed by the power station.

Agricultural uses apply mainly to neutralizing soil acidity. The current practice principally involves the use of pulverized limestone or aglime. In the case of some sandy soils, dolomitic liming is carried out to help balance magnesium deficiencies.

Miscellaneous uses for lime relate to sugar refining (removal of acids from the crude sugar liquids), control of storage conditions for fruit and vegetables, and petroleum refining (neutralization of sulphur compounds and sulphur dioxide emissions). Lime is also used in making plaster, mortar, leather and rubber, paint, glass, dolomitic refractories, and calcium-silicate bricks.

ENERGY AND TECHNOLOGY

Energy costs to produce quicklime account for nearly 40% of total production costs, one of the highest ratios in the manufacturing sector. Calcining takes place mainly in vertical (shaft-type) or rotary-type kilns, the latter technology being the most common in North America. Preheater systems and computerized process control systems are now commonplace.

Approximately 80% of the kilns in service use natural gas, 12% use coal, and less than 6% use electricity. Long rotary-kiln systems consume an average of about 6.4 gigajoules per tonne (GJ/t) of calcined lime. New rotary kilns, with preheaters, consume less than 5.0 GJ/t, and short-shaft kilns consume about 4.2 GJ/t of calcined lime. Other types of kilns, of comparatively recent design, are the rotary hearth, travelling grate, fluo-solid, and the inclined vibratory kiln. Dust-collecting equipment to meet current environmental control regulations is required for all systems.

PRICES

Published prices for lime represent only a broad range. Actual prices vary according to marketing strategies and supply and demand. Average prices for high-calcium quicklime and high-calcium hydrated lime, f.o.b. plant, in Ontario, in bulk, were quoted at $70.80/t and $80.40/t, respectively.

INTERNATIONAL DEVELOPMENTS

In 1991, world lime production was an estimated 134.9 Mt compared to 136.2 Mt in 1990, based on revised figures. The former U.S.S.R., the largest producing area, accounted for 21% followed by China (12%), the United States (11.3%), the former Federal Republic of Germany (7.5%), and Japan (6.4%). Canada ranked fifteenth with a 2% share.

The United States produced 15.24 Mt of lime in 1991 compared to 15.83 Mt in 1990. Apparent consumption in 1991 amounted to 15.4 Mt compared to 15.9 Mt in 1990, according to preliminary figures. This decrease in output and use was the first break in an upward trend since 1986. During the period of economic expansion before 1991, higher consumption was mainly attributed to growing sales to the chemical and industrial sectors, accounting for about 90% of the market.

OUTLOOK

The production of lime in Canada in 1992 is expected to be about the same as in 1991. Sales to the steel industry, characterized by low demand and weak prices, are expected to remain weak. In Ontario, the outlook in this sector will be influenced mainly by the success of a long-term restructuring plan by The Algoma Steel Corporation, Limited. Over the medium-to-long term, demand for lime as a flux in steelmaking is forecast to decline because of several factors. These include: more use of continuous casting, growing energy efficiency, the use of larger amounts of scrap in basic oxygen furnaces, and improved ore grades having a lower silica content.

Demand for lime in the pulp and paper and chemical sectors will continue to be affected by low operating rates. Consumption in the environmental sector is expected to expand in the short term, with increased treatment of effluents in the industrial and mining sectors. Ontario Hydro is installing wet scrubbers using limestone at Lambton and Nanticoke. Similarly, limestone technology is planned for controlling sulphur dioxide emissions at major power installations in Nova Scotia and New Brunswick. In the United States, the choice between lime and limestone for wet scrubbing technology remains uncertain.

The demand for precipitated calcium carbonate (PCC) for use as a filler and a coater in printing and writing papers is expected to grow. Trends suggest an 85%-90% conversion to alkaline papermaking in North America by 1994, and for higher PCC filler loadings in specialty papers, rising from 15%-20% in 1989-90 to about 30% in 1995.

After some consolidation, restructuring and recent plant improvements, the lime industry has become more concentrated as fewer companies control more operations. These companies or corporate groups (often diversified geographically and in product line) will be in a better position to meet future economic downturns. However, the current low rate of capacity utilization, in combination with announced expansions, will allow the lime industry to be well positioned to respond to any major increases in demand.

Note: Information in this review was current as of January 31, 1992.

PRICES

Canada lime prices quoted in "Camford Chemical Report":	December 1990	December 1991
	($ per tonne)	
Lime, carload and truckload f.o.b. Ontario plant		
High calcium quicklime, bulk	70.80	70.80
High calcium hydrated lime, bulk	80.40	80.40

f.o.b. Free on board.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2522.10	Quicklime	Free	Free	Free	Free
2522.20	Slaked lime	Free	Free	Free	Free
2522.30	Hydraulic lime	Free	Free	Free	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, LIME PRODUCTION AND TRADE, 1989-91

Item No.		1989		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION[1]							
	By type						
	Quicklime	2 349 312	182 943	2 137 996	168 854	2 146 207	168 008
	Hydrated lime	202 622	18 627	202 741	19 429	189 595	18 279
	Total	2 551 934	201 571	2 340 737	188 283	2 335 802	186 287
	By province						
	New Brunswick	x	x	x	x	x	x
	Quebec	x	x	x	x	x	x
	Ontario	1 656 404	126 496	1 366 082	102 338	1 402 272	103 550
	Manitoba	x	x	x	6 850	x	7 199
	Alberta	195 157	16 379	240 254	22 336	218 804	20 488
	British Columbia	176 887	16 758	x	x	x	x
	Total	2 551 934	201 571	2 340 737	188 283	2 335 802	186 287
IMPORTS						(Jan.-Sept.)	
2522.10	Quicklime						
	United States	27 979	2 845	29 876	2 673	24 412	2 228
	India	–	–	3	1	–	–
	Total	27 979	2 845	29 879	2 674	24 412	2 228
2522.20	Slaked lime						
	United States	1 090	181	4 611	668	1 322	218
	United Kingdom	485	326	–	–	–	–
	Total	1 575	507	4 611	668	1 322	218
2522.30	Hydraulic lime						
	United States	9 541	1 256	7 597	1 185	6 297	894
	United Kingdom	–	–	1 628	358	–	–
	Total	9 541	1 256	9 225	1 543	6 297	894
EXPORTS							
2522.10	Quicklime						
	United States	63 217	5 898	90 938	7 711	68 152	6 080
	Other countries	–	–	–	–	16	2
	Total	63 217	5 898	90 938	7 711	68 168	6 082
2522.20	Slaked lime						
	United States	6 738	637	24 879	2 611	14 740	1 513
	Bermuda	18	2	17	2	–	–
	Total	6 756	640	24 896	2 613	14 740	1 513
2522.30	Hydraulic lime						
	United States	13 617	1 500	22 561	2 014	17 654	1 602
	Other countries	17	5	15	6	16	2
	Total	13 635	1 506	22 575	2 021	17 670	1 604

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; p Preliminary; x Confidential.
[1] Producers' shipments, and quantities used by producers.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, LIME PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970, 1975, 1980, AND 1985-91

	Production[1]			Imports	Exports	Apparent Consumption[2]
	Quick	Hydrated	Total			
			(tonnes)			
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
1980	2 364 000	190 000	2 554 000	40 901	403 166	2 191 735
1985	2 054 294	157 286	2 211 580	23 056	194 097	2 040 539
1986	2 069 043	173 534	2 242 577	46 917	189 512	2 099 982
1987	2 140 793	189 278	2 330 071	44 290	163 767	2 210 594
1988[a]	2 306 831	211 151	2 517 982	28 861	111 177	2 435 666
1989	2 349 312	202 622	2 551 934	37 520	76 852	2 512 602
1990	2 137 996	202 741	2 340 737	39 104	113 513	2 266 328
1991[p]	2 146 207	189 595	2 335 802	36 278	114 869	2 257 211

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[p] Preliminary.
[a] Beginning in 1988, Exports and Imports are based on the new Harmonized System and may not be in complete accord with previous method of reporting. Imports and Exports include H.S. classes 2522.10 and 2522.30.
[1] Producers' shipments and quantities used by producers. [2] Production, plus imports, less exports.

TABLE 3. CANADIAN LIME INDUSTRY, 1991

Company	Plant Location	Calcining Capacity	Market	Type of Quicklime and Other Products
		(000 t/y)		
NEW BRUNSWICK				
Havelock Lime, a division of Dickenson Mines Limited	Havelock	175	Merchant	High calcium[1]
QUEBEC				
Graybec Inc., Domlin Division	St. Adolphe de Dudswell	300	Merchant	High calcium[1]
Graybec Inc., Jolichaux Division	Joliette	282	Merchant	High calcium[1]
Dolo-Mine Inc.	St-Bruno de Guigues	40	Merchant	High calcium and dolomitic[1]
ONTARIO				
The Algoma Steel Corporation, Limited	Sault Ste. Marie	200	Captive	High calcium and dolomitic
BeachviLime Limited	Ingersoll	922	Mechant/Captive	High calcium[1]
Dymond Clay Products Limited	Haileybury	40	Merchant	High calcium
General Chemical Canada Ltd.	Amherstburg	292	Captive	High calcium
Guelph DoLime Limited	Guelph	122	Merchant	Dolomitic[1]
Reiss Lime Company of Canada, Limited	Spragge	200	Merchant	High calcium
Steetley Quarry Products Inc.	Dundas	345	Merchant	Dolomitic
Stelco Steel	Ingersoll	215	Merchant/Captive	High calcium
Timminco Limited	Haley	53	Captive	Dolomitic
MANITOBA				
The British Columbia Sugar Refining Company, Limited	Fort Garry	16	Captive	High calcium
Continental Lime Ltd.	Faulkner	117	Merchant	High calcium
ALBERTA				
The British Columbia Sugar Refining Company, Limited	Taber	66	Captive	High calcium
Continental Lime Ltd.	Exshaw	130	Merchant	High calcium[1]
Summit Lime Works Limited	Hazell	50	Merchant	High calcium and dolomitic[1]
BRITISH COLUMBIA				
Continental Lime Ltd.	Pavilion Lake	235	Merchant	High calcium
Texada Lime (BP Resources Canada Limited, Mining Division)	Fort Langley	135	Merchant	High calcium[1]

Source: Mineral Policy Sector, Energy, Mines and Resources Canada.
[1] Production of hydrated lime.

TABLE 4. CANADA, CONSUMPTION[1] OF DOMESTIC LIME, QUICK AND HYDRATED, 1989 AND 1990

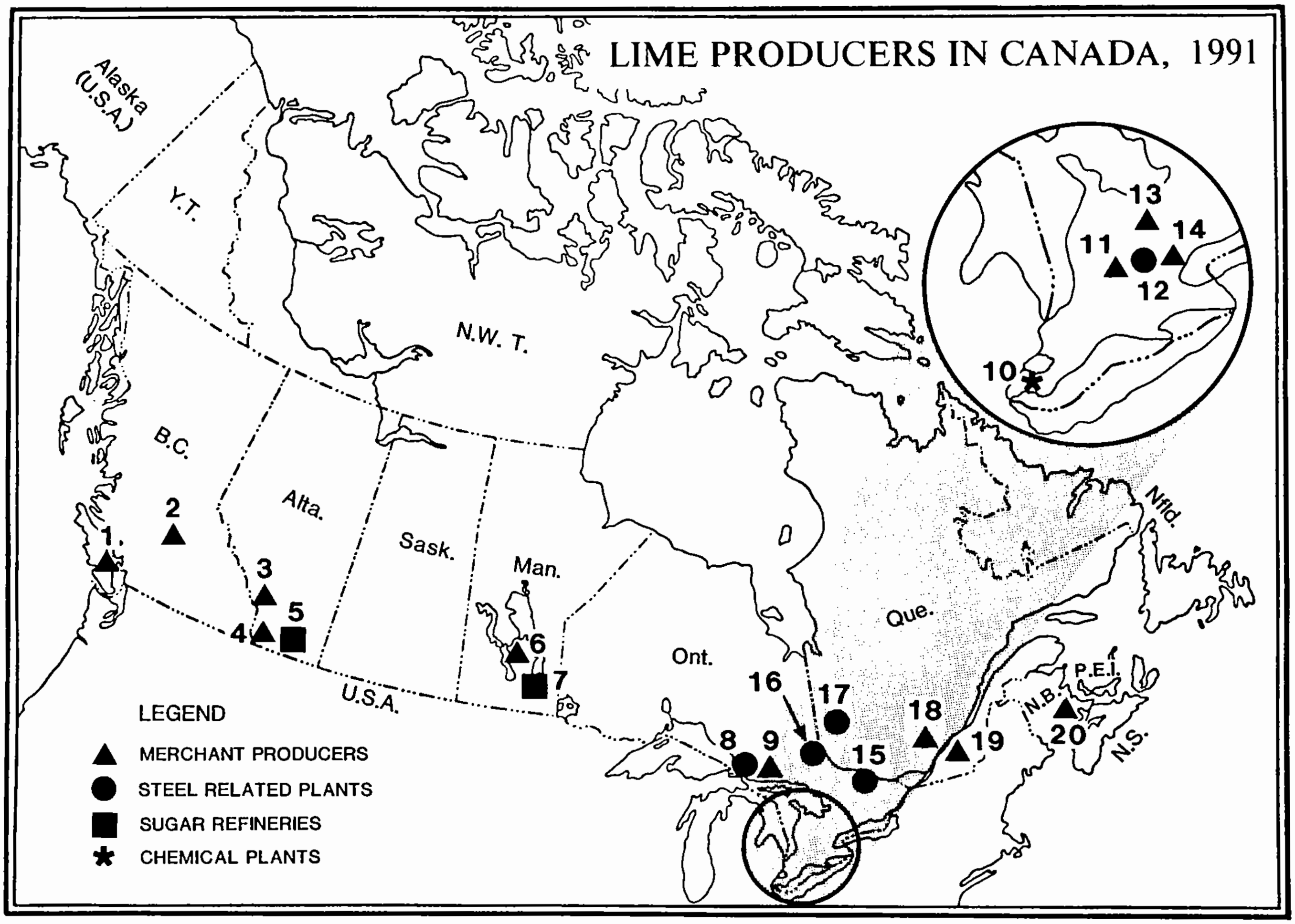
End Uses	1989	1990
	(tonnes)	
Chemical and metallurgical		
Steelmaking	514 794	438 000
Water and sewage treatment	353 922	412 710
Water purification	72 495	42 329
Gas scrubbing	6 544	13 922
Metal concentration	47 698	59 248
Pulp and paper mills	224 831	234 917
Chemicals	126 541	119 587
Other industrial uses	78 296	88 531
Construction		
Road and soil stabilization	9 384	14 329
Mason and finishing lime	14 630	7 095
Other	1 876	21 230
Agriculture	5 048	10 519
Total	1 456 059	1 462 417

Sources: Energy, Mines and Resources Canada; producing companies' surveys 1989-90.
[1] Excluding captive use.

TABLE 5. WORLD PRODUCTION OF QUICKLIME AND HYDRATED LIME INCLUDING DEAD-BURNED DOLOMITE SOLD AND USED, 1986-91

	1986	1987	1988	1989	1990	1991[e]
			(000 tonnes)			
U.S.S.R.	30 115	30 115	30 110	30 020	27 996	27 950
China	8 980	10 975	12 970	15 960	16 964	16 800
United States	13 150	14 290	15 490	15 580	15 832	15 250
Japan[1]	6 715	6 740	7 725	7 890	8 528	8 600
Germany	10 020	9 485	10 680	10 745	10 197	10 150
Brazil	4 905	5 300	5 495	5 495	5 697	5 600
Poland	4 150	4 260	4 100	4 100	4 400	4 250
Mexico	5 540	6 250	6 000	5 995	5 996	5 900
Romania	3 720	3 630	3 535	3 265	3 202	3 200
Czechoslovakia	3 330	3 235	3 300	3 200	3 348	3 350
France	2 900	2 990	3 090	3 080	2 994	3 000
United Kingdom	2 495	2 810	2 810	2 810	2 604	2 550
Yugoslavia	2 635	2 495	1 990	1 995	1 996	2 000
Italy	3 600	3 890	3 900	3 900	3 846	3 850
Canada	2 240	2 330	2 520	2 550	2 341	2 350
Belgium	1 785	1 760	1 890	1 905	1 796	1 800
South Africa	1 940	1 580	1 915	1 940	1 831	1 800
Other countries	14 675	14 395	15 195	14 980	22 455	22 250
Total	122 895	126 530	132 705	135 310	142 023	140 650

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Bureau of Mines, Mineral Commodity Summaries, 1992 (data for West and East Germany are combined).
[e] Estimated.
[1] Quicklime only.



1. Texada Lime (BP Resources Canada Mining Division), Fort Langley
2. Continental Lime Ltd., Pavilion Lake
3. Continental Lime Ltd., Exshaw
4. Summit Lime Works Limited, Hazell
5. The British Columbia Sugar Refining Company Limited, Taber
6. Continental Lime Ltd., Faulkner
7. The British Columbia Sugar Refining Company, Limited, Fort Garry
8. The Algoma Steel Corporation, Limited, Sault Ste. Marie
9. Reiss Lime Company of Canada, Limited, Spragge
10. General Chemical Canada Ltd., Amherstburg
11. Guelph DoLime Limited, Guelph
12. Stelco Steel, Ingersoll
13. Steetley Quarry Products Inc., Dundas
14. BeachviLime Limited, Ingersoll
15. Timminco Limited, Haley
16. Dolo-Mine Inc., St-Bruno-de-Guigues
17. Dymond Clay Products Limited, Haileybury
18. Graybec Inc., Domlin Division, Joliette
19. Graybec Inc., Joliette Division, Saint-Adolphe-de-Dudswell
20. Havelock Lime, a division of Dickenson Mines Limited, Havelock

Magnesium

Gilles Couturier

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4404

In 1991, world shipments of magnesium are estimated to have dropped to 243 500 tonnes (t), a 3.4% decrease from the 1990 total. In response to weak markets, producers reduced output by 2.3% to 254 800 t, but this was not sufficient to prevent a buildup in stocks. By December 1991, magnesium stocks had increased to 55 100 t, their highest level since 1983 and an increase of nearly 11 300 t over the previous year.

CANADIAN DEVELOPMENTS

Canada's total refinery magnesium production increased to 35 200 t in 1991, an increase of about 35% from 1990, mainly because of Norsk Hydro Canada Inc.'s Bécancour plant reaching approximately 80% of its production capacity. Canadian magnesium consumption in 1990 declined by nearly 300 t to 15 100 t.

On September 5, 1991, the Magnesium Corporation of America (Magcorp) filed an anti-dumping and countervailing petition requesting the imposition of anti-dumping and countervailing duties on the imports of pure and alloy magnesium from Canada and Norway. Subsequently, the countervailing petition against Norway was dismissed by the International Trade Council on grounds of insufficient information of alleged subsidies.

On December 2, 1991, the U.S. Department of Commerce issued its preliminary subsidy determination in the countervailing case. The Department fixed the rate for Norsk Hydro in its preliminary determination at 32.9% on an ad valorem basis. The high rate is attributed to those programs determined to provide benefits, specifically the electricity contracts between Norsk Hydro and Hydro-Québec (24.8% ad valorem), as well as assistance provided by the province of Quebec under its Société de développement industriel (SDI) program (6.3% ad valorem). Other programs were also identified as "countervailable," for example, the exemption of payments of water bills 1.46% ad valorem for Norsk Hydro, the Canada-Quebec Subsidiary Agreement on Industrial Development (0.1%), and the government funding for the Institute of Magnesium Technology (IMT) 0.2% ad valorem for Norsk Hydro. Timminco, the only other Canadian producer, received a 0.4% de minimus preliminary rate, which means it will not be subject to duties.

On February 12, 1992, the United States issued its anti-dumping preliminary determination which placed a 32.7% dumping margin against Norsk Hydro Canada Inc. The dumping margin for Timminco was zero. At the request of the petitioner, the Department of Commerce decided to extend the date of the final countervailing duty determination from February 12 to the date of the final determination of the anti-dumping duty, which is expected before April 27, 1992.

The Canadian government has been challenging MagCorp's standing to file for this action to the General Agreement on Tariffs and Trade (GATT), since the company accounts for only slightly more than 20% of U.S. production. This matter is currently being addressed by a panel established under the dispute settlement provision of the GATT Subsidies Code. If the final settlement of this trade action is not satisfactory to Canada, it could eventually be brought before the binational tribunal established under the Canada-U.S. Free Trade Agreement.

The Norsk Hydro magnesium plant in Bécancour, Quebec, which started production in December 1989, produced at close to 80% of its capacity of 45 000 t/y. However, shortly before the announcement by the U.S. Department of Commerce, Norsk Hydro had indicated that it would cut its production by 50% and lay off 136 of its 481-member workforce.

The Bécancour plant receives its raw magnesite material supply from China. At the current magnesium production rate of 20 000 t/y, magnesite consumption at Bécancour is estimated to be 80 000 t/y. The process technology used at the Bécancour plant involves leaching the magnesite with hydrochloric acid to produce a brine of magnesium chloride ($MgCl_2$), and then reducing the $MgCl_2$ granules in electrolytic cells to produce metallic magnesium.

Norsk Hydro commissioned a $7 million refining facility in Bécancour to convert magnesium scrap into high-purity alloys. The facility will have the capacity to process internally generated scrap and customer die-cast scrap.

Norsk Hydro bought a 20% share in Meridian Technologies Inc. for $5 million. Meridian Technologies is the owner of Magnesium Products Industries of Strathroy, Ontario, and is a major die caster of magnesium. Earlier in 1991, Norsk Hydro had announced the signing of a joint venture with Meridian Technologies to study the feasibility of producing magnesium wheels.

Norsk Hydro Canada Inc. and Norsk Hydro AS indicated that, as of December 31, 1991, they will no longer be a member of the International Magnesium Association.

The Magnesium Company of Canada (MAGCAN) continued to develop its 12 500-t/y plant at Aldersyde, Alberta, during the first five months of 1991. However, Alberta Natural Gas, which owned a 54% interest in the project, announced that, as of May, it would no longer fund the ongoing operation and development of the project. According to the company, the main reasons to drop the project were the low magnesium price, the high value of the Canadian dollar, high interest rates, lower-than-anticipated production, and higher-than-estimated operating costs. Some 150 people were laid off. Start-up problems resulted in significant cost overruns for plant construction, originally estimated at $105 million. The participants' investments in the plant totalled approximately $200 million.

The Alberta government had provided a 75% loan guarantee on the MAGCAN project up to a maximum of $103 million for the first phase of the project. Two additional phases of 25 000 t/y were previously anticipated at an additional cost of $270 million. Following the announcement by Alberta Natural Gas, the Alberta government hired consultants to examine the feasibility of the project. Some companies have apparently expressed an interest in buying the plant. However, various issues, including who owns the technology, will have to be examined further before a final decision is reached.

Timminco Metals, a division of Timminco Limited, produces high-purity metal (up to 99.98% pure) for specialized market applications at its 6000-t/y magnesium plant in Haley Station, Ontario. In June 1991, Timminco laid off, for an indefinite period, 100 workers at its magnesium plant due to decreased demand. Production capacity was temporarily reduced to 4000 t/y.

Magnesium produced by Timminco is used as an alloying agent with aluminum and calcium, as Grignard reagents for the pharmaceutical industry, and in electronic products. Timminco also produces metallic calcium and strontium.

Timminco uses the Pidgeon magnesium process which involves calcined dolomite being reduced by ferrosilicon in a vacuum retort. The dolomite is mined at the plant site and ferrosilicon feed is now bought on the open market after the closure of the company's Beauharnois, Quebec, ferrosilicon plant.

The Magnola joint venture of Noranda Minerals Inc. and LavalinTech Inc. finalized its technical feasibility study concluding that the production of magnesium metal from asbestos tailings is economically feasible. However, the takeover of LavalinTech by Benvest Capital Inc. has created uncertainty about the future of the joint venture. The new owners have decided to write down their $3 million investment in the Magnola joint venture and to change their core activity from research and development to investment banking. Noranda has indicated that it will continue to seek partners for the $600 million plant which would produce about 50 000 t/y of magnesium.

The Institute of Magnesium Technology Inc. (IMT) was established in 1990 to promote the development of a downstream magnesium industry in Canada, and to contribute to a greater use of the metal generally. The IMT is expected to become an international centre of excellence for magnesium technology where magnesium alloys and processing technologies will be developed.

Currently, more than 80% of the IMT's research projects are from companies outside Canada. The Institute's membership has grown to about 29 members (12 from Japan), including producers, converters and end users. The Institute was set up to accommodate about 15 researchers and 5 support staff.

Researchers at the Canada Centre for Mineral and Energy Technology (CANMET) completed their second year of a four-year research program on magnesium and corrosion. However, the joint program between CANMET and the International Magnesium Association (IMA) ceased as of December 31, 1991. The IMA indicated that, under current circumstances, it could no longer support on a 50:50 basis the US$760 000 research program.

WORLD DEVELOPMENTS

The United States, which is the world's largest magnesium producer, has three primary magnesium plants. The Dow Chemical Company, the largest U.S. producer, operates a 95 000-t/y electrolytic magnesium plant in Freeport, Texas. Despite weak magnesium markets, Freeport produced at full capacity throughout 1991. The magnesium chloride feedstock for the plant is derived from a seawater/dolomite process. The company has recently completed the construction of a new 25 million kg/y vertical direct-chill caster.

Magnesium

As a result of a modernization program undertaken in the 1970s and productivity improvements in the 1980s, Dow's plant is generally regarded as a very low-cost producer of magnesium.

In 1991, Dow announced the formation of new magnesium alloy development groups in Europe. In anticipation of a greater use of magnesium in automobile parts, the new centres will supplement the existing Detroit Dow Automotive Centre. Dow also announced that they have entered into an agreement with Garfield Alloys Inc. concerning the manufacturing and sale of magnesium secondary products. Increased consumption of magnesium in structural applications will increase the potential for magnesium recycling. Finally, Dow announced the commercialization of a new magnesium die-casting alloy AE2X1. The new alloy was developed for use in structural parts such as in automatic transmissions which require long-term stress at elevated temperatures. The new alloy will have an important content of rare earths and aluminum.

The Magnesium Corporation of America (Magcorp) operates a 33 000-t/y electrolytic plant in Rowley, Utah. The company employs more than 500 workers.

The magnesium chloride feedstock for the Magcorp plant is normally derived from the natural brines of Great Salt Lake. However, high water levels on the lake in 1986 caused US$20 million in damage to the solar ponding system. The company has been drawing brine since the end of 1989 from a new pond system in the west desert. MagCorp estimated that the new ponds have a 10-to-15-year supply of brine.

Magcorp has announced that since its chlorine reduction burner came on stream in June 1990, the company has reduced its chlorine emissions by 50%, while total emissions have decreased by 40%. In addition, Magcorp is planning a further 40% reduction in chlorine emissions by 1993. These programs to reduce air pollution followed information published in 1989 by the U.S. Environmental Protection Agency (EPA) stating that Magcorp was the country's biggest air polluter.

Northwest Alloys Inc., a subsidiary of the Aluminum Company of America (Alcoa), operates a 33 000-t/y magnesium plant in Addy, Washington, which uses the Magnetherm process whereby magnesium is produced by reducing dolomite with ferrosilicon. In December 1991, Alcoa announced its intention to cut production and staff by 50% by the end of March 1992 because of depressed domestic and foreign market conditions.

Brazil's Companhia Brasileira de Magnesio (Brasmag) operates a 12 000-t/y magnesium metal plant. Production was temporarily reduced to 8000 t/y because of difficult market conditions. Future expansion plans at the Bocaiuva plant have been put on hold due to weak markets and the financial situation of Brasmag, which filed for bankruptcy protection in 1990. Under Brazilian law, the company has two years to repay its debts or be declared bankrupt. In October 1991, Brasmag filed a petition alleging dumping by Norway, Canada and the United States.

Norsk Hydro AS operates a 55 000-t/y primary magnesium plant at Porsgrunn, Norway. The plant produces magnesium by the electrolysis of magnesium chloride derived from a seawater/dolomite process and from magnesium chloride brine imported from Germany.

Norsk Hydro AS was also challenged by U.S. trade actions on countervailing and anti-dumping. Although the U.S. Department of Commerce dropped the countervailing charges against magnesium from Norway, the dumping charges were maintained. On February 12, the Department issued its anti-dumping preliminary determination which placed an 8.3% dumping margin against Norway.

In August 1991, Norsk Hydro announced that one of the two production lines at its Porsgrunn plant will be temporarily closed until at least 1994. Production will be reduced to 35 000 t/y. The company will consider the possibility of building a raw materials plant to feed the production that was closed. The closure will affect approximately 275 jobs. Production cutbacks were the result of an increase in raw material costs together with weak magnesium market conditions. With production cutbacks in Bécancour and Porsgrunn, total production at Norsk Hydro's Norwegian and Canadian plants will be reduced temporarily from 100 000 t/y to around 55 000 t/y.

Norsk Hydro has also announced that it will take a special charge of $278 million to cover costs related to restructuring measures and write-downs in the company's magnesium division.

Pechiney Électrométallurgie operates a 17 000-t/y smelter in Marignac, France. During 1990, the company continued the rationalization of its magnesium division. Pechiney anticipated reducing its production costs by 15% and increasing capacity by 2000 t/y through a reduction in the workforce, diminishing overhead costs, technological improvements, energy savings, etc. Pechiney also developed a new dolomite quarry at Bois des Teuses, 25 km from the Marignac plant, at a cost of 31 million francs. Pechiney uses its proprietary Magnetherm process. Given the current market conditions, the company intends to implement further plant restructuring during 1992 and 1993 to reduce costs.

The Societa Italmagnesio, which had completed a plant restructuring in 1989 by reducing production from 10 000 t/y to 8000 t/y, has announced that it temporarily stopped production at its Bolzano plant in northern Italy. According to company officials, the main justification for the plant shut-down was an increase in magnesium metal from the Commonwealth of Independant States (C.I.S.) and the generally weak market conditions. Approximately 10% of the 250-member workforce will be maintained since the magnesium alloy and anode production will continue based on stockpiled material.

Magnohrom operates a 9000-t/y magnesium smelter in Bela Stena, Serbia. In response to prevailing market conditions, Magnohrom announced its intention to cut production by 20% for a period of two years.

In Australia, Queensland Metal Corp., MIM Holdings Ltd., UBE Industries Ltd., and the Commonwealth Scientific Industrial and Research Organization (CSIRO) created a joint venture to invest A$50 million to develop a process to produce magnesium. The three private companies will fund half the cost of the Magmetal project while the Australian government will provide $20 million and the Queensland government will provide $5 million. The partners are planning to build a 60 000-t/y magnesium metal plant adjacent to Queensland Metal Corp.'s magnesite deposit in Kunwarara. Initially, the company is expecting to commission a 1000-t/y pilot plant in 1992.

The five-year program comprises up to 18 months of laboratory work followed by testing at a plant to be built at Gladstone, 150 km south of Kunwarara. The target of the joint-venture partners is to start production in 1997 when the market in Japan is expected to be booming. Initially, the promoters of the Magmetal project are planning to build a 10 000-20 000-t/y smelter and increase capacity as the market warrants.

In India, Tamil Nadu Industrial Development Corporation commissioned a 600-t/y magnesium electrolytic plant in 1990.

PRICES

In December 1991, magnesium stocks had increased by 11 300 t over the December 1990 level of 43 800 t. The December inventory figure of 55 100 t represents the highest level recorded since a quarterly statistical program was introduced in 1983.

The published price for primary ingots remained at US$1.43/lb, a 20¢ decrease from the quoted price in 1990. The official price for die-casting alloy AZ91D was reduced by 9¢ to US$1.34/lb.

Due to large inventories and increased sales by the C.I.S., heavy discounts and premiums were reported to have taken place. In Europe, magnesium traded at prices reported to be as low as 90¢/lb.

Starting in 1992, Norsk Hydro AS will publish a quarterly European magnesium price. This decision is partly in response to increased sales of lower grade magnesium by C.I.S. countries. The quoted price for 99.8% magnesium to be purchased from January 1, 1992, was established at DM3.85/kg (approximately US$1.10/kg).

USES AND MARKETS

The main application of magnesium is as an alloying agent for aluminum, accounting for close to 57% of non-socialist consumption in 1991. Despite an overall decrease of 3.4% in magnesium use, consumption for this application increased by 5.6% to 137 900 t/y in 1991. It is predicted that magnesium consumption for this application should enjoy a 3% growth despite increased recycling of cans and a reduction in their thickness.

The second largest use of magnesium is in structural applications, of which pressure die-cast products constitute the most important use. Consumption increased from 21 000 t in 1982 to 30 700 t in 1991, and should exceed 70 000 t/y within five years. During the next decade, this sector should show more growth than any other magnesium application. Rapid growth in the die-casting sector is expected to be particularly important in the United States and Japan.

The increased interest in magnesium metal by the automotive market is largely due to weight savings of around 33% compared to aluminum, and also because of magnesium's good vibration-dampening characteristics. Magnesium die casting has a number of other advantages over aluminum, such as its lower heat of solidification, which increases die-casting production capacity by approximately 25% and results in major process energy savings. In addition, magnesium dies are reported to last as much as two times longer than aluminum dies. Some aluminum parts which require several castings can be produced in magnesium with a single casting. Furthermore, some die casters note that even at a magnesium-aluminum price ratio of 2:1, some magnesium metal parts can be fabricated at the same cost as those made of aluminum.

A greater awareness of energy conservation and air pollution, partially due to recent studies on the greenhouse effect, has led the U.S., European and Japanese governments to take steps to reduce carbon dioxide emissions. In 1990, stricter Corporate Average Fuel Economy (CAFE) requirements by the U.S. government came into effect. The average consumption of new vehicles produced in the United States increased from 26.0 miles per gallon in 1989 to 27.5 miles per gallon in 1990.

In addition, the Japanese government has introduced the NOx Regulations which require the average weight of automobiles to decrease by 35% over the next ten years. The principal aim of the Japanese legislation, as with the U.S.'s CAFE requirement, is to reduce both fuel consumption and automobile emissions of CO_2, SO_2 and NO_x. According to the Japan Automobile Manufacturers Association (JAMA), magnesium use per Japanese car is expected to grow from 1 kg in 1989 to 5 kg in 1995, and to 40 kg by the year 2000. In anticipation of this market growth, Norsk Hydro has established a market development centre in Japan. Norsk Hydro and Dow are also operating such centres in the United States and Europe. These market development centres are making consultants available to automobile manufacturers to suggest appropriate uses for the metal.

Also in Japan, Kobe Steel is planning to construct a new aluminum alloy and magnesium alloy casting and forging plant. Kobe will spend about US$155 million on the new plant in anticipation of a substantial growth in demand for aluminum and magnesium castings and forgings over the next three to four years in the automotive, railway, aerospace and electronics industries. The plant is scheduled to begin partial operation in the summer of 1992 and to be in full operation by 1995.

According to some reports, the energy consumption levels for new vehicles will be reached through improved traction (50%), reduced weight (35%) and modifications related to friction and aerodynamics (15%). If the only means of reaching the new consumption levels were through reduced vehicle weight, 250 pounds would have to be eliminated to obtain one extra mile per gallon. In other words, any 10% reduction in weight translates into a 5% decrease in energy consumption.

Other automobile manufacturers recently announced plans to make greater use of magnesium, which averaged between two and three kilograms per American car in 1991.

The Dodge Viper high-performance sports car, to be introduced in 1992, incorporates about 5 kg of magnesium components in its engine and further magnesium castings in valve covers and accessory brackets. General Motors North-Star V-8 Cadillac engine, scheduled for production in 1992, also contains about 7 kg of magnesium. The main parts made of magnesium on the GM Cadillac model will be the induction system, valve covers and oil filter adapters. The 1994 edition of the Ford Aerostar front-wheel-drive minivan should contain some 7 kg of magnesium parts such as 2.5-kg seat stanchions and steering sytems.

New applications in European luxury cars should also translate into further applications for magnesium. Mercedes Benz started to use an 8.5-kg magnesium one-piece seat frame on some of its models. Audi uses a 4.2-kg magnesium component in the dashboard bulkhead on its V-8 sedan. The company anticipates using this part on other models. Volvo is currently evaluating magnesium and aluminum doors for one of its models. The use of magnesium and aluminum doors would provide a weight reduction of around 13 kg. Such an application could also be used for electric cars in which weight limitations are very important.

Aside from automotive applications, die-cast magnesium products are widely used in the manufacture of portable tools and sporting goods. The use of magnesium in electronics equipment, particularly for computer housings and components, has grown substantially, and this trend is expected to continue. Magnesium is preferred for these applications not only because of its good strength-to-weight ratio, but also because it dissipates heat well, confines electromagnetic fields, and dissipates radio frequency interference. Chicago White Metal Casting Inc. specializes in this type of casting and recently acquired equipment with a higher capacity and greater precision.

The third largest use of magnesium is as a deoxidizing and desulphurizing agent in the ferrous industry. Magnesium used for that application in 1991 was 28 100 t, equivalent to the 1990 total. This sector, which has grown an average of 15%/y in the late 1980s, should enjoy a moderate growth because of a major rationalization taking place in the steel industry. However, the increase in steel scrap recovery should create more markets for magnesium in that application.

Magnesium is used to produce nodular iron (13 700 t, or 5.6% of total Western World consumption), primarily ductile iron pipes and die-cast parts for use in automobiles and farm equipment. This application is expected to remain stable as the water pipe market is expected to be captured by plastics. Magnesium is also used as a reducing agent (5600 t, or 2.3%) in the production of titanium, beryllium, zirconium, hafnium and uranium. Electrochemical applications account for 3.8% of magnesium consumption for use in the manufacture of batteries and anodes for cathodic protection of gas pipelines and water heaters. As in the case of nodular iron, potential increases will be offset by substitution with plastics in the gas pipeline market. Chemical applications (7100 t, or 2.9%) include the manufacture of pharmaceutical products, perfumes and pyrotechnics. Wrought products (2.3%) mainly include extruded products except anodes, sheets and plates; gravity casting (0.9%) includes the production of complex or large parts by sand casting or with other materials. Other applications together account for 1.4% of magnesium consumption.

RECYCLING

The anticipated growth of magnesium die-cast parts in the automotive sector should provide greater opportunities for magnesium recycling. Norsk Hydro Canada Inc. and The Dow Chemical Company will both collect magnesium scrap from their clients. This trend should continue as magnesium metal further penetrates the automobile market.

Currently, the magnesium present in aluminum alloys, primarily in beverage cans, accounts for approximately 75% of the magnesium recycled throughout the world.

OUTLOOK

The economic recovery in the second half of 1992 is expected to have some positive impacts on magnesium consumption, particularly in the aluminum alloying and die-casting end uses. The effects of the rationalization and a decrease in exports from the former U.S.S.R. should also improve prices.

Within five years, Western World magnesium consumption should rise to more than 350 000 t/y, primarily because of the substantial increase expected in the die casting of automobile parts. Magnesium die-casting consumption should well exceed 70 000 t/y by 1997.

Increased production capacity and the slow economic recovery is expected to keep magnesium prices low. In light of a more competitive environment where magnesium must compete with other structural metals such as aluminum to enjoy growth, further rationalizations could take place and force high-cost producers to cut their production or abandon the market.

If growth in consumption is to be sustained, magnesium will have to perform well, especially against aluminum in the automobile parts sector. A long-term magnesium-aluminum price ratio of 1.7:1.0 could lead to important breakthroughs for new applications. In order to remain competitive with aluminum in structural applications, magnesium prices will have to remain close to US$1.25/lb.

Canada's comparative advantages, such as low-cost energy and raw material, as well as its relative proximity to major world markets, should make it an important player in this promising market.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
81.04	Magnesium and articles thereof, including waste and scrap						
	Unwrought magnesium:						
8104.11	Containing at least 99.8% by weight of magnesium	4%	2.5%	2.4%	5.6%	5.3%	6.5%
8104.19	Other	4%	Free	2.4%	4.5%	5.3%	6.5%
8104.20	Waste and scrap	Free	Free	Free	Free	Free	3.2%
8104.30	Raspings, turnings and granules, graded according to size; powders						
8104.30.10.00	Raspings, turnings and granules; powders, alloyed	10.2%	6.5%	6.1%	4.5%	5.3%	7.2%
8104.30.20.00	Powders, not alloyed	4%	2.5%	2.4%	4.5%	5.3%	7.2%
8104.90	Other						
8104.90.10	Bars, rods, plates, sheets, strip, foil, tubes and pipes, alloyed	4%	Free	2.4%	a	5.3%	7.2%
8104.90.90	Other	10.2%	6.5%	6.1%	a	5.3%	7.2%
8104.90.90.10	Structural shapes	10.2%	6.5%	6.1%	a	5.3%	7.2%
8104.90.90.90	Other	10.2%	6.5%	6.1%	a	5.3%	7.2%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Customs Tariff Schedules of Japan, 1991.

[a] 10.3¢/kg on Mg content plus 2.4%.

[1] GATT rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITIES AND COUNTRIES, 1990 AND 1991

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS					
8104.11	Magnesium unwrought containing by weight at least 99.8% of magnesium				
	United States	14 562	49 878	10 719	31 309
	Japan	377	1 464	262	855
	Venezuela	24	78	256	834
	Netherlands	676	2 942	171	682
	Switzerland	333	1 604	110	363
	United Kingdom	356	2 424	105	530
	Australia	285	1 703	81	382
	Other countries	312	1 339	129	470
	Total	16 927	61 432	11 834	35 425
8104.19	Magnesium unwrought, n.e.s.				
	United States	2 361	8 209	2 171	7 369
	Netherlands	31	191	115	575
	Australia	68	341	73	488
	Italy	18	105	74	377
	Other countries	12	337	36	128
	Total	2 490	9 183	2 469	8 937
8104.20	Magnesium waste and scrap				
	United States	3 346	8 544	2 093	2 669
	United Kingdom	12	25	–	–
	Total	3 358	8 569	2 093	2 669
8104.30	Magnesium raspings, turnings or granules graded according to size and powders				
	United States	505	3 161	453	2 495
	Ireland	207	1 502	120	784
	South Korea	70	361	30	147
	Netherlands	...	1	5	20
	Total	782	5 027	608	3 448
8104.90	Magnesium and articles thereof, n.e.s.				
	Australia	–	–	48	279
	United States	59	260	5	87
	Other countries	4	24	4	31
	Total	62	284	57	397
	Total exports	23 619	84 495	17 061	50 876
IMPORTS					
8104.11	Magnesium unwrought containing by weight at least 99.8% of magnesium				
	United States	5 218	17 550	4 221	13 110
	Norway	388	1 347	495	1 512
	France	408	1 595	36	137
	United Kingdom	1	4	1	5
	Germany[1]	2	8	1	3
	Total	6 018	20 507	4 754	14 769
8104.19	Magnesium unwrought n.e.s.				
	United States	3 361	10 502	1 683	4 951
	United Kingdom	42	353	43	619
	Norway	2 299	7 159	37	112
	Other countries	37	131	–	–
	Total	5 738	18 145	1 762	5 682
8104.20	Magnesium waste and scrap				
	United States	41	116	88	258
	Total	41	116	88	258
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	367	1 492	41	161
	France	–	–	3	10
	Total	367	1 492	44	171
8104.90	Magnesium and articles thereof n.e.s.				
	United States	760	4 554	513	3 152
	Other countries	–	–	1	5
	Total	760	4 554	514	3 158
	Total imports	12 924	44 814	7 162	24 038

Source: Statistics Canada.
– Nil; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary.
[1] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. MAGNESIUM PRODUCERS - NEW DEVELOPMENTS

Producer	Plant Location	Production Capacity (t/y)	Remarks
CANADA			
Norsk Hydro Canada Inc.	Bécancour, Quebec	45 000	Production was temporarily reduced to around 20 000 t/y in October 1991.
Magnesium Company of Canada Ltd. (MAGCAN)	Aldersyde, Alberta	12 500	The plant was temporarily shut down in May 1991.
Timminco Limited	Haley Station, Ontario	6 500	Production capacity was temporarily reduced to 4000 t/y.
Noranda Minerals Inc. Benvest Capital Inc.[1]	East Broughton, Quebec	50 000	The Magnola project is on stand-by until an additional joint-venture partner is found.
UNITED STATES			
The Dow Chemical Company	Freeport, Texas	95 000	
Magnesium Corporation of America (Magcorp)	Rowley, Utah	36 000	Filed an anti-dumping and countervailing petition against Canada and Norway.
Northwest Alloys, Inc.	Addy, Washington	33 000	Production was reduced by 50% in December 1991.
BRAZIL			
Companhia Brasileira de Magnesio (Brasmag)	Bocaiuva	12 000	Filed a petition alleging dumping by producers from Norway, Canada and the United States. Production capacity has been temporarily reduced to 8000 t/y.
WESTERN EUROPE			
Norsk Hydro AS	Porsgrunn, Norway	55 000	Production capacity has been temporarily reduced by 20 000 t/y at least until 1994.
Societa Italmagnesio	Bolzano, Italy	8 000	Production was temporarily halted in February 1992.
Pechiney Électrométallurgie	Marignac, France	17 000	Further rationalization is expected.
Magnohrom	Bela Stena, Serbia	9 000	Has cut output by 15%-20% for a period of two years.
ASIA AND OCEANIA			
UBE Industries Ltd.	Yamaguchi, Japan	9 000	
Japan Metals & Chemicals Co. Ltd.	Takaoka, Japan	5 000	Production was temporarily halted in 1991.
Queensland Metals Corp., MIM Holdings Ltd., UBE Industries Ltd. and CSIRO[1]	Kunwarara, Australia	20 000	Presently undertaking a $50 million technical study.
Tamil Nadu Industrial Development Corporation	India	600	The plant began production in April 1990.
Southern Magnesium and Chemicals	Hyderabad, India	1 000	Started production in 1990.

[1] Proposed magnesium plants.

TABLE 3. CANADA, CONSUMPTION[1] OF MAGNESIUM, 1984-90

	1984[a]	1985[a]	1986[a]	1987	1988[a]	1989[a]	1990[p]
				(tonnes)			
Castings and wrought products[2]	2 047	1 814	2 628	3 837	5 067	5 661	5 849
Aluminum alloys	4 841	4 813	4 907	4 508	7 810	7 761[r]	7 672
Other uses[3]	1 455	1 316	1 191	1 124	1 189	1 985[r]	1 604
Total	8 343	7 943	8 726	9 469	14 066	15 407	15 125

Source: Energy, Mines and Resources Canada.
[p] Preliminary; [r] Revised.
[a] Increase in number of companies being surveyed.
[1] Available data as reported by consumers. [2] Die, permanent mould and sand castings, structural shapes, tubings, forgings, sheet and plate. [3] Cathodic protection, reducing agents, deoxidizers and other alloys.

TABLE 4. WORLD PRIMARY MAGNESIUM PRODUCTION, 1986-90

	1986	1987	1988	1989p	1990e
			(tonnes)		
Brazil	4 356	5 488	5 865	6 200	8 700
Canadae	5 100	8 800	7 600	7 200	25 300
Chinae	3 000	3 000	3 200	3 200	3 400
France	13 361	13 601	13 800	14 600r	14 000
Italy	12 417	7 626	5 436	5 469r	5 400
Japan	8 116	8 180	9 012	8 381r	12 843
Norway	56 522	56 907	50 300	49 827	48 222
U.S.S.R.e	89 000	90 000	91 000	91 000	88 000
United States	125 639	124 396	141 983	152 066	139 333
Yugoslavia	4 897	5 932	6 176	6 100r	6 000
Total	322 408r	323 930	334 372	344 043r	351 198

Source: U.S. Bureau of Mines.
e Estimated; p Preliminary; r Revised.

TABLE 5. PRIMARY MAGNESIUM PRODUCTION BY WORLD ZONE,[1] 1980-91

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 5 Asia and Oceania	Total
			(000 tonnes)		
1980	163.0	–	64.4	9.2	236.6
1981	138.4	–	64.4	5.7	208.5
1982	97.8	–	52.8	5.8	156.4
1983	109.0	–	51.0	6.0	166.0
1984	152.8	1.0	71.6	6.7	232.1
1985	142.9	2.0	80.8	8.2	233.9
1986	130.7	3.7	81.4	8.1	233.9
1987	133.2	5.2	84.0	7.9	230.3
1988	149.6	5.8	76.2	9.6	241.2
1989	159.3	6.2	76.5	11.4	253.4
1990	164.6	8.7	74.6	12.9	260.8
1991p	166.8	7.8	68.7	11.5	254.8

Source: International Magnesium Association.
– Nil.
p Preliminary.
[1] There is no production in Area 4 (Africa and the Middle East).

TABLE 6. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE, 1980-91

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 COMECON C.I.S. & PRC	Total
				(000 tonnes)			
1980	111.0	17.0	66.0	2.0	23.0	–	219.0
1981	104.0	12.0	61.0	2.0	24.0	–	203.0
1982	85.5	8.3	60.6	1.3	17.7	–	173.7
1983	98.6	9.6	60.4	2.4	33.4	–	204.4
1984	110.1	8.0	66.8	1.6	29.5	–	216.0
1985	102.4	9.4	72.2	2.4	38.4	–	224.8
1986	103.3	11.3	73.6	3.2	35.0	–	226.4
1987	113.7	8.3	66.9	5.2	28.7	13.2	236.0
1988	125.0	11.7	70.6	3.8	33.8	6.2	251.2
1989	127.9	9.4	69.5	2.6	33.7	4.1	246.2
1990	127.3	11.6	68.7	4.0	37.6	2.8	252.0
1991p	121.3	10.3	66.6	4.5	40.1	0.7	243.5

Source: International Magnesium Association.
p Preliminary.
– Nil.

TABLE 7. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE AND CATEGORY, 1991

Use	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 Other	Total
				(000 tonnes)			
Aluminum alloying	61.3	2.9	38.8	3.9	31.8	–	137.9
Die casting	15.2	5.8	8.2	–	1.5	–	30.7
Desulphurization	19.4	0.3	8.4	–	–	–	28.1
Nodular iron	5.0	0.8	4.8	0.3	2.8	–	13.7
Electrochemical applications	7.6	0.2	0.6	–	0.8	–	9.2
Chemical applications	2.2	–	3.0	–	1.9	–	7.1
Wrought products	4.8	–	0.8	–	0.1	–	5.7
Metal reduction	4.4	–	0.9	–	0.3	–	5.6
Gravity casting	0.6	–	1.4	–	0.2	–	2.2
Other	0.8	0.3	0.5	0.3	0.7	0.7	3.3
Total	121.8	10.3	66.6	4.5	40.1	0.7	243.5

Source: International Magnesium Association.
– Nil.

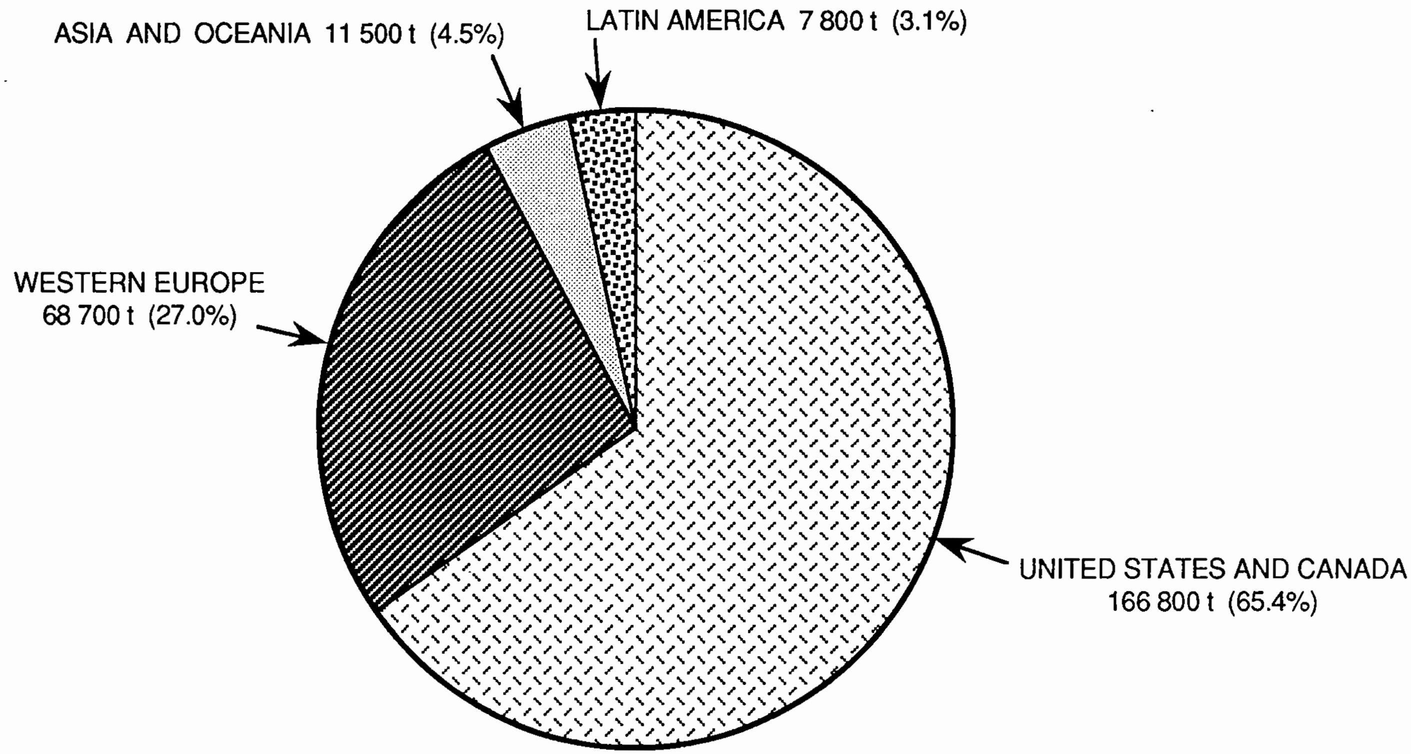
TABLE 8. PRIMARY MAGNESIUM SHIPMENTS BY CATEGORY, 1983-91

	1983	1984	1985	1986	1987	1988	1989	1990	1991
					(000 tonnes)				
Aluminum alloying	110.8	113.5	121.0	122.1	122.1	134.3	130.8	130.6	137.9
Die casting	27.9	30.4	29.7	26.8	26.6	28.5	28.6	36.3	30.7
Desulphurization	13.4	17.4	19.1	20.3	21.9	28.6	32.3	28.0	28.1
Nodular iron	8.9	9.8	11.3	12.3	14.2	15.8	16.9	14.4	13.7
Electrochemical applications	7.6	7.7	9.1	8.3	8.0	8.0	8.1	9.6	9.2
Chemical applications	8.2	7.8	8.0	8.0	7.2	8.1	5.5	7.1	7.1
Wrought products	7.1	6.6	4.8	5.4	8.4	7.4	6.2	6.7	5.7
Metal reduction	9.2	12.2	10.3	9.6	8.8	10.2	9.4	8.8	5.6
Gravity casting	2.0	1.3	1.2	1.6	1.8	2.1	2.5	3.3	2.2
Other	9.3	9.3	10.3	10.0	17.0	8.2	6.9	7.2	3.3
Total	204.4	216.0	224.8	226.4	236.0	251.2	247.2	252.0	243.5

Source: International Magnesium Association.

Figure 1

PERCENTAGE OF MAGNESIUM METAL
PRODUCTION BY WORLD ZONE, 1991

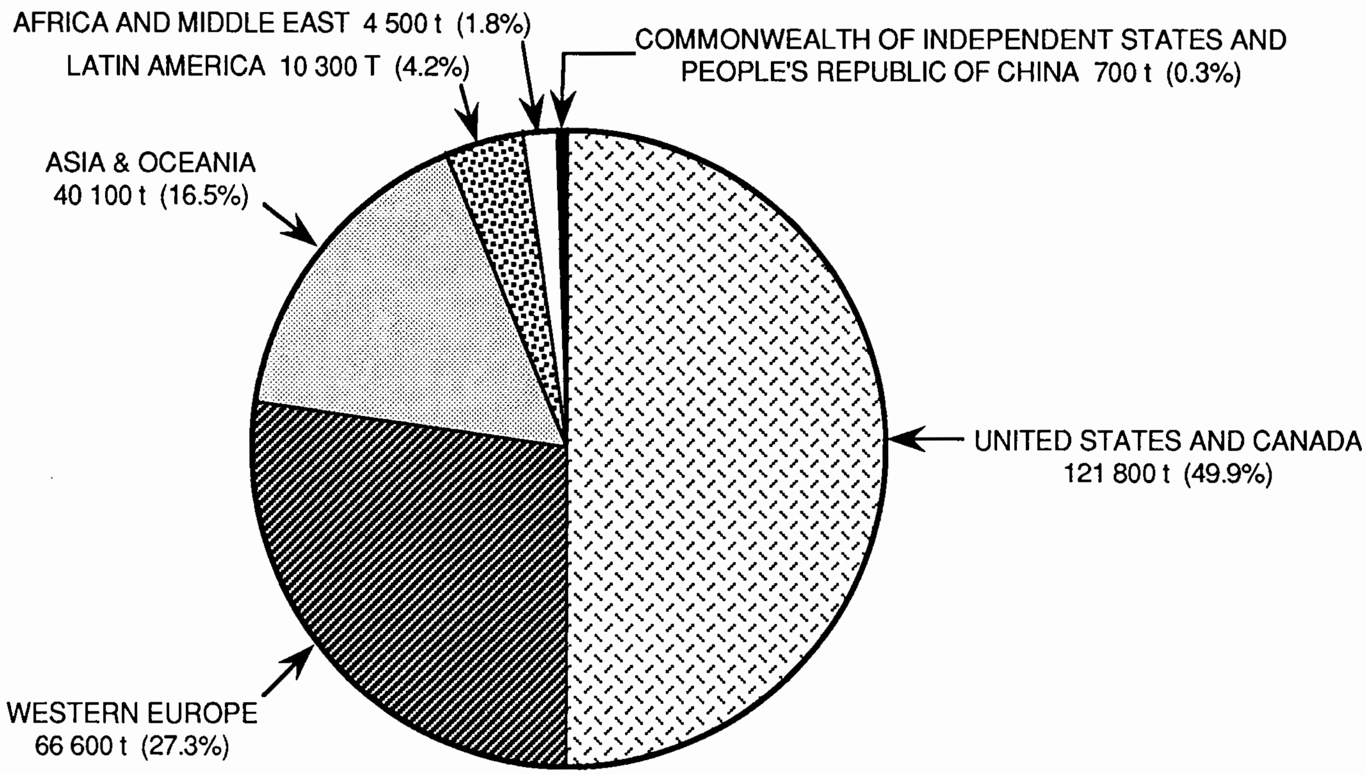


TOTAL WESTERN WORLD PRODUCTION: 254 800 t

Source: International Magnesium Association.

Figure 2

PERCENTAGE OF MAGNESIUM METAL
SHIPMENTS BY WORLD ZONE, 1991



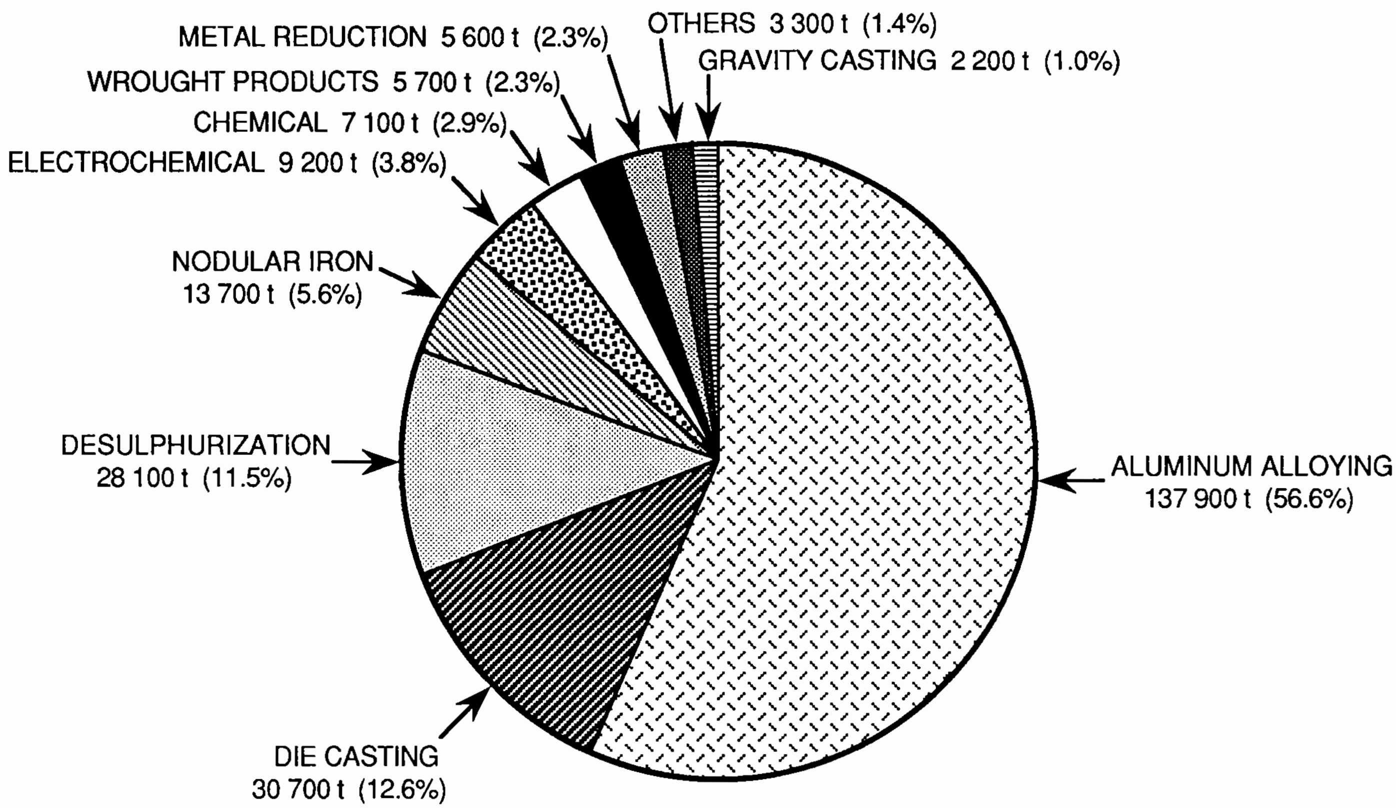
TOTAL SHIPMENTS: 243 500 t

Source: International Magnesium Association.

Figure 3

PERCENTAGE OF MAGNESIUM SHIPMENTS

BY USE IN 1991



TOTAL SHIPMENTS: 243 500 t

Source: International Magnesium Association.

Mercury

Elaine Koren

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-8200

(For additional information, telephone Bill McCutcheon at (613) 992-5480.)

Mercury (Hg), also known as "liquid silver" or *hydragyrum*, was known to ancient Chinese and Hindus and was found in Egyptian tombs of 1500 B.C. It is the only common metal liquid at ambient temperatures. Mercury occurs in its natural state in only small amounts, estimated at 50-80 parts per billion (ppb). It exists mainly in the form of various sulphides, especially the red sulphide known as cinnabar (HgS). Primary deposits of this metal commonly occur in geologic formations of limestone, calcareous shale, sandstone, chert, andesite, basalt and rhyolite. The only mercury ores other than cinnabar of commercial significance are corderoite and livingstonite. Table 2 outlines the mercury content of minerals.

Mercury deposits are generally concentrated in mercuriferous belts, which correspond to the mobile zones of dislocation of the earth, i.e., the East Pacific Rise (involving the west coast of America and the eastern part of Asia) and the Mid-Atlantic Ridge. All industrially used deposits of mercury are located within these belts. The highest contents of mercury are reported from Spain, with an average of 60 lb/tonne (t) Hg and as high as 1400 lb/t in some places. Spain and Italy produce about 50% of the world's supply of mercury. The commercial unit for handling mercury is the "flask," which weighs 76 lb (i.e., 34.47 kg).

In general, mercury also occurs in three forms in coals, namely HgS, metallic Hg, and organometallic Hg compounds. Mercury is found associated with mineral occurrences of sphalerite and epigenetic pyrite in coals. For most coals, mercury content ranges from 0.02 to 1.0 parts per million (ppm) Hg, while most Australian coals are in the range of 0.01-0.25 ppm Hg. Table 3 describes the Hg content of materials from the various sectors of the environment.

CANADIAN DEVELOPMENTS

Since the closure of Cominco Ltd.'s Pinchi Lake mine in July 1975, mercury is primarily an imported commodity in Canada. However, there is some by-product production of mercury from Cominco's lead and zinc smelter/refinery at Trail, British Columbia.

In 1990, 53 890 kg of mercury metal valued at $614 000 were imported. Estimates of imports for January through September 1991 are 8327 kg valued at $155 000.

Canadian consumption of mercury metal for electrical apparatus, industrial and control instruments, and the electrolytic preparation of chlorine and caustic soda was 33 907 kg in 1990, an increase of 6.04% from 31 914 kg in 1989.

WORLD PRODUCTION

Belgium

Vieille Montagne (VM) sold off the surplus mercury it had accumulated at its Overpelt operation and has stopped producing the metal as a by-product of zinc powder production at Overpelt. While uncertain of precise stock levels, the company was willing to accept much lower prices (i.e., \$80-\$100/flask), which conflicted with values that trade and producer sources were indicating (i.e., \$115-\$135/flask). VM reduced its mercury production from 60 t/y to 15-20 t/y for 1992 since the bulk of the company's output was based at Overpelt, which is being closed in January 1992. The remainder is produced in Calais.

China

China, which is known to have mercury reserves in the provinces of Kweichow, Huna, Kwangsi, Liaoning and Shanxi, was an active buyer in the fourth quarter. Normally a self-sufficient producer of the metal, China discontinued its production at the beginning of 1991 because it found it cheaper to buy the metal in the free market as its average production cost is estimated at \$135/flask. This contributed in part to a tightness for prime virgin mercury supplies at year-end, given that China previously supplied the market with 35 000-40 000 flasks of mercury annually. There were rumours that the price of mercury would have to go as high as \$300/flask for China to resume production.

India

In February, Minerals & Metals Trading Corp. of India (MMTC) tendered 1000 flasks, attracting a lowest offer of \$139.80/flask c.i.f. from the Algerians. This offer was subsequently cancelled. The tender was re-issued during March when another low offer of \$128.00/flask was received on behalf of Placer Amex, which was also cancelled. Finally, in October, MMTC offered 1800 flasks for tender for October/November delivery. This attracted five offers ranging from \$87-\$111/flask. At year-end, this too appeared to be a non-starter.

In October, Hindustan Zinc's new lead and zinc smelting complex at Chanderiya in Rajasthan started up. One of its main by-products will be 350 t/y of cadmium, which would increase India's cadmium output from around 250 t/y to 600 t/y. The new smelter is also expected to produce some 74 t/y of silver, 10 t/y of bismuth and 30 t/y of mercury, as well as an unspecified amount of cobalt.

In November, Hindustan Paper Corp. offered for tender 15 t of mercury, which attracted nine bids ranging from \$91 to \$125/flask. The low bid of \$91, which included commission, was received from Lambert Metals, while the high of \$125 came from the Spanish producer Almaden. The material was to be shipped in two lots of 7.5 t in December and January.

Japan

Japanese mercury consumption declined by 15.9% from 166.2 t in 1989 to 139.7 t in 1990, according to the Japanese Ministry of Industry and International Trade (MITI). As well, Japanese domestic mercury demand in the battery sector declined sharply in 1990 by 36.3% to 91.6 t from the 1988 total of 143.9 t.

Russia

The emergence of substantial Russian mercury shipments in the second half of 1990 was one of the key factors depressing mercury prices. In the first quarter of 1991, it was believed that as much as 58 000-68 000 flasks were available from Moscow, with about 1000 flasks being rejected by a consumer in Rotterdam.

As a result of discontinued mercury production in Western countries, the badly needed mercury finished product, mercury oxide powder, which is usually produced abroad, was being manufactured at the Khaydarken mercury combine in Russia. The technology used to produce mercury oxide powders, which is commonly used to produce mercury oxide batteries, was developed in conjunction with Novosibirsk University. A joint venture was established for the commercial production of the mercury oxide powder.

At year-end, the persistent oversupply of Russian metal continued to depress prices. Relative tightness was seen in spot market trading as a result of delays in deliveries from Russian suppliers. Russian mercury was available for as low as $40/flask.

Spain

Due to poor market conditions, Minas de Almaden y Arrayanes (Almaden) stopped production in 1991 and was selling from stockpiled material. The company, which is owned by the state, had stockpiled 60 000 flasks (4.56 million lb). In 1990, Almaden produced about 25 000 flasks while operating at 40% of capacity. However, in association with Empresa Nacional de Gestion Residuos Industriales (INI Group), Almaden invested 6 billion pesetas in a plant for the incineration of industrial residues, which should be in operation by the end of the first quarter in 1993. The company expected to obtain authorization from the regional authority to start a mercury-recycling plant by year-end. The plant will be able to recycle approximately 1500 t/y of mercury waste, mostly from chlorine and caustic soda operations.

In February, Almaden of Spain, the largest producer of mercury in the Western World, posted losses of 3.51 billion pesetas for 1990, which represents a 156% increase on the loss from the previous year.

In November, Almaden entered into a joint venture with a United Kingdom-based company which will hold a 40% interest in the project to build a plant to treat residues at Almadenejos, the site of its open-pit Entredicho mine. Work on the plant could begin in 1992. As a result of poor market conditions, Almaden has diversified its portfolio with the mercury business now accounting for only 13% of total sales.

United States

Although Placer Dome U.S. Inc., of San Francisco, the sole U.S. producer of mercury, halted operations at its McDermitt mine at the end of November 1990, the company reached its output goal of 12 000-14 000 flasks. The mine closing had little effect on the market due to the considerable amount of material already available.

In 1991, mercury continued to be produced as a by-product of gold and silver mining operations based in Nevada, California and Utah. Freeport McMoRan Co. was reported to have produced around 1970 flasks (33.95 t) in 1991, while Newmont Gold was producing at a rate of about 100-200 lb/week (0.45-0.90 kg/week).

Several U.S. companies involved in recycling or triple distilling are operating at a profit. Bethlehem Apparatus, one of the few triple distillers of mercury, earns about 80% of its revenues from mercury, with the remainder being derived from glass and waste products recycling. The operation has been described as a niche business which supplies approximately 500 small customers.

D.F. Goldsmith, another triple distiller, views the declining domestic market less optimistically. Shipments have fallen off by 40%-50% in the past two years due to increasing environmental regulation in the United States. Market access abroad will continue to increase in areas where environmental regulations are not as stringent.

Mercury Refining of Albany, New York, treats any kind of mercury-bearing material and claims to be the only mercury recycler in the United States treating mercury waste classified as hazardous. It also treats batteries, but claims the amount of batteries being recycled has decreased by 50% given that less are being produced. The company obtains most of its revenues from mercury recycling, which is mostly on a toll basis for customers.

Secondary mercury is recovered from waste and scrap, such as dental amalgams, batteries and electronic instruments; from chlorine and caustic soda plants; and from the U.S. Department of Energy's stocks of secondary mercury. As U.S. demand exceeds supply from internal sources, the United States is a net importer of mercury, largely from China and Spain.

PROPERTIES AND USES

Mercury is a heavy, silvery white metal. It is a rather poor conductor of heat, compared with other metals, and is a fair conductor of electricity. The most important salts are mercuric chloride ($HgCl_2$, corrosive sublimate, a violent poison), mercurous chloride (Hg_2Cl_2, calomel, occasionally used in medicine), mercury fulminate ($Hg(ONC)_2$, a detonator widely used in explosives), and mercuric sulphide (HgS, vermillion, a high-grade paint pigment). Organic mercury compounds are important. It has been found that an electrical discharge causes mercury vapour to combine with neon, argon, krypton and xenon. These products are held together by van der Waals' force.

According to the U.S. Bureau of Mines (USBM), mercury has three remaining areas of application: electrical applications (29%), the manufacture of chlorine and caustic soda (34%), and in measuring and control instruments and dental equipment (37%).

EVENTS AND TRENDS IN END USE

Brazil

In June, the Brazilian government was alerted to the need to prevent further mercury contamination in Brazil's Amazon Basin, a by-product of Brazil's gold rush. A biophysicist from the Federal University of Rio de Janerio stated that more than 1000 t of mercury were discarded into the Amazon environment and urged the government to import sealed retorts to extract gold.

As a result of current methods used for gold extraction in Brazil, there have been 84 cases of mercury poisoning diagnosed; these are the first known cases of mercury poisoning in the country. This problem is further compounded by the fact that most Amazon doctors do not know how to identify mercury poisoning and therefore confuse it with hepatitis, malaria and other common tropical diseases.

In 1990, the German government contributed $17 million to Brazil to help determine the extent of mercury poisoning and to study alternatives for decontaminating the rivers.

In May, Japan's National Research Institute for Pollution and Resources announced that it would be assisting Brazil's Mining Industry Bureau to tackle mercury pollution from gold mining in the Amazon Basin. These departments will jointly endeavour to develop low-cost, mercury-free gold-refining technology to replace the existing methods that have discharged an estimated 1200 t of mercury-contaminated water into the Basin over the past ten years.

Germany

A subsidiary of Metallgesellschaft signed an agreement with Buna Ag to clean up the site of its closed chloralkali plant. This involves the formation of a new company, Umwelt-Ingenieur GmbH, which will manage an environmental remediation centre in Schkopau. Its initial goal will involve decontaminating the mercury-laden rubble and soil at the works.

The Buna plant, in the Halle district of the former East Germany, was one of the two chloralkali producers in the area which had been using mercury in its process for about 40 years. Due to a lack of statistics, it is unclear how much mercury was consumed by the plant during that period. Furthermore, given the depressed market conditions for mercury, it is uncertain whether the secondary mercury will be available for resale or disposed of in landfill sites.

United States

In response to environmental needs and regulations, there has been a considerable decline in the consumption of mercury in the United States. The battery, paint and caustic soda/chlorine industries have been required to reduce and/or remove mercury from their products and/or processes when Maximum Achievable Control Technology (MACT) or alternatives become available.

In May, the U.S. Environmental Protection Agency (EPA) received requests for voluntary cancellation of the only two remaining pesticide registrations which permit the use of mercury in the production of exterior paint and coatings. After these cancellations take effect (60 days after appearing in the Federal Register), all registrations for use of mercury in paints will be cancelled.

Cosan Chemical Corp. and Troy Chemical Corp. both initiated the cancellations due to rising environmental costs. Troy Chemical Corp. chose not to renew its permit to handle mercurial biocide last November and stopped selling the product. Cosan Chemical Corp. stopped production early in July and was not permitted to market the additive after September 30.

Mercurial biocide was used to hamper bacterial growth in the paint can and to prevent mildew on outside paint applications. The biocide, named "phenylmercuric acetate," contains 60% metallic mercury. Paint manufacturers were allowed to add up to 32 ounces of mercurial biocide per 100 gallons of exterior paint.

SUBSTITUTES

With increasing concern being expressed worldwide over cyanide and mercury hazards, many operations are re-evaluating alternative gold recovery routes. Gold has been recovered from concentrates by amalgamation since ancient times. Today, this practice is used by artisanal miners, giving rise to serious effects on the environment. In the best-regulated plants, there is bound to be some leakage of the mercury; in less sophisticated operations, spillage is a serious hazard. This is both uneconomic and unacceptable; therefore, it is essential to provide an alternative, such as direct smelting.

If carefully controlled, the combination of gravity concentration with flotation and direct smelting can be a viable substitute for cyanidation and amalgamation. In the case of non-refractory ores, results are good with continuous control of sizing tests, assays, and testing of tailings for gold losses. If assay facilities are not available, panning tests may be substituted.

According to the USBM, present and potential mercury substitutes include lithium, zinc-air and nickel-cadmium cells in batteries; diaphragm and membrane cells in the electrolytic production of chlorine and caustic soda; composite materials for dental fillings; and organic mildewicides in latex paints.

HEALTH AND SAFETY ISSUES

An awareness of the toxicity of mercury and mercuric salts has led to more stringent occupational exposure limits and tougher environmental regulations. Mercury, a known virulent poison, is readily absorbed through the respiratory tract, the gastrointestinal tract, or through unbroken skin. It acts as a cumulative poison since only small amounts of the element can be eliminated at a time by humans. Elemental mercury and mercuric salts are easily ingested by fish and then concentrated up the food chain, ultimately impacting on humans. Occupational exposure occurs via inhalation of mercury vapour or absorption of mercury metal, which becomes concentrated in the kidneys, liver and/or brain.

The environmental awareness of mercury has been largely due to the publicity surrounding minamata disease, which was discovered in Japan in the late 1950s. Minamata disease is caused by methylmercury, an alkylmercury compound from inorganic mercury found in industrial effluent in Minamata, Japan, and more recently in the Amazon Basin of Brazil. (Minamata became synonymous with mercury poisoning after a chemical factory dumped hundreds of tons of mercury into the local bay following World War II.)

REGULATORY DEVELOPMENTS

At the beginning of January, the U.S. EPA announced that cadmium, chromium and mercury were on a list of 38 contaminants it would regulate under its final drinking water standards. According to the Agency's statement, most of the 38 contaminants are only rarely found in public drinking water supplies. Tighter regulations would better protect the public and give increased protection against cancer as well as against damage to the liver, kidney, circulatory and nervous systems.

Under the new rules, 80 000 drinking systems throughout the United States would be covered. Of these 80 000 systems, 60 000 are residential community systems with the remainder being non-residential community systems, such as those used by the mining industry and industrial plants.

In March, the Land Use Committee of the New Jersey Senate passed a bill requiring the recycling of small button-cell batteries and imposing restrictions on the use of mercury in their manufacture. This bill has provisions similar to those of battery-recycling statutes now on the books in Connecticut and Minnesota.

The bill pertains to all dry-cell batteries, and in particular to mercuric oxide button-sized batteries used in wrist watches and rechargeable batteries using nickel and cadmium. It requires these batteries to be recycled or returned to the manufacturer for proper disposal. In addition, the bill imposes a mercury reduction standard that would effectively phase out the sale of mercury-containing batteries in the state. Common alkaline and zinc-carbon batteries would not have to be recycled under the new law, but they would be subject to a mercury contamination level standard.

In April, the New York Senate and Assembly will be considering different approaches to the disposal of household batteries. The Senate agreed with proposals supported by the battery industry to reduce mercury in dry-cell batteries to 0.025%. The Assembly wanted mercury to be eliminated. (At the time of writing, this issue had not been resolved.)

At the end of January, the third Organization for Economic Co-operation and Development (OECD) report on the State of the Environment (1970-90) highlighted the risks posed by a group of metals as toxic trace air pollutants. These metals include arsenic, beryllium, cadmium, chromium, lead, mercury, nickel, thallium and vanadium. The major health hazards caused by each of these metals are outlined. The report also calls for tighter controls on heavy metals emissions.

The report stated that ". . . despite their name 'heavy' metals can remain in the atmosphere for one to ten days and be transported over distances of up to 2000 km." The report also stated that ". . . to reduce the long-range transport of heavy metals, lower and strictly enforced emission levels need to be established for particulate matter given off by coal and waste combustion facilities and metal smelting plants."

In March, the EC Council Directive on batteries and accumulators containing dangerous substances (91/157/EEC) was approved. It established objectives and principles aimed at reducing and eliminating pollution and ensuring sound management of raw material resources on the basis of the "polluter pays" principle which comes into force on January 1, 1994. It requires that member states take appropriate steps to ensure that spent batteries and accumulators are collected separately with a view to their recovery or disposal.

Batteries and accumulators covered by the directive include: those with more than 25 mg of mercury per cell, except alkaline manganese batteries, which are banned; those with more than 0.025% cadmium by weight; those with more than 0.4% lead by weight; and alkaline manganese batteries containing more than 0.025% mercury by weight placed on the market as of the date provided in Article 11.

PRICES (US$)

The price of mercury peaked in 1988 at $335.52/flask, declining to $287.72 in 1989, $249 in 1990 and $122 in 1991. The price drop is related to declining demand in response to environmental and health concerns as well as changing consumption patterns for mercury.

OUTLOOK

Mercury consumption in OECD countries will continue to decline rapidly, and it is only a matter of time before other nations take steps to eliminate or severely restrict its use. As a result, the market outlook is bleak with increasingly stringent regulations being promulgated and current users searching for unregulated substitutes. As supplies and reserves of mercury continue to remain high, prices are not expected to rise in real terms.

Note: Information in this review was current as of January 31, 1992.

AVERAGE MERCURY PRICES

	1987	1988	1989	1990	1991
			(US$ per flask, 99.99% purity)		
January	217	351	282	290	177
February	208	353	316	290	159
March	240	346	312	285	143
April	273	345	295	285	122
May	313	345	295	282	115
June	307	361	295	270	111
July	296	370	283	254	101
August	313	364	270	241	98
September	342	334	261	220	85
October	355	297	268	200	91
November	350	285	286	191	119
December	332	276	290	181	149
Average	296	336	288	249	122

Source: Metals Week.

TABLE 1. CANADA, MERCURY TRADE, 1987-91, AND CONSUMPTION, 1987-90

Item No.		1987		1988		1989		1990		Jan.-Sept. 1991p	
		(kg)	($000)	(kg)	($000)	(kg)	($000)	(kg)	($000)	(kg)	($000)
EXPORTS											
2805.40	Mercury										
	United States	..	..	28 697	302	–	–	32 624	85	50 858	174
	Other countries	..	..	20 004	7	14	2	541	12	–	–
	Total	..	..	48 701	309	14	2	33 165	97	50 858	174
IMPORTS											
2617.90.00.20	Mercury ores and concentrates										
	United States	..	..	366	2	–	–	–	–	–	–
	Total	..	..	366	2	–	–	–	–	–	–
2805.40	Mercury										
	Ireland	–	–	–	–	–	–	4 363	93	936	81
	United States	33 000	346	36 245	421	32 442	346	49 331	519	7 391	74
	Other countries	–	–	–	–	–	–	196	2	–	–
	Total	33 000	346	36 245	421	32 442	346	53 890	614	8 327	155
2825.90.10.20	Mercury oxides										
	United States	..	..	22 518	212	13 729	222	1 303	26	854	16
	Germany[1]	..	..	–	–	171	3	52	1	57	1
	Other countries	..	..	21 518	364	6 113	100	28	...	6	...
	Total	..	..	44 036	576	20 013	325	1 383	27	917	18
CONSUMPTION[2] (Metal)											
Electrical apparatus, industrial and control instruments		23 555		16 084		18 104		15 584p			
Electrolytic preparation of chlorine and caustic soda and other uses		12 159		10 955r		13 810r		18 323p			
Total		35 714		27 039r		31 914r		33 907p			

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; ... Amount too small to be expressed; p Preliminary; r Revised.
[1] Where applicable, data for East and West Germany have been combined. [2] As reported by consumers.
Note: Numbers may not add to totals due to rounding.

TABLE 3 (cont'd)

Sector	Range
	(in parts per billion, except where noted)
NATURAL WATERS	
Rainwater, snow	0.01-0.48
Normal stream, river, and lake waters	0.01-0.1
Coal mine waters (Donets Basin, Russia)	1-10
Stream and river waters near mercury deposits	0.5-100
Oceans and seas	0.005-5.0
Hot springs and certain mineral waters	0.01-2.5
Normal groundwaters	0.01-0.10
Groundwaters and mine waters near polymetallic sulphide deposits	1-1000
Oil field and other saline waters	0.1-230

Source: NRCC No. 16739.

Mineral Aggregates

Oliver Vagt

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-2667

Total shipments of mineral aggregates, including crushed stone and sand and gravel, dropped about 20% to less than 280 million tonnes (Mt) in 1991, the lowest level since 1982. During each of the past four years from 1987 to 1990, total shipments were in excess of 350 Mt/y.

Related unit values have increased in pace with average annual inflation rates, with selling prices varying considerably depending on proximity to consumers. Housing starts, a broad indicator of demand for most primary construction materials, were 215 000 in 1989, 182 000 in 1990, and then fell to 156 000 in 1991. Total construction expenditures in 1991 were an estimated 20% lower than the $104 billion forecasted.

Recent federal/provincial government programs to assess aggregate resources and future market needs were concluded. In some cases, new mineral-related agreements may have similar components.

CANADIAN DEVELOPMENTS

Demand for mineral aggregates is mainly local or regional, reflecting trends in domestic construction. International bulk shipping, however, is becoming more important in some areas.

In the context of land-use planning and the environment, there is considerably more awareness of the importance of this large sector of the mining industry. Ontario's new *Aggregate Resources Act*, probably the most comprehensive act of its kind in Canada, requires that producers file detailed site plans describing present uses and planned rehabilitation as resources are extracted.

Numerous constraints to increasing aggregate reserves persist because property owners generally oppose the opening of nearby quarries or pits. The Ontario Ministry of Natural Resources, however, is involved with a number of economic assessment studies relating to supply/demand, costs, recycling and re-use, with the goal of ensuring that decision-makers are aware of alternatives, the non-renewable resource aspects of the issues, and the socio-economic impacts of longer haul distances. Several other provinces are involved with related, but less comprehensive, studies.

Sand and Gravel

Sand and gravel deposits are widespread and large producers have established plants as convenient as possible to major consuming centres. These large aggregate operations are usually associated with other activities, such as ready-mix or asphalt plants, and are complemented by many small producers who serve local markets seasonally or only on demand. Also, some relatively large operations may operate intermittently serving, when required, as suppliers to heavy construction companies. Provincial highway departments operate regional or divisional quarries supplying roadbed material for new work and repair work. This activity by a wide range of groups has been an obstacle to capturing complete production and consumption data. In the case of

Ontario, which is the largest producing province, estimates indicate that the total production of aggregates from all sources is 25%-30% higher than official surveys indicate. Included in the all-source estimates are designated areas, wayside sources, Ministry of Transportation sites, Crown lands and private lands.

Crushed Stone

Many operations producing crushed stone are part-time or seasonal; others are operated as subsidiaries of construction or manufacturing establishments not classified with the stone industry. In addition, some operations are operated by municipal or provincial government departments producing stone only for their own use. Quarries removing rock by drilling, blasting and crushing are generally associated with work by large construction companies, and not with the smaller, more local needs often associated with gravel pits. Depending on cost and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications, it is subject to the same physical- and chemical-testing procedures as gravel and sand aggregates are.

Steetley Quarry Products Inc. completed an expansion and modernization program at its Dundas quarry near Hamilton, Ontario. The capacity of the operation has nearly doubled to about 5.5 Mt/y. The largest quarrier in Canada is Dufferin Aggregates (a subsidiary of St. Lawrence Cement Inc.) operating near Milton, Ontario, and producing about 7.0 Mt/y.

Quarrying to supply high-quality construction aggregates or chemical stone has been successful on the east and west coasts where the use of large-volume ocean transportation facilities serves to reduce unit transportation costs. Producers of high-calcium limestone on Texada Island, situated about 100 km north of Vancouver, have for many years provided raw material to cement and lime producers on the lower mainland and in the state of Washington. Holnam West Materials Ltd., formerly Ideal Basic Industries Limited, has been shipping from Texada since 1957. The main product is high-calcium limestone; however, road-base material as well as riprap for the lower mainland are also important. Occasionally, orders are from as far away as Alaska.

In Ontario, Manitoulin Dolomite, owned by Standard Aggregates Inc., is situated on Manitoulin Island in Lake Huron. Approximately 2.2 Mt/y of white-to-grey, fine-grained dolomite is shipped for construction, chemical and metallurgical markets in Canada and the United States. Also, granite aggregate from the Porcupine Mountain quarry at Auld's Cove near Port Hawkesbury, Nova Scotia, has been transported to markets in Atlantic Canada. In recent years, 50 000-60 000-t loads have been shipped as far as Houston, Texas.

Newfoundland Resources and Mining Company (NRMC) increased shipments in 1991 from its crushed limestone operation at Lower Cove on the Port-au-Port Peninsula in Newfoundland. The new $30 million plant and handling facility is designed mainly for shipping bulk quantities; approximately 500 000 t can be stockpiled, with capacity to produce about 4.3 Mt/y. The company gained considerable profile recently with a 60 000-t shipment of aggregates into New York.

Kelly Rock Limited announced that it has a contract with Nova Scotia Power Corporation to supply limestone for flue-gas desulphurization at the utility's plant in Point Aconi. The contract is for five years to supply 100 000 t/y. A plan by Kelly Rock and an associate to develop a major coastal marine quarry for construction aggregates has been placed on hold pending an environmental review. Plans are to develop a site on deep water at Kelly's Mountain, about 40 km north of Sydney, Nova Scotia.

Aguathuna Mining Inc. plans a limestone and dolomite quarry at Aguathuna, Newfoundland, on the Port-au-Port Peninsula which will produce up to 500 000 t/y of high-calcium limestone and high-purity dolomite.

Marconi Quarries Ltd., situated on the north shore of the St. Lawrence River at Point Noire, near Sept-Îles, began producing a wide range of construction aggregates for widespread distribution. Reserves of anorthositic gabbro are said to be very large.

Recycling

Recycling has become more important, particularly as it relates to hot-mix asphalt. In Ontario, more than 90 plants of a total 144 are now producing some recycled hot-mix material, according to a recent study. In the future, there is expected to be more recycling of old pavements as a result of limitations on the use of landfill sites and as technical and other problems are better understood.

WORLD DEVELOPMENTS

Large-scale coastal marine quarrying of aggregates for international markets continues to attract considerable attention. In the United Kingdom, Redland Aggregates proposes to develop a 1 Mt/y quarry off the coast of Scotland on the Isle of Harris. The initial cost of the project is expected to be about US$36 million. Plans are being considered for producing up to 9 Mt/y over 70 years of operation and leaving the site open for a new tidal inlet. This type and scale of aggregates operation was pioneered in 1986 by Foster Yeoman Ltd. at its Glensanda quarry on the west coast of Scotland. This was followed recently by Vulcan Materials Co.'s joint venture on Mexico's Yucatan Peninsula as well as NRMC's large project, as described earlier.

International investments in North American aggregates production continued to slow down in 1991. Relatively fewer opportunities, as well as growing interest in other areas, including Eastern Europe, may have been factors influencing corporate strategies. Major companies involved in recent years include Tarmac plc, RMC Group plc, Redland plc, C.H. Beazer, English China Clays plc, Alfred McAlpine, Blue Circle Industries Ltd., BTR Ltd., Hanson PLC, Consolidated Gold Fields PLC, and Wimpey Construction Ltd.

Offshore dredging projects for unconsolidated aggregates have become more important because of growing demand and the impact of more on-land environmental and zoning constraints. This is particularly true in the United States, but also applies to Japan where seabed sands account for about 40% of the total domestic production of fine aggregates needed for concrete.

In the United States, funding for an aggregates research centre has been established through the National Stone

Association and the National Aggregates Association. It is expected that there will be more public/private partnerships to solve pavement-performance problems and to address performance-based design, construction and material specifications.

Lightweight Aggregates

The classification of lightweight aggregates is based on elements of source, processing methods and end uses. Source rocks include pumice, scoria, volcanic cinders and tuff. Manufactured lightweight aggregates are bloated or expanded products commonly obtained by heating certain clays, shales and slates. Ultra-lightweights, produced mainly from perlite and vermiculite, are expanded or exfoliated by heating. Fly ash, resulting from the combustion of coal and coke, and slag from metallurgical processes are classed as by-product aggregates.

Perlite

Perlite is a glassy volcanic rock containing 2%-5% of combined water and, after crushing and heating rapidly to 760°-1100°C, its volume expansion is from 4 to 20 times. With attention to pre-blending of kiln feed and retention time in the kiln, expanded material can be manufactured to weigh as little as 30-60 kg/m^3.

Imported perlite is expanded at numerous locations for use mainly in horticultural mixes and lightweight and fire-resistant construction products. Other uses relate to loose insulation and insulating media in concrete products. Imports of crude perlite are mainly from New Mexico and Colorado, with production from companies such as Grefco, Inc., Manville Corporation, USG Corporation, and United Perlite Corp.

A perlite processing plant in Surrey, British Columbia, operated by an associate of Aurun Mines Ltd., closed in 1990. Horticultural grades were produced from imported raw material and, for a time, used domestic raw material. With improved markets over a wider range of grades, there is optimism that local occurrences may be used in the future.

Pumice

Numerous concrete product manufacturers, mainly including block producers, use pumice imported from Greece or the northwestern United States. In Canada, a major potential use for this durable and angular material is in highway asphalt overlay as a highly skid-resistant ingredient.

Vermiculite

Vermiculite refers to a small group of minerals–physically resembling the lamellar structure of the micas–that expand or exfoliate greatly when heated rapidly. Canadian consumption is mainly for horticultural uses, with lesser amounts for insulation and other products.

The United States is the world's leading producer of vermiculite, with W.R. Grace and Company being the major supplier from the Enoree region of South Carolina. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd. (PMC) is the major producer. Vermiculite occurrences have been reported in British Columbia, and deposits near both Perth and Peterborough in Ontario have attracted attention in the past.

Clay, Shale and Slag

Common clays and shale are used throughout Canada for manufacturing lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s. Raw clay materials, usually quarried adjacent to plant sites, receive little beneficiation other than drying before going to the kiln where they are expanded. Shales are crushed and screened before burning. Slag, a porous, glassy, nonmetallic by-product resulting from controlled cooling conditions at the end of the steel-making process, may be crushed and sized for many construction-related applications.

Ongoing research (sponsored through the Canada Centre for Mineral and Energy Technology (CANMET)), relating to supplementary cementing materials, led to the successful use of granulated blast furnace slag for manufacturing a slag cement. Reiss Lime Company of Canada, Limited processes this type of cement from a grinding plant at Spragge, Ontario. The granulated slag is from a plant owned by The Algoma Steel Corporation, Limited, of Sault Ste. Marie, Ontario. Plant capacity is 200 000 t/y of slag cement for complete or partial replacement of Portland cement, depending on requirements. The primary use at present is in mine backfill; however, construction-related uses are also being investigated.

PRICES

In addition to supply/demand factors, prices are determined locally or regionally by production and transportation costs, by the degree of processing prior to final use, and by site-specific volume requirements.

USES

The principal uses for sand and gravel are for highway construction and concrete aggregate. Construction of single-family homes triggers an overall demand of about 300 t of aggregate per unit, while apartment construction requires only about 50 t per unit, according to a recent study by the Ontario Ministry of Natural Resources.

More than 90% of the total stone output used by the construction industry is for crushed material as an aggregate in concrete and asphalt for highway and railway construction, and as heavy riprap for facing wharves and breakwaters. Specifications vary greatly depending on intended uses, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution, as assessed by grading tests or sieve analysis, affects the uniformity and workability of concrete, the strength of the final product, the density and strength of an asphalt mix, and the durability, strength and stability of aggregates compacted as fill or base-course material. Also of importance are tests concerning organic impurities or other deleterious material, resistance of the aggregate to abrasion and freeze-thaw cycles, the effects of thermal expansion, porosity and absorption, reactivity with associated materials, and surface texture.

Lightweight concrete used in commercial and institutional projects has facilitated the construction of taller buildings and the use of longer clear spans in bridges and buildings. Other advantages of using lightweight aggregates relate to their thermal and acoustical properties, fire resistance, freeze-thaw properties, low water absorption characteristics, and their durability as it influences concrete products.

As yet, there are no Canadian Standards Association (CSA) specifications for lightweight aggregates. Their production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM C 332-87, Lightweight Aggregates for Insulating Concrete; C 330-89, Lightweight Aggregates for Structural Concrete; and C 331-89, Lightweight Aggregates for Concrete Masonry Units.

OUTLOOK

Shipments of aggregates in 1992 are expected to be marginally higher, based on a moderate recovery in residential construction. However, a recovery in non-residential building construction is expected to be slower, given relatively high office and industrial vacancy rates.

The construction sector in the United States is expected to improve in 1992, based on an increase in housing starts early in the year and the possibility of more relaxed credit conditions.

Urban expansion has greatly increased the demand for aggregates in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but it has also extended into areas containing potentially valuable reserves and resources. Clearly, municipal and regional zoning, given advancements in land rehabilitation, reclamation and redevelopment, is expected to become more regulation-oriented to help ensure optimal sequential land use.

Sand and gravel will continue to be competitive with crushed stone in many areas and, in some applications, with lightweight aggregates. New reserves are expected to be located and assessed as part of the community planning or regional zoning process. Prices for aggregates will continue to rise with increasing land values, more sophisticated operating techniques and equipment, the depletion of more accessible reserves, and added rehabilitation expenditures.

Estimates have indicated that available sand and gravel supplies in some regions will be depleted during the 1990s, resulting in a need for outlying deposits. Predicted shortages could encourage exploitation of offshore deposits and even underground mining in some regions.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1989-91

	1989		1990		1991p	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE1						
Newfoundland	862	5 364	1 501	9 952	987	5 015
Nova Scotia	6 732	33 718	7 271	39 459	4 177	23 576
New Brunswick	2 336	14 277	2 711	18 098	2 770	18 398
Quebec	42 605	230 455	40 634	243 573	34 979	206 173
Ontario	59 417	339 380	50 418	300 561	37 331	222 374
Manitoba	2 861	13 099	3 737	15 193	1 693	7 948
Saskatchewan	–	–	–	–	–	–
Alberta	374	3 619	313	2 702	300	2 892
British Columbia	3 421	22 922	3 271	24 327	3 040	22 725
Northwest Territories and Yukon	727	4 344	1 495	9 079	508	3 735
Total	119 335	667 178	111 352	662 945	85 785	512 837
BY USE2						
Dimensional stone			..	..	..	..
Rough	254	23 423	..	..	..	..
Monumental and ornamental stone (n.f.)	68	8 212	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	38	3 210	..	..	..	..
Chemical and metallurgical						
Cement plants, Canada	13 899	31 805	..	..	..	..
Cement plants, foreign	807	2 444	..	..	..	..
Lining, open-hearth furnaces	–	–	..	..	..	..
Flux in iron and steel furnaces	1 270	6 203	..	..	..	..
Flux in nonferrous smelters	52	1 258	..	..	..	..
Glass factories	258	4 930	..	..	..	..
Lime plants, Canada	2 162	13 386	..	..	..	..
Lime plants, foreign	237	1 397	..	..	..	..
Pulp and paper mills	216	1 928	..	..	..	..
Sugar refineries	40	318	..	..	..	..
Other chemical uses	1 316	7 780	..	..	..	..
Pulverized stone						
Whiting (substitute)	54	3 929	..	..	..	..
Asphalt filler	143	903	..	..	..	..
Dusting, coal mines	2	75	..	..	..	..
Agricultural purposes and fertilizer plants	1 031	14 238	..	..	..	..
Other uses	397	14 291	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	7	63	..	..	..	..
Roofing granules	328	6 379	..	..	..	..
Poultry grit	59	1 453	..	..	..	..
Stucco dash	10	1 120	..	..	..	..
Terrazzo chips	3	161	..	..	..	..
Rock wool	–	–	..	..	..	..
Rubble and riprap	1 605	9 167	..	..	..	..
Concrete aggregate	11 513	68 969	..	..	..	..
Asphalt aggregate	9 487	55 599	..	..	..	..
Road metal	55 496	260 780	..	..	..	..
Railroad ballast	2 743	17 838	..	..	..	..
Other uses	31 901	151 111	..	..	..	..
Total	135 395	712 370	..	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; n.f. Not finished or dressed; p Preliminary.
1 Data exclude stone used in the Canadian cement and lime industries. 2 Data include stone used in the Canadian cement and lime industries.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, PRODUCTION OF SAND AND GRAVEL[1] BY PROVINCE, 1989-91

	1989		1990		1991p	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Newfoundland	4 241	18 039	3 016	14 456	2 784	11 701
Prince Edward Island	826	2 214	1 311	3 271	1 075	2 453
Nova Scotia	6 585	22 049	6 890	22 945	4 876	15 045
New Brunswick	9 249	16 023	8 285	16 405	6 843	14 387
Quebec	36 025	107 586	29 895	89 533	28 790	83 022
Ontario	92 264	324 649	79 970	286 391	63 748	209 649
Manitoba	13 880	37 347	12 355	38 384	10 537	35 203
Saskatchewan	12 960	27 031	12 022	23 462	7 924	17 597
Alberta	41 959	145 072	43 905	158 198	35 663	106 584
British Columbia	52 469	156 580	41 278	140 585	34 864	120 708
Yukon and Northwest Territories	4 390	17 488	5 387	23 689	3 395	15 043
Total	274 848	874 078	244 316	817 317	200 497	631 391

Source: Energy, Mines and Resources Canada.
p Preliminary.
1 Production values for silica have been included in sand and gravel.
Note: Numbers may not add to totals due to rounding.

TABLE 3. AVAILABLE DATA ON CONSUMPTION OF SAND AND GRAVEL,[1] BY PROVINCE, 1988 AND 1989

		Atlantic Provinces	Quebec	Ontario	Western Provinces[2]	Canada
				(000 tonnes)		
Roads	1988	20 733	19 705	53 373	90 749	184 560
	1989	14 727	20 308	48 401	86 140	169 576
Concrete aggregate	1988	2 191	7 109	18 042	10 807	38 149
	1989	1 802	5 192	15 974	13 913	36 881
Asphalt aggregate	1988	1 894	3 570	6 543	6 674	18 681
	1989	1 795	3 735	7 270	8 697	21 498
Railroad ballast	1988	9	256	458	1 511	2 234
	1989	129	285	423	1 125	1 961
Mortar sand	1988	97	602	2 231	297	3 227
	1989	103	540	1 726	309	2 680
Backfill for mines	1988	24	463	614	461	1 562
	1989	15	119	557	116	806
Other fill	1988	1 216	4 519	14 531	7 225	27 491
	1989	1 407	3 023	12 714	8 640	25 783
Other uses	1988	1 474	1 456	5 255	3 562	11 747
	1989	923	2 878	5 199	6 720	15 716
Total	1988	27 638	37 680	101 047	121 286	287 653
	1989	20 901	36 079	92 264	125 658	274 901

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Data include natural silica sand, silica sand manufactured from quartz or silica rock, and silica used in Canadian cement plants. [2] The western provinces include the Yukon and Northwest Territories.
Note: Numbers may not add to totals due to rounding.

TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL AND CRUSHED STONE, 1989-91

Item No.		1989		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS							
2505.90	Natural sands n.e.s., excluding metal-bearing sands						
	Saint Lucia	–	–	–	–	53 240	1 069
	Bahamas	5	1	42 696	723	20 248	377
	Other countries	12 040	307	49 061	370	23 504	274
	Total	12 045	308	91 757	1 093	96 992	1 720
2517.10	Pebbles, gravel, broken or crushed stone used for aggregates, etc.						
	United States	975 194	8 419	1 274 312	7 776	770 301	4 400
	Saint Lucia	–	–	–	–	36 900	752
	Other countries	48 657r	917r	56 655	992	60 250	950
	Total	1 023 851r	9 336r	1 330 967	8 768	867 451	6 102
2517.41	Marble granules, chipping and powder of 25.14 or 25.16 heat-treated or not						
	United States	–	–	220	36	281	50
	Total	–	–	220	36	281	50
2517.49	Granules, chippings and powder, n.e.s., of 25.15 or 25.16 heat-treated or not						
	Saint Lucia	–	–	–	–	9 000	167
	United States	11 415	35	62	8	30	8
	Other countries	38 581	668	20 135	380	–	–
	Total	49 996	703	20 197	388	9 030	176
2518.10	Dolomite, not calcined						
	United States	459 914	4 159	858 327	4 208	322 274	1 558
	Total	459 914	4 159	858 327	4 208	322 274	1 558
2518.20	Calcined dolomite						
	United States	24 881	3 591	38 074	4 615	20 384	3 118
	United Kingdom	–	–	175	40	–	–
	Total	24 881	3 591	38 249	4 655	20 384	3 118
2518.30	Agglomerated dolomite (including tarred dolomite)						
	United States	915	88	149	11	–	–
	Total	915	88	149	11	–	–
2521.00	Limestone flux; limestone and other calcareous stone used for lime or cement						
	United States	928 680	5 864	1 364 506	6 802	843 801	4 577
	Other countries	43	10	3 114	22	–	–
	Total	928 723	5 874	1 367 620	6 824	843 801	4 577
IMPORTS							
2505.90	Natural sands n.e.s., excluding metal-bearing sands						
	United States	800 369r	7 997r	288 191	4 365	115 100	2 439
	Other countries	374	45r	188	20	814	135
	Total	800 743r	8 042r	288 379	4 385	115 914	2 574
2517.10	Pebbles, gravel, broken or crushed stone used for aggregates, etc.						
	United States	738 339	4 278	993 622	5 471	824 789	5 090
	Other countries	881	14	2 429	38	1 291	18
	Total	739 220	4 292	996 051	5 509	626 080	5 108

TABLE 4. (cont'd)

Item No.		1989		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
2517.20	Macadam of slag, dross or similar industrial waste, etc.						
	United States	8 810	54	3 810	44	24 031	54
	Total	8 810	54	3 810	44	24 031	54
2517.30	Tarred macadam						
	United States	5	. .	80	6	26	1
	Total	5	. .	80	6	26	1
2517.41	Marble granules, chippings and powder of 25.15 or 25.16 heat-treated or not						
	United States	34 014	4 255	45 316	5 500	38 879	4 828
	France	108	21	450	88	592	93
	Italy	202	43	50	9	132	16
	Total	34 324	4 320	45 817	5 598	39 603	4 937
2517.49	Granules, chippings and powder, n.e.s. of 25.15 or 25.16 heat-treated or not						
	United States	121 805	1 475	132 254	1 428	106 069	1 020
	Other countries	1 670	60	232	20	5	. .
	Total	123 475	1 535	132 486	1 448	106 074	1 020
2518.10	Dolomite, not calcined						
	United States	10 273	54	1 630	364	1 760	348
	United Kingdom	61	11	12	3	5	1
	Total	10 334	66	1 642	367	1 764	350
2518.20	Calcined dolomite						
	United States	6 613	573	3 022	332	3 333	329
	Total	6 613	573	3 022	332	3 333	329
2518.30	Agglomerated dolomite (including tarred dolomite)						
	United States	42	21	57	30	511	146
	Total	42	21	57	30	511	146
2521.00	Limestone flux; limestone and other calcareous stone used for lime or cement						
	United States	3 275 132r	12 208r	3 816 993	14 703	1 258 099	5 631
	Thailand	190	. . .	230	. . .	792	4
	Total	3 275 323r	12 210r	3 817 225	14 705	1 258 891	5 635

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary; r Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 5. LIGHTWEIGHT AGGREGATE PRODUCERS IN CANADA, 1990

Company	Location	Commodity	Remarks
ATLANTIC PROVINCES			
Annapolis Valley Peat Moss Company Limited	Berwick, N.S.	Vermiculite	Processed for use in horticulture.
Avon Aggregates Ltd.	Minto, N.B.	Expanded shale	Processed for concrete products industry.
Fafard Peat Moss Company Ltd.	Shippagan, N.B.	Perlite	Processed for use in horticulture.
Fisons Horticulture Inc.	Maisonnette, N.B.	Perlite	Processed for use in horticulture.
QUEBEC			
Armstrong World Industries Canada Ltd.	Gatineau	Perlite	Processed for use in ceiling tile manufacture.
Miron Inc.	Ville Mont-Royal	Pumice	Purchased for concrete block manufacture.
Premier Peat Moss Ltd.	Rivière du Loup	Perlite, vermiculite	Processed for use in horticulture.
Vermi-lite Inc.	Baie-du-Febvre	Perlite	Processed for use in horticulture, insulation and concrete products.
VIL Vermiculite Inc.	Lachine	Vermiculite	Processed for use in loose insulation, horticulture and concrete products
ONTARIO			
CGC Inc.	Hagersville	Perlite	Processed for use in gypsum plaster.
National Slag Limited	Hamilton	Slag	Used in concrete products industry and as slag cement.
W.R. Grace & Co. of Canada Ltd.	St. Thomas	Vermiculite	Vermiculite processed for use in horticulture and as loose insulation.
	Ajax	Vermiculite, perlite	Perlite processed for use in gypsum plaster, in horticulture, in refractories, as loose insulation, in friction materials and in fire-proofing.
PRAIRIE PROVINCES			
Cindercrete Products Ltd.	Saskatoon, Sask.	Expanded clay	Processed for concrete block manufacture.
	Regina, Sask.	Expanded clay	Processed for concrete block manufacture.
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale	Processed for concrete products industry and for loose insulation.
CBR Cement Canada Limited	St. Albert, Alta.	Expanded clay	Processed for concrete products industry and for loose insulation.
Fisons Horticulture Inc.	Elma, Man.	Perlite	Processed for use in horticulture.
Fisons Horticulture Inc.	Seba Beach, Alta.	Perlite	Processed for use in horticulture.
Kildonan Concrete Ltd.	Winnipeg, Man.	Expanded clay	Processed for concrete products industry.
W.R. Grace & Co. of Canada Ltd.	Winnipeg, Man.	Vermiculite, perlite	Perlite processed for use in gypsum plaster and in horticulture.
	Edmonton, Alta.	Vermiculite, perlite	Vermiculite processed for use in horticulture and as loose insulation.
BRITISH COLUMBIA			
Ocean Construction Supplies Limited	Vancouver	Pumice	Purchased for concrete products industry.
W.R. Grace & Co. of Canada Ltd.	Vancouver	Vermiculite, perlite	Mainly for horticulture.

Source: Energy, Mines and Resources Canada, reported from EMR survey "Production of Lightweight Aggregates in Canada."

TABLE 6. CANADA, IMPORTS OF VERMICULITE, PERLITE AND PUMICE, 1989-91

Item No.		1989		1990		Jan.-Sept. 1991[p]	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
2513.11	Pumice stone, crude or in irregular pieces, including crushed pumice						
	Turkey	429	174	1 985	300	2 695	861
	United States	1 588	880	10 830	830	3 724	569
	Other countries	4 919	447	4 698	293	116	42
	Total	6 936	1 501	17 514	1 423	6 535	1 472
2513.19	Pumice stone, other						
	United States	1 332	912	3 656	756	4 444	674
	Other countries	317	208	553	195	314	102
	Total	1 649	1 120	4 209	951	4 759	776
2530.10.10.10	Vermiculite, unexpanded						
	United States	19 286	3 118	15 211	2 371	8 209	1 204
	Other countries	9 918	1 424	3 000	461	2 421	350
	Total	29 204	4 542	18 211	2 832	10 630	1 554
2530.10.10.20	Perlite, unexpanded						
	United States	19 689	2 451	21 894	2 801	21 194	2 452
	Greece	4 084	304	8 387	598	5 229	375
	Total	23 733	2 755	30 281	3 399	26 423	2 828
3802.90.20	Activated perlite, excluding perlite ground to be employed in filtering						
	United States	601[r]	293[r]	210	92	1 733	765
	Total	601[r]	293[r]	210	92	1 733	765
6806.20.00.10	Exfoliated (expanded) vermiculite						
	United States	233	611	455	1 351	251	622
	Total	233	611	455	1 351	251	622
6806.20.00.20	Expanded perlite						
	United States	1 645[r]	1 483[r]	3 365	1 803	2 573	1 175
	Other countries	22	46	–	–	42	35
	Total	1 667[r]	1 530[r]	3 365	1 803	2 615	1 210

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; [p] Preliminary; [r] Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 7. CANADA, LIGHTWEIGHT AGGREGATES PRODUCED, SOLD AND USED, 1989 AND 1990

	1989[2]				1990			
	Produced		Sold and Used		Produced		Sold and Used	
	(m^3)	($)	(m^3)	($)	(m^3)	($)	(m^3)	($)
From domestic and/or imported raw materials								
Expanded clay, shale and slag[1]	706 700	14 304 356	595 687	12 200 478	298 178	7 771 761	292 064	7 548 100
From imported crude materials								
Expanded perlite and exfoliated vermiculite[1]	451 935	19 647 256	451 935	19 647 256	462 652	25 501 609	462 652	25 501 609
Total	1 158 635	33 951 612	1 047 622	31 847 734	760 830	33 273 370	754 716	33 049 709

Source: Energy, Mines and Resources Canada, reported from EMR survey "Production of Lightweight Aggregates in Canada." See Table 5 for list of establishments surveyed.
[1] Combined to avoid disclosing confidential company data. [2] Increase in number of companies being surveyed.

TABLE 8. CANADA, SALES OF EXPANDED SLAG, PERCENTAGE BY END USE, 1988-90

Use	1988	1989	1990
Concrete block manufacture	85.9	85.9	90.0
Ready-mix concrete	8.5	8.5	10.0
Precast concrete manufacture	5.6	5.6	–

Source: Energy, Mines and Resources Canada, reported from EMR survey "Production of Lightweight Aggregates in Canada." See Table 5 for list of establishments surveyed. Sales also imply quantities consumed for own use.
– Nil.

TABLE 9. CANADA, SALES OF EXPANDED CLAY AND SHALE, PERCENTAGE BY END USE, 1988-90

Use	1988	1989	1990
Concrete block manufacture	86.3	75.0	67.7
Loose insulation	0.6	12.5	25.5
Precast concrete manufacture	3.6	7.5	2.8
Ready-mix concrete	3.8	3.1	3.1
Horticulture and miscellaneous uses	5.7	1.9	0.9

Source: Energy, Mines and Resources Canada, reported from EMR survey "Production of Lightweight Aggregates in Canada." See Table 5 for list of establishments surveyed. Sales also imply quantities consumed for own use.

TABLE 10. CANADA, SALES OF EXPANDED PERLITE, PERCENTAGE BY END USE, 1988-90

Use	1988	1989	1990
Insulation			
in gypsum products	2.7	1.7	0.8
in other construction materials	31.1	28.7	24.0
Horticulture and agriculture	56.1	58.9	67.0
Loose insulation and miscellaneous uses	10.1	10.7	8.2

Source: Energy, Mines and Resources Canada, reported from EMR survey "Production of Lightweight Aggregates in Canada." See Table 5 for list of establishments surveyed. Sales also imply quantities consumed for own use.

TABLE 11. CANADA, SALES OF EXPANDED VERMICULITE, PERCENTAGE BY END USE, 1988-90

Use	1988	1989	1990
Loose insulation	12.6	14.2	9.9
Horticulture	61.5	56.1	68.1
Miscellaneous uses	25.9	29.7	22.0

Source: Energy, Mines and Resources Canada, reported from EMR survey "Production of Lightweight Aggregates in Canada." See Table 5 for list of establishments surveyed. Sales also imply quantities consumed for own use.

TABLE 12. CANADA, VALUE OF CONSTRUCTION BY TYPE,[1] 1989-91

	1989	1990	1991
		($ millions)	
BUILDING CONSTRUCTION[2]			
Residential	42 729	41 767	39 687
Industrial	4 487	4 205	3 787
Commercial	16 193	15 987	14 927
Institutional	5 111	5 680	6 220
Other building	2 718	2 535	2 568
Total	71 238	70 174	67 189
ENGINEERING CONSTRUCTION[2]			
Marine	614	629	736
Highways, airport runways	6 199	6 814	7 523
Waterworks, sewage systems	2 569	2 911	3 263
Dams, irrigation	470	523	542
Electric power	5 153	6 137	7 678
Railway, telephones	3 511	3 295	3 274
Gas and oil facilities	7 403	8 185	10 200
Other engineering	3 255	3 190	3 393
Total	29 174	31 684	36 609
Total construction	100 412	101 858	103 798

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Actual expenditures 1989, preliminary 1990, intentions 1991. [2] Includes total value of new and repair work purchased.

TABLE 13. CANADA, VALUE OF CONSTRUCTION BY PROVINCE,[1] 1989-91

	1989			1990			1991		
	Building Construction[2]	Engineering Construction[2]	Total	Building Construction[2]	Engineering Construction[2]	Total	Building Construction[2]	Engineering Construction[2]	Total
					($ millions)				
Newfoundland	1 050	608	1 659	1 065	609	1 674	1 169	1 172	2 341
Nova Scotia	1 821	737	2 558	1 880	907	2 787	1 705	1 076	2 780
New Brunswick	1 394	501	1 896	1 407	702	2 109	1 270	900	2 170
Prince Edward Island	269	92	361	268	92	360	265	111	376
Quebec	15 830	5 720	21 549	16 003	6 483	22 485	15 713	7 526	23 238
Ontario	32 434	7 828	40 263	29 705	7 809	37 514	28 380	9 538	37 917
Manitoba	1 967	1 115	3 082	1 854	1 348	3 202	1 802	1 384	3 186
Saskatchewan	1 797	1 633	3 431	1 809	1 908	3 717	1 846	2 082	3 928
Alberta	5 581	6 604	12 185	6 191	7 346	13 537	5 971	7 994	13 965
British Columbia, Yukon and Northwest Territories	9 096	4 332	13 428	9 993	4 480	14 473	9 070	4 827	13 897
Total Canada	71 238	29 174	100 412	70 174	31 684	101 858	67 189	36 609	103 798

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Actual expenditures 1989, preliminary 1990, intentions 1991. [2] Includes total value of new and repair work purchased.
Note: Numbers may not add to totals due to rounding.

Nickel

P. Chevalier and B. Sutherland

The authors are with the Mineral Policy Sector, EMR Canada.
Telephone Barbara Sutherland:
(613) 992-7568.

Demand for nickel in the Western World was flat in 1991 which, in combination with increased production and higher exports from Russia, resulted in weak prices. Spot nickel prices on the London Metal Exchange (LME) were at US$3.20/lb at year-end, compared to about $4.00/lb at the beginning of 1991. The average price on the LME was US$3.70/lb for the year compared to $4.03/lb in 1990. Production cuts, particularly by Inco Limited at its Sudbury operations and Falconbridge Limited at operations in Sudbury and the Dominican Republic, were a factor in stemming the downward price slide on world markets.

Nickel inventories on the LME increased significantly in 1991. By year-end, stocks on the LME had surpassed 10 000 tonnes (t) for the first time since 1984. Producer stocks were also up sharply over the previous year.

CANADIAN DEVELOPMENTS

Canadian mine production decreased slightly in 1991. Preliminary data indicate that Canada produced 196 900 t of nickel compared to 199 400 t in 1990.

In September, Inco announced that it would reduce its Sudbury nickel output by 4500 t for the balance of 1991 because of weak nickel prices. The company suspended production at the Creighton No. 3 mine and the Whistle open-pit, and stopped mining at several small deposits next to the Garson mine. It also delayed development of the new McCreedy East mine. In addition, Inco froze hiring and production overtime at its Manitoba Division, and additional cash-conservation measures, including deferral of certain capital expenditures at both the Ontario and Manitoba Divisions, were placed under review.

Inco continued work on the sulphur abatement program at Sudbury. The $600 million smelter modernization project is expected to reduce sulphur dioxide (SO_2) emissions at the Copper Cliff complex from 685 000 t/y to 265 000 t/y by 1994. The consolidation of Inco's milling operations was completed in January 1991. The 40 000-t/d Clarabelle mill at Copper Cliff processes all of Inco's Sudbury ore. The result has been a reduction in SO_2 emissions by 100 000 t/y. Other major components of the first phase included the new flash furnace and oxygen plant, additional sulphuric acid facilities, concentrate driers and accessory equipment. In November, His Royal Highness the Prince of Wales officially inaugurated the new oxygen furnace at the Copper Cliff smelter.

Falconbridge Limited later announced cuts of 500 t of nickel at its Sudbury smelter for the balance of 1991. The company suspended mining of the Falconbridge crown pillar and slowed exploration and development work on the Lindsley deposit.

A failure at one of Inco's reverberatory furnaces at its Port Colborne nickel plant disrupted production of utility nickel in November. The Port Colborne facility produces 2700 t of utility nickel per month, primarily for the stainless steel industry. The company increased output of utility nickel at Sudbury until repairs at the Port Colborne facility were completed.

In April, Sherritt Gordon Limited started receiving nickel-cobalt feed from Cuba for its Fort Saskatchewan refinery. Shortages of nickel feedstock had forced the company to reduce production in 1990. The addition of the Cuban feed will allow the company to operate the refinery at close to full capacity (25 000 t/y). The decision to process the Cuban material, however, has meant that Sherritt Gordon can no longer sell its products to the United States because of the U.S. trade embargo against Cuba.

Exploration

In September, Inco announced that it had discovered two new nickel deposits in the Sudbury Basin. The Victor deposit, located 25 km northeast of Sudbury, contains an estimated 18-36 Mt of copper-nickel mineralization, as well as platinum, palladium and gold, at a depth of between 2400 and 2700 m below the surface. The other deposit, 900 m from the McCreedy East mine, contains an estimated 7 Mt of ore at a depth of about 1500 m. Together, the two deposits have the potential to represent about 10% of Inco's total Sudbury production of 90 000 t/y. Work on the two deposits will continue in order to evaluate their economic potential.

Elsewhere in the Sudbury district, Falconbridge and Flag Resources Limited began exploration of the Wanapitei anomaly. Often called "Sudbury's Twin," the Wanapitei anomaly is a deep-seated magnetic anomaly located about 30 km northeast of the Sudbury Basin. It is similar in size and shape to the Sudbury anomaly. Falconbridge's first drill-hole reached a depth of 2200 m but did not penetrate the overlying sedimentary rocks. Exploration on the project will continue next summer. Flag Resources announced some anomalous results from chip and grab samples taken from its property.

In April, Falconbridge announced plans for the second phase of exploration on the New Quebec Raglan Project (Katinniq mine) located west of Ungava Bay in northern Quebec. The $35 million underground program will include construction of a ramp and 2000 m of underground development, including 60 000 m of definition diamond drilling. In addition, the company will upgrade the airfield and other facilities, and survey roads, and make other preparations to develop the mine's infrastructure. To date, drilling has outlined 17 Mt at an average grade of 3.13% nickel and 0.88% copper. The company estimates development costs would be $375 million for a mine and mill that could produce 20 000 t/y of nickel in concentrate. Falconbridge expects its feasibility studies to be completed by the fall of 1992.

Black Hawk Mining Inc.'s Minago property in Manitoba is reportedly on hold until the company can raise the $10 million-$15 million needed to conduct an underground study. Surface drilling has outlined 10.5 Mt at an average grade of 1.19% nickel to a depth of 550 m.

In May, Timmins Nickel Inc. signed an agreement with Dumont Nickel Corporation for a first-phase exploration program of the Dumont Nickel property west of Amos, Quebec. The $1.5 million program will allow Timmins Nickel to earn a 55% equity interest in the property. Proven and probable reserves are currently just over 500 Mt at an average grade of 0.39% nickel.

Drilling results announced by Fort Knox Gold Resources Inc. sparked interest in the Shining Tree area of northeastern

Ontario. The company intersected nickel-copper mineralization in three drill-holes. Inco, which holds a 41% interest in the property, will take over supervision of the project.

WORLD DEVELOPMENTS

Several producers, including Inco in Indonesia and Falconbridge in the Dominican Republic, operated at below their effective capacities for the latter half of the year in an attempt to stem the downward slide in prices. Despite weak nickel markets, consideration was given to the development of some new projects or the expansion of existing operations.

Australia

Dominion Mining Limited announced that it would proceed with plans to develop its Yakabindie prospect in central Australia. The company plans to develop an open-pit mine by late 1993 to produce about 110 000 t/y of nickel concentrate containing 21 000 t of nickel. Development costs are estimated at A$470 million. The company received the go-ahead to develop the mine after the federal government dismissed aboriginal claims to the site.

Outokumpu Metals and Resources Oy acquired a 100% equity interest in the Forrestania Nickel deposit in Western Australia from the previous joint-venture partner Arimco. The deposit has reserves of about 4.4 Mt grading 2% nickel. By year-end, the company had announced plans to spend A$100 million to bring the deposit into production. The project will comprise three mines and a 500 000-t/y concentrator. The company expects to produce about 8000 t/y of nickel in concentrate to be shipped to its Harjavalta refinery in Finland.

Australia's Western Mining Corporation Holdings Limited (WMC) embarked on a campaign to increase its nickel production to 65 000 t/y through the expansion of its existing operations and the 50% acquisition of the Mount Keith deposit in Western Australia. In the second half of 1991, WMC announced the approval of several expansion projects for its nickel operations in Western Australia. The company will spend A$127 million over the next two years to double mine production at its Leinster mine to about 2 Mt/y. It will also spend A$50 million to expand its Kwinana refinery to 42 000 t/y from the current 30 000 t/y, and an additional A$41 million will be spent to expand its Kalgoorlie nickel smelter to treat 65 000 t/y of nickel in concentrate. The company also announced plans to expand its operations at Kambalda; however, the expansion is conditional upon the unions agreeing to seven-day-per-week operations. Negotiations between the company and the union were continuing at year-end.

WMC and Normandy Poseidon Limited (NPL) jointly took control of the assets of Australian Consolidated Minerals Ltd. (ACM). WMC took control of ACM's share of the Mount Keith nickel project, while NPL took control of ACM's copper, zinc and gold deposits. WMC and Outokumpu will jointly develop the 28 000-t/y Mount Keith deposit in Western Australia. Outokumpu plans to refine its share of production at its Harjavalta refinery in Finland, while WMC will process its share at Kambalda.

AGIP Australia brought the Radio Hill nickel-copper project in Western Australia on stream. The new smelter uses Australia's Isasmelt technology to produce a matte containing 45% of combined nickel and copper with a rated capacity of 11 000 t/y. The project was placed on care and maintenance in January 1992 as a result of low prices.

New Caledonia

Société Métallurgique Le Nickel (SLN) of France declared force majeure on shipments of ferronickel due to a fire in mid-December 1990 at one of their three furnaces installed at the company's Doniambo nickel plant. In October, the company announced that it would shut down one of its three furnaces at the plant for six months to carry out essential maintenance. Weak nickel prices and the fire were cited as the main reasons for the decision.

Inco and the Bureau de Recherches Géologiques et Minières (BRGM) signed an agreement in principle to evaluate the development of laterite nickel resources in southern New Caledonia. Under the terms of the agreement, Inco will purchase BRGM's subsidiary, Société de Promotion de Mines (Sopramines), as well as patents and technical expertise related to nickel oxide ores.

Indonesia

PT Inco Indonesia completed the US$80 million Soroako expansion that will increases Inco's Indonesian production capacity to 47 600 t/y of nickel in matte. The company lost about 9000 t of nickel matte at its Soroako plant due to an electrical failure in the No. 3 furnace in early June. The furnace was returned to full capacity by mid-July, but was again shut down in November for a major overhaul and upgrading.

Philippines

Attempts continued to restart the former Nonoc Mining and Industrial Corporation's idle nickel complex. The International Finance Corporation (IFC), a subsidiary of the World Bank, agreed to put US$15 million into Philnico Mining and Industrial Corporation, the company that bought the Nonoc refinery in 1990. In addition, four international banks joined the IFC to loan Philnico another US$115 million. A consortium of companies, led by Billiton and which also includes Outokumpu, will provide US$15 million in exchange for exclusive marketing rights. Rehabilitation work is estimated at US$190 million.

The Philippine nickel producer, Hinuatan Mining Corporation, announced plans to test a new nickel deposit on Marican Island. The company has spent more than US$600 000 on the site. Hinuatan hopes to bring the property on stream before reserves are exhausted at its Surigao open-pit in four or five years.

Africa

The British Columbia-based exploration company, Sutton Resources Limited, announced encouraging results from a 7000-m drilling campaign on the Kabanga nickel deposit in Tanzania. Drill-indicated reserves are reportedly 40.5 Mt grading 1.05% nickel, 0.2% copper and 0.1% cobalt.

In Botswana, BCL Limited received US$26 million from the European Community to deepen its operations at the Selebi-Phikwe nickel-copper mine. Ore supplies are dwindling at Selebi and only low-grade material is being mined at Phikwe. BCL produces about 20 000 t/y each of nickel and copper in matte. Elsewhere in the country, BCL-owned Tati Nickel announced that it would start trial mining at its Phoenix nickel project. A final production decision will be made following the results of an 18-month feasibility study and after the necessary financing is obtained.

Anglo American Corporation (AAC) announced that it was shelving plans to develop the Uitkomst nickel deposit in eastern Transvaal, South Africa. A feasibility study concluded that the nickel grade was too low to support a viable operation at or near current world prices.

Europe

Finland's Outokumpu lost an estimated 500 t of nickel in January due to a problem at its Harjavalta smelter. The company closed the smelter for six weeks in August to carry out a renovation program that increased the smelter's capacity by 25% to about 20 000 t/y. In addition, the modernization will cut SO_2 emissions by about 1000 t/y to below 5000 t/y. The summer shut-down reduced the company's annual nickel production by about 2000 t.

Falconbridge announced plans to cut production by 10%-15% to about 75% of capacity at the Nikkelverk nickel refinery at Kristiansand, Norway. The cuts were apparently due to interruptions of matte feedstock from the U.S.S.R. Reduced production at Falconbridge's Sudbury operations also contributed to the cutback.

The Kavadarci ferronickel plant in southern Yugoslavia restarted production after being closed for approximately eight years. The plant will initially operate at a rate of 7100 t/y.

U.S.S.R.

Finland's Outokumpu presented a tender for a $640 million modernization of the Pechenga nickel smelter at Nikel in the Kola Peninsula to increase efficiency and reduce pollution. The three-year plan would include a new flash furnace to replace an existing electric furnace and the construction of a sulphuric acid plant. Both Outokumpu and Elkem Technology would supply the technology required for the project. The new smelter would process ore from the Pechenga mine and some from Norilsk. The Pechenga smelter is reported to emit close to 300 000 t/y of SO_2 and 3.19 t/y of heavy metals.

Nickel production at the 140 000-t/y Monchegorsk smelter in the Kola Peninsula was reduced somewhat during the summer as a result of a shortage of soda ash needed for nickel production. Transportation difficulties and cash shortages were cited as the main reasons for the reduction. At the Orsk nickel plant in the Urals, production was reduced because of less feedstock from Cuba and shortages of coal and coke.

Cuba

Nickel production declined in Cuba, compared to 1990, primarily as a result of shortages of raw materials. The Ernesto Che Guevara nickel plant at Punta Gorda was re-opened in April after closing in August 1990 as a result of fuel shortages. A joint-venture project between Spain's Miesa SA of Bilbao and a unit of Cuba's Union Nacional Electrica will look at ways of introducing energy-saving ways to modernize the plant. The Punta Gorda plant has a rated capacity of 30 000 t/y.

Construction at Cuba's newest nickel plant, Las Camariocas near Moa, is reportedly continuing, despite the announcement that the reunified German government would not participate in the former East Germany's share of the project. Once commissioned, the plant's capacity will be 30 000 t/y.

Dominican Republic

Falcondo Dominicana C por A, a subsidiary of Falconbridge, temporarily closed one of its two ferronickel furnaces due to weak nickel market conditions. The company expected to operate at 50% of capacity until February 1992.

United States

Glenbrook Nickel Company, a subsidiary of Cominco Resources International Limited, announced plans to double its production to 1360 t/m. The company plans to import 800 000 t/y of high-grade lateritic ore from Société Minière du Sud Pacifique in New Caledonia. Plans include building port facilities near its Riddle, Oregon, plant at a capital cost of about US$30 million. Glenbrook Nickel is the only U.S. producer of nickel.

Venezuela

Vancouver-based Jordex Resources obtained exploration and mineral rights to the Lomo de Hierro lateritic nickel-cobalt deposit in Venezuela. The deposit was previously explored by Inco in the 1970s and is estimated to contain more than 38 Mt grading 1.55% nickel and 0.05% cobalt. Additional drilling will be carried out in 1992 through Jordex's joint-venture partner, Cofeminas.

CONSUMPTION AND USES

Its resistance to corrosion, high strength over a wide temperature range, pleasing appearance, and suitability as an alloying agent are characteristics of nickel which make it useful in a wide range of applications. After stainless steels, which account for about 65% of total nickel consumption, the major uses are nickel-based alloys, electroplating, alloy steels, foundry products, and copper-based alloys. Nickel is extensively used as an alloying agent and is a component in some 3000 different alloys which are used in more than 250 000 end-use applications.

Nickel is used in chemical and food processing, nuclear power plants, aerospace equipment, motor vehicles, oil and gas pipelines, electrical equipment, machinery, batteries, catalysts, and many other applications.

Nickel-containing stainless steel tanks are used for road, rail and sea transport of various liquids, including dairy products, petrochemicals and toxic chemicals. These stainless steels are used for their resistance to corrosion, strength, and ease of cleaning. Their ability to handle a wide variety of liquids adds to the tanks' capability for back-haul loads.

In recent years, some Japanese and European auto manufacturers have been using a zinc-nickel-coated steel for various body panels and some structural parts. Zinc-nickel coatings can provide five to six times more resistance to road salt corrosion than ordinary galvanized steel. Bethlehem Steel Corporation acquired the licence from Nippon Kokan KK of Japan for the manufacture in the United States of the coating, which contains about 13% nickel. Commercial production of the coating started in 1989 from a plant in Walbridge, Ohio.

In 1990, it was reported that a new nickel-hydrogen battery had been developed. While more than 30% more expensive than existing nickel-cadmium batteries, the new battery provides significantly more power. Although the new battery is potentially more environmentally acceptable, the discovery of a new energy-efficient recycling process, which can recover 99% of the cadmium and 60% of the nickel from spent nickel-cadmium batteries, may limit market penetration of the new product.

The major nickel markets of the United States, Japan and Western Europe continue to account for close to 90% of the demand for nickel in the Western World, but the newly industrialized countries, particularly in the Pacific Rim region, are increasing their share of the market and this trend is expected to continue in the future. While the United States is a major nickel consumer, its per-capita consumption of stainless steel is only one half that of many Asian and European markets.

It is anticipated that the major growth areas for nickel will be in nickel stainless steels and new high-performance alloys, as well as in electroplating applications. In addition, it is expected that nickel will be used increasingly in the electronics industry.

MARKETS AND PRICES

Nickel prices on the London Metal Exchange (LME), which averaged US$3.89/lb in January, peaked at an average of $4.10/lb in April. Reduced demand, increased inventories and greater-than-expected exports from the former U.S.S.R. depressed prices by year-end. Nickel averaged $3.23/lb in December.

Nickel stocks on the LME increased from 3300 t in January 1991 to about 12 000 t by the end of the year. Producer stocks are estimated to have increased sharply as well from 73 000 t at the end of 1990 to about 90 000 t at the end of 1991. Consumer stocks also rose.

The increased stocks, particularly in the third and fourth quarters of 1991, were a reflection of the downturn in demand from the stainless steel sector. In addition, increases on the LME were partly attributed to increased exports of Russian nickel to the West. Exports from the former U.S.S.R. increased from 85 000 t in 1990 to 110 000 t in 1991.

HEALTH AND THE ENVIRONMENT

Under a 1985 Ontario government regulation, Inco and Falconbridge must reduce their emissions of SO_2 to 265 000 t and 100 000 t, respectively, by 1994. In 1985, the limit was 685 000 t for Inco and 154 000 t for Falconbridge.

To meet the regulations, Inco embarked on a $600 million SO_2 emission abatement project at its Sudbury operations. The ores at Sudbury contain eight pounds of sulphur for every pound of nickel. To deal with the complex problem of reducing sulphur emissions, Inco's research scientists and smelting experts developed new production techniques to process a single bulk copper-nickel concentrate. New milling technology at the Clarabelle mill eliminates much of the pyrrhotite before it reaches the smelter, thereby reducing SO_2 emissions by about 100 000 t/y. In addition, the program includes new fluid bed driers, two new oxygen flash furnaces, a new oxygen flash-smelting reactor, a sulphuric acid plant and an oxygen plant. With the introduction of this technology, Inco will no longer burn fossil fuels in the smelting process, thereby reducing CO_2 production as well. The intensive use of pure oxygen will also reduce the production of nitrogen oxides (NO_x). Once the new facilities are fully operational, 90% of the sulphur originating in the ore will be contained.

Falconbridge is spending $38 million on research, development and capital projects related to increasing pyrrhotite rejection and greater roasting to be able to conform to the regulations. While actual emissions of sulphur dioxide in 1990 were below the required 1994 level, the company was producing below capacity. The company is conducting research on methods to reduce emissions to 75 000 t/y, at capacity production, by 1998. Increased pyrrhotite rejection is the focus of the research.

An issue of increasing concern to the nickel industry is the institution by various countries of stiffer regulations on exposure to nickel, some of which may be unduly restrictive or too broad in scope. Unnecessary expenses can result for nickel producers and consumers, and certain markets can be adversely affected.

Changes to regulations affecting nickel in the United States included an amendment to the *Clean Air Act*. The amended act requires that nickel compounds be regulated by the U.S. Environmental Protection Agency as hazardous air pollutants. Elsewhere in the United States, the American Conference of Governmental Industrial Hygienists postponed a proposal to set more stricter occupational exposure limits for nickel and its compounds so that existing scientific evidence could be more closely reviewed.

In October, the Organization for Economic Co-operation and Development set in motion the assessment of inorganic chemicals under the Screening Information Data Set (SIDS) program. Most nickel compounds were placed in a "set aside" category. Research on these compounds is not considered a high priority since sufficient data on these compounds already exist.

OUTLOOK

Stainless steel demand, which accounts for over 60% of nickel usage, is showing signs of slowing in both Europe and Japan, after remaining strong in the first half of 1991. However, demand in this sector is forecast to increase in 1992 as the major economies emerge from the recession.

Inco announced that its 1992 capital expenditures will be $100 million less than in 1991. The reduction reflects, in part, the company's efforts to control costs and a reduction in the expenditures required for the sulphur abatement program. The company estimates capital expenditures at $350 million for 1992; it will direct most of the expenditures toward mine development and productivity improvement programs.

In 1992, prices are forecast to average within the range of US$3.25-$3.75/lb. Western World economies, except for Japan, are forecast to recover from the recession in the latter half of 1992. Increased consumption for stainless steel and other applications is expected to result in higher nickel prices by 1993. For technical and other reasons, Russian exports are expected to be lower in 1992 than in 1991. In the longer term, as the Western World economies strengthen, prices are forecast to average between US$3.75 and $4.75/lb in constant 1990 dollars.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
2604.00	Nickel ores and concentrates	Free	Free	Free	Free	Free	Free
7501.10	Nickel mattes	Free	Free	Free	Free	Free	Free
7501.20	Nickel oxide sinters and other intermediate products of nickel metallurgy	Free	Free	Free	Free	Free	Free-81 yen/kg[2]
7502.10	Unwrought nickel, not alloyed	Free	Free	Free	Free	Free	81 yen/kg
7502.20	Unwrought nickel alloys	Free	Free	Free	Free	Free	Free-9%[3]
7503.00	Nickel waste and scrap	Free	Free	Free	Free	Free	Free
7504.00.10	Nickel powders containing by weight 60% or more nickel	Free	Free	Free	Free	0.5%	Free
7504.00.20	Nickel powders containing by weight less than 60% of nickel; flakes	10.2%	6 .5%	2%	Free	0.5%	65 yen/kg-6%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No.259, 1991, "Conventional" column; Customs Tariff Schedules of Japan, 1991.

[1] GATT rate is shown; lower tariff rates may apply circumstantially. [2] Free except for nickel oxide sinters containing by weight not less than 88% nickel which is 81 yen/kg, and nickel oxide containing by weight not more than 1.5% copper which is 7.2%. [3] Tariff rate of 9% applies to nickel alloys other than those containing by weight less than 50% of nickel and not less than 10% of cobalt.

Nickel

TABLE 1. CANADA, NICKEL PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION[1]					
	All forms				
	Ontario	128 828	1 345 630	127 027	1 237 668
	Manitoba	66 176	682 286	62 135	590 567
	Total	195 004	2 027 917	189 161	1 828 235
EXPORTS[2]				(Jan.-Sept.)	
2604.00	Nickel ores and concentrates, nickel content				
	United States	–	–	1	8
	United Kingdom	–	–	1	2
	Total	–	–	2	10
7501.10	Nickel mattes				
	Norway	35 240	378 596	29 885	321 476
	United Kingdom	32 842	229 661	22 475	158 895
	United States	–	–	130	162
	Total	68 082	608 257	52 490	480 535
7501.20	Nickel oxide sinters and other intermediate products of nickel metallurgy				
	United States	589	5 311	311	2 553
	Total	589	5 311	311	2 553
7502.10	Nickel unwrought, not alloyed				
	United States	63 884	648	48 093	470 301
	Total	63 884	648	48 093	470 301
7502.20	Nickel, unwrought, alloyed				
	United States	815	8 580	513	5 864
	Belgium	731	10 105	391	5 344
	Sweden	142	1 931	58	774
	Other countries	137	1 939	60	788
	Total	1 825	22 555	1 022	12 770
7503.00	Nickel waste and scrap				
	United States	4 352	32 256	2 714	14 135
	Netherlands	576	1 917	225	1 413
	Finland	–	–	312	859
	United Kingdom	237	509	173	422
	Japan	15	124	13	28
	Sweden	308	1 846	–	–
	Other countries	68	62	7	19
	Total	5 556	36 714	3 444	16 876
7504.00	Nickel powders and flakes				
	United States	7 202	85 451	5 935	67 921
	Japan	2 314	26 785	1 562	17 225
	Netherlands	386	4 012	234	2 348
	Hong Kong	73	870	108	1 335
	Singapore	61	735	81	986
	People's Republic of China	72	871	65	789
	Taiwan	39	471	70	774
	Other countries	486	6 655	234	3 599
	Total	10 633	125 850	8 289	94 977
7505.12	Bars, rods and profiles of nickel alloy				
	United States	2	35	1	17
	Poland	–	–	1	8
	Japan	...	17	–	–
	Total	2	53	2	25
7508.00	Articles of nickel, n.e.s.				
	Netherlands	..	5 550	..	3 128
	United States	..	689	..	607
	Sudan	..	1 384	..	460
	South Africa	..	7 354	..	–
	Other countries	..	467	..	332
	Total	..	15 444	..	4 527

TABLE 1 (cont'd)

Item No.		1990 (tonnes)	1990 ($000)	Jan.-Sept. 1991p (tonnes)	Jan.-Sept. 1991p ($000)
IMPORTS[2]					
2604.00.00.20	Nickel ores and concentrates, nickel content				
	United States	1	4	2	12
	Norway	24	468	–	–
	Finland	8	80	–	–
	Total	33	552	2	12
7501.00	Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy				
	Cuba	–	–	8 251	43 278
	Australia	3 199	19 494	2 193	13 474
	United States	5 345	8 921	3 718	7 954
	Belgium	–	–	2 118	3 358
	United Kingdom	1 767	5 961	854	2 790
	U.S.S.R.	2 250	17 175	–	–
	Other countries	769	1 870	910	1 951
	Total	13 330	53 421	18 044	72 805
7502.10	Nickel unwrought, not alloyed				
	U.S.S.R.	822	8 231	5 134	50 809
	Norway	1 550	25 394	1 499	13 283
	United Kingdom	1 443	15 366	1 338	12 306
	Other countries	234	2 481	143	1 406
	Total	4 049	51 472	8 114	77 804
7502.20	Nickel unwrought, alloyed				
	U.S.S.R.	–	–	233	2 421
	Norway	30	352	267	1 751
	United States	92	913	135	913
	Other countries	123	492	46	389
	Total	245	1 757	681	5 474
7503.00	Nickel waste and scrap				
	United States	8 008	20 477	9 403	21 878
	United Kingdom	410	538	470	2 019
	Germany[3]	80	211	627	1 261
	U.S.S.R.	–	–	156	824
	France	134	243	185	537
	Switzerland	75	96	73	202
	Norway	337	438	102	125
	Other countries	162	857	51	119
	Total	9 206	22 860	11 067	26 965
7504.00	Nickel powder and flakes				
	Netherlands	–	–	296	2 799
	United States	119	1 761	69	1 054
	United Kingdom	111	1 266	14	290
	Other countries	15	275	6	106
	Total	245	3 302	385	4 249
7505.12	Bars, rods and profiles of nickel alloy				
	United States	414	5 641	112	1 898
	Other countries	21	554	16	273
	Total	435	6 195	128	2 171
7508.00.10	Nickel anodes for electroplating				
	United States	27	167	50	426
	Other countries	1	10	2	7
	Total	28	177	52	433

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available or not applicable; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary.
[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Imports from "other countries" may include re-imports from Canada. [3] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, NICKEL PRODUCTION AND CONSUMPTION, 1970, 1975, AND 1980-91

	Production[1]	Consumption[2]
	(tonnes)	
1970	277 490	10 699
1975	242 180	11 308
1980	184 802	9 676
1981	160 247	8 603
1982	88 581	6 723
1983	125 022	5 010
1984	173 725	7 502
1985	169 971	7 206
1986	163 640	8 865
1987	193 391	9 732
1988	216 589	9 250
1989	200 899	10 423
1990	196 225	8 451
1991p	196 868	..

Source: Energy, Mines and Resources Canada.
.. Not available; p Preliminary.
[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. Data for 1987-91 are nickel contained in concentrates produced.
[2] Consumption of metallic nickel, all forms (refined metal, and in ferronickel oxides and salts) as reported by consumers on the EMR survey "Consumption of Nickel."

TABLE 3. CANADIAN PROCESSING CAPACITY, 1991

	Inco Limited		Falconbridge Limited	Sherritt Gordon Limited
	Sudbury	Thompson	Sudbury	Fort Saskatchewan
			(t/y of contained nickel)	
Smelter	110 000[a]	81 600	45 000	n.a.
Refinery	56 700	49 900	n.a.	25 000

n.a. Not applicable.
[a] Capacity is constrained to this level by the Ontario government regulation on SO_2 emission limits.

TABLE 4. WORLD MINE PRODUCTION OF NICKEL, 1989 AND 1990

	1989	1990
	(tonnes)	
U.S.S.R.	280 000	280 000
Canada	200 900	196 200
New Caledonia	96 200	85 000
Australia	65 000	67 000
Indonesia	64 200	68 600
Cuba	46 300	39 000
South Africa	34 000	30 000
Dominican Republic	32 900	30 200
People's Republic of China	27 500	27 000
Botswana	20 500	19 700
Other	107 300	109 300
Total	974 800	952 000

Sources: Energy, Mines and Resources Canada; International Nickel Study Group.

TABLE 5. WORLD CONSUMPTION OF NICKEL, 1989 AND 1990

	1989	1990
	(tonnes)	
U.S.S.R.	170 000	165 000
Japan	167 300	161 600
United States	108 800	110 100
Federal Republic of Germany	89 100	88 800
France	40 000	44 800
United Kingdom	29 500	32 600
People's Republic of China	29 500	28 000
Italy	30 500	27 300
Republic of Korea	18 300	24 000
Belgium/Luxembourg	18 000	21 300
Other	191 700	180 900
Total	892 700	884 400

Sources: Energy, Mines and Resources Canada; International Nickel Study Group.

TABLE 6. AVERAGE ANNUAL NICKEL PRICES, 1980-91

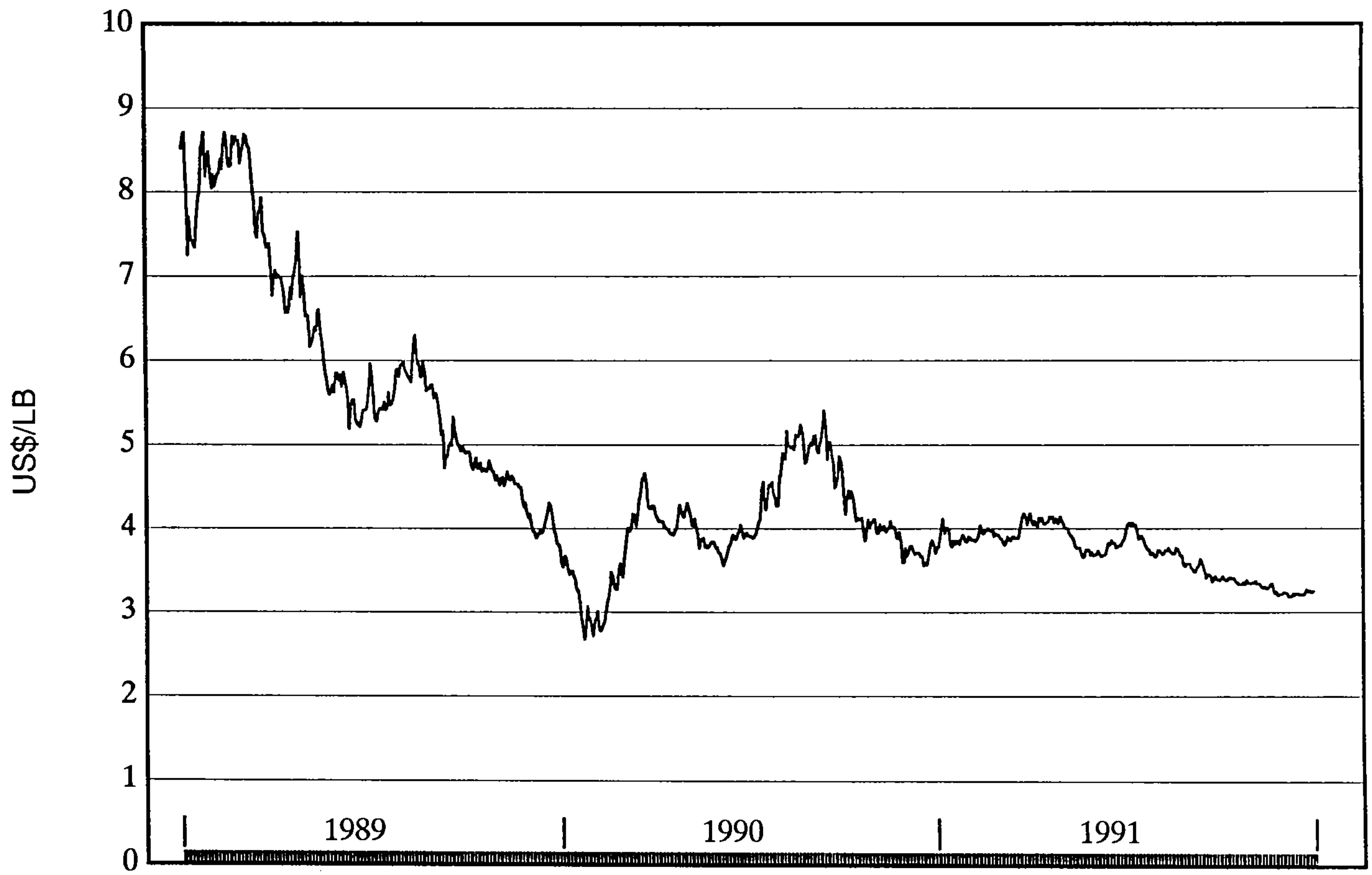
	London Metal Exchange - Spot
	(US$/lb)
1980	2.96
1981	2.71
1982	2.18
1983	2.12
1984	2.16
1985	2.22
1986	1.76
1987	2.19
1988	6.25
1989	6.04
1990	4.03
1991	3.70

TABLE 7. AVERAGE MONTHLY NICKEL PRICES, 1990 AND 1991

	1990	1991
	(US$/lb)	
January	3.21	3.89
February	3.17	3.94
March	4.21	3.95
April	4.06	4.10
May	3.95	3.84
June	3.82	3.76
July	4.23	3.88
August	4.98	3.83
September	4.93	3.48
October	4.16	3.38
November	3.90	3.29
December	3.70	3.23

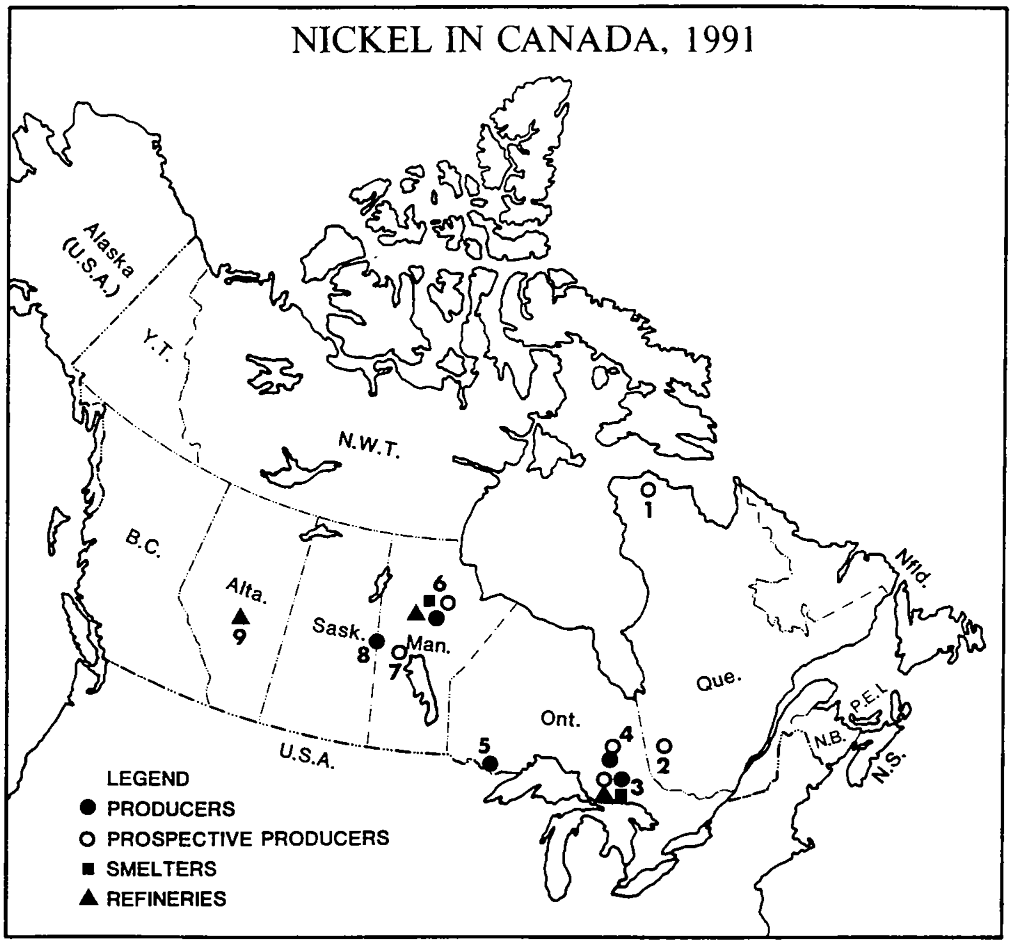
Figure 1

LONDON METAL EXCHANGE NICKEL PRICES, 1989-91



Source: Energy, Mines and Resources Canada.

Nickel



Producers, Prospective Producers, Smelters and Refineries
(numbers refer to locations on map above)

Producers

3. Falconbridge Limited
   (Fraser, Lockerby, Onaping, Strathcona)
   Inco Limited
   (Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood, Levack, Little Stobie, Lower Coleman, McCreedy West, Stobie and Whistle)
4. Timmins Nickel Inc.
   (Redstone, Langmuir)
5. Inco Limited
   (Shebandowan)
6. Inco Limited
   (Thompson, Birchtree, Thompson Open Pit)
8. Hudson Bay Mining and Smelting Co., Limited (Namew Lake)

Prospective Producers

1. Falconbridge Limited (New Quebec Raglan)
2. Timmins Nickel Inc. (Dumont)
3. Inco Limited (Clarabelle, Garson, Murray Totten, McCreedy East, Victor)
   Falconbridge Limited (Craig, Lindsley)
4. Teck Corporation
   (Moncalm Township)
6. Inco Limited (Soab North, Soab South and Pipe No. 1)
7. Black Hawk Mining Inc. (Minago)

Smelters

3. Falconbridge Limited (Falconbridge)
   Inco Limited (Copper Cliff, Sudbury)
6. Inco Limited (Thompson)

Refineries

3. Inco Limited (Sudbury)
6. Inco Limited (Thompson)
9. Sherritt Gordon Limited
   (Fort Saskatchewan)

Peat

Michel Bergeron

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-5474

Peat is an accumulation of organic residues obtained from the partial decomposition of plant debris under very high humidity and anaerobic conditions. In its raw material form, it is ligneous, fibrous and elastic. It has a pH of 2.8-4.0 and an ash content of 0.5%-2.5%. Peat is found in bogs, swamps and marshes. Its main properties are its high water-retaining capacity, low density, high resistance to decomposition, low heat conductivity and high porosity. It can hold up to 20 times its weight in liquids and gas. Peat is divided into two principal types: horticultural peat and fuel peat. Horticultural peat is characterized by a low decomposition corresponding to a von Post value of H1-H5. It has a high fibre content, is light yellowish brown in colour, and contains few colloid residues. Fuel peat is highly decomposed with a von Post value of H6-H10. It is blackish in colour and contains colloid residues.

The total area of peatlands in Canada is estimated at 111 328 000 hectares (ha), covering close to 12% of the country's land surface. Approximately 1.5% of that area is used for agriculture, while urban development accounts for 0.8%, forestry for 0.022%, and horticultural peat harvesting for 0.014%. In 1984, Agriculture Canada estimated Canadian peat resources at 3 004 996 million m^3, a volume which is equivalent to 338 003 million tonnes (Mt) of oven-dry peat.

Canada mainly produces sphagnum peat, which is used in horticulture and agriculture. It is harvested from May to September, primarily in eastern and south-eastern parts of the province of Quebec, in eastern and northeastern parts of the province of New Brunswick, and in the western provinces near Edmonton, Alberta; Carrot River, Saskatchewan; and Giroux and Elma, Manitoba. Some peat production is also found in the provinces of Nova Scotia, Prince Edward Island and Newfoundland.

DOMESTIC DATA COVERAGE

Peat production in Canada in 1991 was estimated at 762 116 t. That tonnage represents a 6.5% increase over the revised 1990 production figure of 715 776 t. The latest data on production, supplied by the provinces, show increases for New Brunswick (from 259 267 t to 307 479 t, or 18.6%), Nova Scotia (31.6%),[1] Newfoundland (from 1621 t to 2229 t, or 37.5%), Alberta (from 69 462 t to 75 282 t, or 8.4%), and Saskatchewan (76.7%), and decreases for Quebec (from 305 822 t to 290 948 t, or 4.9%) and Manitoba (13.2%). As in 1990, no production was reported in Ontario and British Columbia. In eastern Canada, except for some parts of Newfoundland, weather conditions were so good in June and during the first three weeks of July that, for eight to nine weeks, production was almost never interrupted. Rainy days at the end of July and in August slowed the momentum but, overall, the peat harvesting season in eastern Canada was good. In Quebec, except for the region of Saint-Fabien, which was often affected by end-of-the-day rain

---

[1] Production figures are confidential for the provinces of Nova Scotia, Manitoba and Saskatchewan.

storms, the season was quite good. Most of the producers enjoyed 10 to 11 weeks of continuous dry weather that started in mid-May. It rained late in August and during the month of September but, overall, weather conditions in Quebec for the 1991 season were favourable. In western Canada the harvesting season was normal, except for Saskatchewan, which was blessed with extremely good weather conditions.

Peat shipments in 1991 were estimated at 737 059 t valued at $91.7 million. That estimate represents a 4.8% decrease in volume and a 2.2% increase in value over the revised 1990 shipments. Shipments from Quebec and New Brunswick, the two major producing provinces, each accounted for about 40% of the total 1991 shipments. The balance of shipments originated mainly from western Canada. Using 1990 shipment and export data, the apparent Canadian consumption is estimated at about 20%. In Atlantic and western Canada, shipments increased respectively from 282 349 t to 294 073 t and from 267 084 t to 292 004 t from 1990 to 1991. In Quebec, annual shipments reported by the producers showed a decline from 350 411 t to 290 948 t for the same period.

Peat stocks in January 1991 were 4.97 million bales and 3.04 million bales of 170 dm^3 in Quebec and New Brunswick, respectively. When compared to the stock levels of January 1990, these stocks represent a drop of about 1.0 million bales in Quebec and 0.4 million bales in New Brunswick. During the first six months of 1991, stocks decreased gradually reaching 1.92 million bales in Quebec and 1.08 million bales in New Brunswick at the start of the harvesting season. These stock levels were respectively 50% lower and 30% higher than the levels reported at the same time in 1990. Thanks to a good harvesting season, stocks were replenished in July and August and, by September, Quebec reported stocks at close to 6.0 million bales and New Brunswick estimated stocks at 3.5 million bales. Stocks are expected to return to the January 1991 level after the fourth-quarter sales.

Peat exports in 1990 increased 16.1% to 615 982 t valued at $130 million. Canadian producers exported to 26 countries with the United States being by far Canada's major customer, accounting for 88% of total peat exports. Japan ranked second with 10.6%, and the remaining 24 countries accounted for the balance of 1.4%. What seemed to be the beginning of a market penetration in Saudi Arabia in the last two to three years vanished in 1990. Only 41 t of peat were exported to that country in 1990 compared to 5593 t in 1988. However, some progress was made in South Africa where peat exports increased from 252 t in 1989 to 607 t in 1990, and also in the Pacific Rim countries, namely South Korea and Taiwan, where exports have more than tripled from 1989 to 1990. Peat exports to the United States increased 17.7% over 1989, and those to Japan increased 16.8%. Exports to other countries suffered a 41% drop from 1989 to 1990. Canada's better performance in the United States is attributed in part to a greater visibility brought about by an intensive promotional campaign. In Japan, Canadian producers are simply keeping their 85% share of a rapidly expanding peat market. Central and Atlantic Canada accounted for close to 70% of the exports to the United States in 1990. The remaining 30% originated from western Canada. With respect to Japan, data from Statistics Canada show that 88% of Canadian peat exports to that country originated from Atlantic Canada. Central and western Canada accounted for 7% and 5% respectively of these exports. When peat exports for the first nine months of 1990 and 1991 are compared, an increase of 8.6% for the United States and 8.7% for Japan is observed.

There are no peat imports to Canada.

CANADIAN DEVELOPMENTS

In Canada, 76 operations harvested and/or processed sphagnum peat in 1991. The Canadian peat industry provided 1947 jobs on an annual basis. In comparison, according to the recently revised employment figures, 1989 and 1990 represented 1713 and 1735 jobs respectively.

In eastern Canada, Canadian Supreme Products Ltd., a Division of Lameque Quality Group, resumed operation at Rivière-du-Portage, New Brunswick, following the identification of markets suitable to the type of peat being harvested at that location. Hi-Point Industries, a Division of Genesis Pipeline Canada Ltd., built a new plant in 1991 and resumed operation at Bishop Falls, Newfoundland, after suffering a fire late in 1990. Annapolis Valley Peat Moss Co. Ltd. of Bernick, Nova Scotia, has put in place a new operation at Miscou, Prince Edward Island. That operation, which is equipped to produce bales, will function under the name of Miscouche Peat Moss Ltd. In 1991, a project was initiated in New Brunswick to demonstrate that domestic effluents can be efficiently treated with peat moss. The project, comprising three different peat bed systems, will be monitored by The Peat Research and Development Centre (PRDC) of Shippagan, New Brunswick. In 1991, a project, whose objective was to develop ways of recovering peat from running waters, was also initiated. The project was awarded to Gemtec Ltd. of Fredericton, New Brunswick. Gemtec will be working closely with PRDC, who is to provide technical expertise.

In Quebec, considerable activities have been observed at Fafard et Frères Ltée, Division of Sainte-Marguerite. The company now regularly supplies Produits Desbiens Inc., an operation located near Lac-St-Jean, which processes peat to be used in the manufacture of sanitary napkins. The new product launched across Canada last spring by Johnson and Johnson Inc. used the equivalent of approximately 500 000 bales of peat in 1991. Premier CDN Enterprises Ltd. of Rivière-du-Loup pursued its strategy of limiting production to substantially reduce inventories and accelerated its efforts to modernize its operations. Four of the company's divisions (Tardif, Saint-Ulric, Sept-Îles and Trump) remained closed while the St-Arsene Division operated intermittently. In 1991, Tourbières Lambert Inc. acquired automatic presses that were installed at its plant at Rivière-Ouelle. That acquisition follows a corporate strategy to automate all of its operations as much as possible. Lambert's major divisions were all active in 1991, including Les Escoumins and Saint-Paul-du-Nord.

Premier CDN Enterprises Ltd. of Rivière-du-Loup considerably increased its research and development (R&D) activities in 1991. Premier's research centre continues to develop products with a high value content giving special attention to products used for protecting the environment. Premier's R&D efforts were also intensified by its subsidiary, Premier Tech, to design and manufacture equipment that can significantly reduce handling costs in the peat industry.

In collaboration with Serrener Consultations Inc., Fafard et Frères Ltée continued experimenting with a process called "Mediaflex." That process is used to treat effluents generated from domestic garbage disposal and mine tailings sites. The process can also be used to handle muds recovered from septic tanks and filtration plants. Late in 1991, a peat-based system was put in place at the now abandoned East Sullivan mine in Abitibi, Quebec, to clean effluents produced by a large tailings pile. Data will be collected in 1992 to measure the efficiency of such a system.

In the last months of 1991, an affiliate of Ste-Geneviève Resources Ltd., KWG Resources Inc., acquired a surface exploration permit to harvest high-energy peat reserves in the Villeroy region near Val-Alain, Quebec. The company intends to produce activated carbons from the combination of peat and fine crystalline graphite. KWG is currently conducting a pre-feasibility study and a commercial operation could be in place within three years. The types of carbons targeted are those with a low ash content and a pore size suitable for applications such as gold processing.

In Ontario, there was little change from last year. No production was reported from the two firms listed in that province. One company, Atkins and Durbrow Ltd., which suffered from a fire in 1990, has no plan to revive its operation. The owners informed Energy, Mines and Resources Canada (EMR) that the property is for sale. The other company, Lindeidt Peat Inc., changed its name to North Peat Inc. That company, held by McKinnon Prospecting Co. of Timmins, Ontario, gave no indication that it would resume operation in the near future.

In western Canada, Premier Sask Inc. completed the construction of its new plant at Carrot River, Saskatchewan, after being affected by a fire late in 1990. Fisons Horticulture Inc. continued to modernize its facilities in both western Canada and New Brunswick.

THE INTERNATIONAL SCENE

World Production

In 1991, world peat production was estimated by the U.S. Bureau of Mines (USBM) at 184.4 Mt, a small 2.4% increase over the recently revised 1990 production. The 1990 world production was determined to be 180 Mt after adjusting the contribution of the Commonwealth of Independent States (C.I.S.), the former U.S.S.R., from 163 Mt to 149 Mt. In 1990, the U.S.S.R. was still by far the largest producer of agricultural peat with a 97% share, followed by West Germany (0.97%), Canada (0.49%) and the United States (0.45%). Fuel peat production accounted for 14.2% of total world output and was mainly produced in the U.S.S.R. (58.4%), Ireland (24.8%) and Finland (15.9%). World resources of peat were estimated at 1.9 trillion t, of which the U.S.S.R. has about 770 billion t and Canada has 500 billion t.

United States

In 1991, U.S. peat production remained almost unchanged at 700 000 t, valued at US$19 million. About 80 operations harvested and processed peat in 22 states. Florida and Michigan accounted for approximately 60% of the total while Minnesota ranked third as a producing state. Sixty-seven percent of the total volume produced was reed-sedge peat. Humus peat accounted for 17%, sphagnum peat for 13% and hypnum moss for

3%. When compared to the 1990 revised figures, the apparent consumption rose slightly (1.6%) in 1991 to 1.26 Mt. Sphagnum peat, imported almost entirely from Canada, accounted for almost 50% of U.S. consumption. In 1990, sphagnum peat was produced by 14 operations and production amounted to about 55 000 t, or 8% of total U.S. peat output. The 1991 domestic consumption of sphagnum peat, estimated at 615 000 t, decreased by 3% over 1990 if it is assumed that only sphagnum peat is imported into the United States. Canada exported 542 357 t of sphagnum peat in 1990, a 17.7% increase over 1989. During 1991, Canada's export figures for the United States for 1988 and 1989 were revised to 445 286 t and 460 606 t respectively. Such a revision allowed EMR to calculate an average increase of close to 11% per year from 1988 to 1990 for these exports. The U.S. peat import reliance remained unchanged in 1991 at 44%. The average price, f.o.b. mine per short ton, increased by 1% to US$24.40. Imported sphagnum peat prices representing the average customs value were quoted at US$146.18 per short ton in 1990, an increase of 10.7% over 1989. The USBM reports that the U.S. horticultural peat market is projected to grow at about 3% per year, reaching 1.54 Mt by the year 2000. The future demand could be even greater if new uses for peat are developed. There is considerable interest in using peat as a filtration medium for the treatment of domestic, municipal and commercial effluents; for composting; for oil absorption; and for hygienic products.

Japan

In 1990, Japan remained the second largest importer of Canadian peat moss, accounting for 10.7% of Canada's exports. The 1990 volume was 65 633 t valued at $16.6 million. The unit value has been increasing steadily from $209/t in 1988 to $252/t in 1990. In the first nine months of 1991, 54 354 t of peat valued at $12.1 million were exported to Japan. For the same period in 1990, 49 992 t valued at $13.4 million were exported to Japan. These figures show that, although volume has increased by 8.7%, the total value has decreased by 10.7% from 1990 to 1991. The unit value, which was exceptionally high in 1990, decreased by $30/t to $222/t during the first nine months of 1991. Canada is always the main supplier of peat to Japan with, on a value basis, an 88% share followed by Germany (8%), the United States (1.1%), the C.I.S. (1.0%), and the Netherlands (0.8%). Major end uses include industrial landscaping (50%), rice nursery bedding (20%) and greenhouse usage (20%). Horticulture and golf courses account for the remaining 10%. For industrial uses, peat sales are handled by large buyers while distributors and wholesalers handle sales for other uses. Japan continues to import six-cubic-foot bales (170 litres) to serve its market. Most Canadian sales are from Atlantic Canada with Halifax, Nova Scotia, being the port of clearance.

The Japanese market continues to grow rapidly. It reached a volume of 79 289 t in 1990, which represents slightly more than twice the amount reported in 1987 and an increase of 28%/y. Although the Japanese peat market is expected to remain firm, statistics for the first nine months of 1991 seem to indicate that future market increases might be in the range of 5%-10%/y. Japan will continue to rely heavily on Canada. However, significant import increases from smaller suppliers, such as the Netherlands, the C.I.S. and the United States, are being observed. These countries have respectively registered increases of 240% to 945 t, 213% to 1204 t, and 256% to 449 t during the first nine months of 1991.

The Canadian embassy in Tokyo has informed EMR that Japanese shipping companies will discontinue their ocean container service to the east coast of Canada. However, no definite date was given for the structural change, which may force Atlantic peat producers to ship from northeastern U.S. ports such as New York, or from the port of Montreal.

Finland

Finland, the third largest peat producer in the world after the C.I.S. and Ireland, reported its 1990 peat production at 18 million m^3, unchanged from 1989. However, its production of horticultural peat for 1990 decreased 17% to 1.46 million m^3, a volume slightly higher than that of 1988. Vapo Oy, the state-owned corporation, accounted for 87% of total Finnish peat production in 1990. During that year, the company harvested 32 000 ha of peatland and employed 2700 persons at the peak of production. Vapo Oy's 1990 production was the second largest ever achieved; their goals for quality and quantity were surpassed.

Production estimates for 1991 reveal a significant drop in both fuel and horticultural peat, probably as a result of unfavourable weather conditions. The former decreased 50% and the latter decreased 32% over 1990 levels. Data provided by the company show a large fluctuation for both fuel peat and horticultural peat production. In the past decade, Finnish fuel peat output varied from 3.9 million to 20.4 million m^3 while horticultural peat production ranged from 0.6 million to 1.8 million m^3. In contrast, as expected, data related to consumption show a fairly regular increase for both types of peat. Except for the year 1989 when 1.7 million m^3 of horticultural peat was used, a steady increase in consumption from 0.9 million to 1.3 million m^3 was observed for horticultural peat in the last decade. The year 1989 also marked a break in fuel peat consumption with 11.8 million m^3 being consumed. Setting aside the 1989 consumption, the data show that the consumption of fuel peat increased regularly and, on a percentage basis, more rapidly than horticultural peat in the last decade. During that period, fuel peat consumption went from 7.0 million to 14.8 million m^3. It is expected that 17 million m^3 will have been consumed in 1991 and, possibly by the year 2000, the demand will be in the order of 25 million m^3.

Ireland

Ireland, the second largest producer after the C.I.S. with 3% of total world production, has seen its 1990/91 production increase very slightly from 7.56 Mt to 7.64 Mt over 1989/90. Weather conditions were good in 1991, but not as good as those of 1989 which led to a production of 8.4 Mt for 1988/89. In 1991, the harvesting season started early in May, was interrupted in mid-June, and resumed in mid-July for another four weeks.

Bord na Mona, the state-owned corporation, contributed 82% of total Irish peat production in 1991. During that year, the company was the sole producer of milled peat with 5.95 Mt being produced. About half of that amount went to the Electricity Supply Board (E.S.B.). Ninety-seven percent of Ireland's peat production is used as a fuel.

In 1990/91, Ireland's horticultural peat production was estimated at 196 000 t, a 6000-t increase over the 1989/90 season. Approximately 60% of that output came from Bord na Mona, and 85% was exported to about 20 countries, mainly in Europe.

USES

Peat is used in several applications due to its wide range of physical and chemical properties. It is used in its natural state in agriculture and horticulture to loosen up clay soils, to maintain moisture in sandy soils, and to add organic matter and fertilizers to depleted soils. Peat is also used as a horse, cattle and poultry litter to absorb liquids and odours. Peat is used in the production of artificial mixtures such as potting soil, seed carriers, peat-perlite and peat-vermiculite mixes, fertilizers and composts. It is also used in the production of peat pots for sprouting plants.

Peat has several industrial applications. It can be used in the production of paper towels, chemical products, metallurgical coke and activated carbons. Peat is also used to treat industrial and domestic effluents. Its cellular structure, absorbing properties and high capacity for ionic exchange form the basis for its use as a natural filter. Peat can reduce the acidity of drainage from old mines and remove iron oxides from waste and drainage water. Peat has also been used as an oil spillage absorbent and in certain medical applications.

Fuel peat is recognized as an alternate source of energy. This form of biomass is widely used as a fuel in several European countries such as Ireland, Finland and the C.I.S. Fuel peat has a high degree of humification, a high bulk density, a high calorific value, a low ash content, and a low percentage of pollutants such as sulphur and mercury. Canadian peat possesses a calorific value of about 4700-5100 kcal/kg. In comparison, the value for coal is 4800-5800 kcal/kg and for oil, 9900-10 000 kcal/kg. Fuel peat is fired in furnaces to produce the steam needed to drive turbines, which in turn generate electricity. It can also be processed to produce coke, synthetic natural gas and methanol.

OPPORTUNITIES

Small volumes of peat are sold every year to European countries. However, a recent study supported by the Canadian embassy in France indicates that substantial quantities of peat could be sold to France, and eventually to other European countries, if producers took advantage of backhauling to reduce freight costs. For example, the study demonstrates that Canadian peat could be shipped to Le Havre and delivered to Paris and Angers at competitive prices. Further investigation by the industry may lead to an interesting market opportunity for Canada.

Japan continues to be a good market for the Canadian peat industry, particularly for Atlantic producers. However, requests for information from other Pacific Rim countries in 1991 seem to indicate that, in addition to Japan, other countries such as Taiwan should be approached to develop new markets.

Opportunities also lie in new applications. A good example of that is the use of peat in the manufacture of extra-thin, super-absorbent sanitary napkins. Peat also has some potential in the treatment of domestic and commercial effluents. Experimental work presently carried out in Canada in these areas will most likely lead to the development of new peat markets. The same applies to a peat mixture which is presently considered as an avenue to clean effluents from mine tailings. That particular project (referred to in an earlier section of this review) is expected to give interesting results.

Peat

The development and manufacture of field and plant equipment is progressing rapidly in Canada. A vast experience in peat harvesting and processing is being put to use to design equipment that will allow operating costs to be maintained at a competitive level. New engineering products are currently marketed worldwide and, as such, represent an interesting diversification and market opportunity for the Canadian peat industry.

Note: Information in this review was current as of January 31, 1992.

PRICES[1] IN THE UNITED STATES, BY TYPE OF PEAT, 1990

Type	Domestic			Imported[2]
	Bulk	Packaged or Bales	Average	Total
	(U.S. dollars per short ton)			
Sphagnum moss	25.20	84.25	71.02	146.18
Hypnum moss	30.06	62.48	49.99	n.a.
Reed-Sedge	21.00	23.62	22.54	n.a.
Humus	12.01	16.59	12.67	n.a.
Other	. .	4.89	4.89	n.a.

Source: U.S. Bureau of Mines, "Peat," 1990.
. . Not available; n.a. Not applicable.
[1] Prices are f.o.b. plant. [2] Average customs values.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2703.00	Peat (including peat litter) whether or not agglomerated	10.2%	6.5%	2.0%	Free
6815.20	Articles of peat	6.8%	4.5%	4.0%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise.

TABLE 1. WORLD PRODUCTION OF PEAT, BY COUNTRY, 1986-90

Country	1986	1987	1988	1989	1990p
			(000 tonnes)		
AGRICULTURAL USE					
U.S.S.R.e	163 260	163 260	163 260	163 260	149 655
West Germany	2 015	2 000	2 124	1 580	1 500
Canada	740	662	736	812	712
United States	827	865	765	690	690
Netherlandse	400	400	300	300	300
Irelandr	228	258	300	266	300
Finland	335	190	363	444	480
Francee	220	210	200	200	200
Polande	200	250	200	200	200
Hungarye	70	70	70	70	70
Sweden	60	60	60	60	60
Denmark	45	50	50	50	50
Norway	30	30	30	30	30
Spain	63	67	75	75	70
Israel	20	20	20	20	20
Other	30	30	20	55	55
Subtotal	168 543	168 422	168 573	168 112	154 429
FUEL USE					
U.S.S.R.e	19 500	11 430	17 500	16 800	14 965
Irelandr	4 710	6 135	4 055	7 760	6 350
Finlandr	5 080	1 815	3 720	4 445	4 080
West Germanyr	245	240	232	232	232
Subtotal	29 535	19 620	25 507	29 237	25 627
Total world	198 078	188 042	194 080	197 349	180 019

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, "Peat," 1990.
e Estimated; p Preliminary; r Revised.

TABLE 2. CANADA, PEAT SHIPMENTS BY PROVINCE, 1987-91

Province	1987		1988		1989		1990		1991p	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Newfoundland	1	45	2	53	1	77	2	68	2	69
Prince Edward Island	–	–	–	–	–	–	–	–	–	–
Nova Scotia	x	x	x	x	x	x	x	x	x	x
New Brunswick	211	20 405	241	25 428	251	24 910	266	23 857	280	26 934
Quebec	274	25 731	317	30 313	335	41 516	350	41 058	291	38 892
Ontario	x	x	x	x	x	x	–	–	–	–
Manitoba	x	x	x	x	x	x	x	x	x	x
Saskatchewan	x	x	x	x	x	x	x	x	x	x
Alberta	78	15 221	78	15 150	93	18 626	72	13 268	76	14 237
British Columbia	–	–	–	–	–	–	–	–		
Total	662	75 484	736	82 832	812	99 666	775	89 735	737	91 675

Source: Energy, Mines and Resources Canada.
– Nil; p Preliminary; x Confidential.

TABLE 3. CANADIAN DOMESTIC EXPORTS OF PEAT, BY COUNTRY, 1987-91

Country	1987		1988		1989		1990		Jan.-Sept. 1991p	
	Tonnage	Value	Tonnage	Value	Tonnage	Value	Tonnage	Value	Tonnage	Value
		($000)		($000)		($000)		($000)		($000)
Angola	–	–	–	–	7	6	–	–	–	–
Anguilla	–	–	1	2	30	21	18	3	–	–
Australia	480	251	2 723	1 403	1 938	645	1 464	372	1 970	354
Austria	–	–	171	77	–	–	–	–	–	–
Barbados	104	11	5	6	5	5	15	6	38	28
Belgium	–	–	497	147	32	20	179	33	57	19
Bermuda	52	13	66	33	56	11	20	7	31	7
Chile	–	–	–	–	–	–	–	–	36	4
China, People's Republic of	–	–	25	3	24	6	90	20	–	–
Costa Rica	–	–	16	6	–	–	–	–	–	–
Denmark	53	26	27	69	75	145	129	385	54	118
Dominican Republic	14	2	14	6	68	11	54	10	–	–
Egypt	27	15	404	162r	–	–	–	–	–	–
France	9	5	19	27	24	62	117	50	8	10
Finland	7	1	–	–	–	–	–	–	–	–
Germany[1]	10	4	502	182	79	14	7	11	8	11
Greece	64	33	1 220	425	–	–	–	–	–	–
Greenland	18	7	–	–	–	–	–	–	–	–
Guadeloupe	–	–	–	–	13	6	–	–	–	–
Haiti	49	33	49	51	76	67	135	143	22	13
Hong Kong	237	55	65r	9	86	18	37	19	58	15
Iceland	–	–	9	2	50	9	9	2	9	2
India	–	–	–	–	27	16	–	–	–	–
Ireland	11	3	9	2	–	–	–	–	18	2
Israel	63	16	417	101	167	39	475	87	123	30
Italy	17	5	277	71	16	47	250	26	–	–
Japan	35 008	7 659	52 691	11 020	56 226r	12 640	65 663	16 567	54 354	12 093
Jordan	–	–	–	–	243	115	199	84	148	73
Korea, South	67	16	154	44	269	88	1 051	202	434	100
Kuwait	40	27	–	–	62	29	–	–	–	–
Leeward-Windward Islands	22	10	–	–	–	–	–	–	–	–
Malaysia	–	–	–	–	–	–	–	–	219	38
Mexico	–	–	77	16	16	5	36	15	120	16
Namibia	–	–	21	4	–	–	–	–	–	–
Netherlands	204	45	2 718	539	4 571	149	719	140	213	41
Netherland Antilles	–	–	13	6	17	4	–	–	–	–
New Caledonia	–	–	–	–	2	3	–	–	–	–
Niger	–	–	139	31	–	–	–	–	–	–
Norway	11	2	47	18	–	–	–	–	–	–
Puerto Rico	1 736	536	2 018	617r	2 672	489	–	–	–	–
St. Kitts-Nevis	–	–	19	4	–	–	–	–	–	–
St. Lucia	–	–	73	38	5	2	–	–	–	–
St. Pierre and Miquelon	–	–	–	–	–	–	1	..	–	–
Saudi Arabia	299	55	5 593	1 572	1 975	579	41	11	–	–
Singapore	64	26	–	–	–	–	12	1	539	100
South Africa	300	68	393	119	709	252	2 300	607	1 144	263
Spain	–	–	100	11	50	14	4	6	–	–
Switzerland	–	–	56	50	8	23	7	13	–	–
Taiwan	108	37	166	70	135	40	424	206	667	286
Thailand	–	–	–	–	–	–	–	–	23	4
Trinidad-Tobago	29	19	15	6	32	28	82	61	30	6
United Kingdom	3 426	960	510	158	7	10	79	41	8	17
United States	434 813	93 279	445 286r	86 556	460 606	90 669	542 357	110 794	456 086	92 054
Uruguay	–	–	–	–	–	–	8	4	–	–
Total	477 342	103 219	516 605r	103 682	530 378r	106 303	615 982	129 943	516 417	105 716

Source: Statistics Canada.
– Nil; .. Not available or not applicable; p Preliminary; r Revised.
[1] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

Potash

Michel Prud'homme

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-3733

SUMMARY

World production of potash in 1991 was estimated at 25.9 million tonnes (Mt) in K_2O equivalent compared to 27.4 Mt in 1990. The decline was mostly due to a reduction in potash output from the former East Germany, whose production fell 40%, and from the former U.S.S.R. with an 8% decrease. The reduction in world potash production was in response to lower demand, especially in Eastern Europe and Brazil. Canadian mine production rose from 7.0 Mt to 7.44 Mt K_2O while mine shipments remained at the 7.0-7.3 Mt level for the third consecutive year. Mine-site inventories rose by about 300 000 t to 1.59 Mt K_2O. A production increase was registered both in Saskatchewan and in New Brunswick, with the latter accounting for 15% of the total.

In 1991, the global potash oversupply still prevailed as supply capability continued to exceed world demand. With the rationalization that took place in 1991, world nominal capacity for potash was estimated at 36.9 Mt/y K_2O. On an annualized basis, Canadian mines ran at 63% of capacity in 1991 (59% in 1990) while other world producers, excluding the U.S.S.R. which operated at less than 65% in 1991, operated at 80%. Lower output prevailed in the former East Germany as five mines have closed there since the fall of 1990. The decline in this country's output accounted for half of the decrease in world potash production in 1991, while the significant decline registered in the former U.S.S.R. for the second consecutive year accounted for one third. French and Spanish production declined marginally while output decreased very slightly in Israel, Jordan and Italy. Increases in output during 1991 were reported in the United States and Canada.

In the United States, potash fertilizer demand remained sluggish during most of the year, despite some significant sales during the fall period. Pricing indications showed a strong resistance from buyers against any price increases proposed by producers during the year. Total domestic sales in North America have been estimated at 4.97 Mt K_2O, a 4% decrease over last year.

The average unit value of potash shipped by Canadian producers was estimated at C$131.06/t K_2O (f.o.b. mines) in 1991, compared to the readjusted value of C$131.38/t in 1990.

The average unit value of exports derived from export statistics on the basis of port of exit (e.g., Vancouver or Saint John) or a border crossing to the United States was $125.02/t potash (KCl) in 1991 (based on nine-month exports), compared to $108.30/t in 1990.

According to the Canadian Fertilizer Institute, the Canadian potash industry (except for one producer) reported a net profit after taxes and interests of $87.2 million in 1990 compared to a profit of $190.3 million in 1989. The average unit value of sales dropped 6%. Sales and revenues from the domestic markets rose 12%-13% between 1989 and 1990. Profits in 1991 are expected to be slightly higher due to improved netback from offshore sales achieved by Canadians companies; however, since all sales are denominated

in U.S. currency, returns on sales have been hampered by the increased value of the Canadian currency.

CANADIAN DEVELOPMENTS

At the end of 1991, Canadian potash productive capacity was computed at 11.8 Mt/y K_2O, a level that could sustain an operating rate of 95% on an annual basis; however, close to 1.2 Mt/y K_2O of capacity could be considered dormant with idle milling units at the Cory and Lanigan operations. It is believed that such facilities could be reactivated in a relatively short period of time. Of the total Canadian capacity, New Brunswick accounts for 1.16 Mt/y K_2O.

Saskatchewan

Saskatchewan produced about 85% of Canadian potash in 1991, with the industry employing about 3320 persons. During the year, several temporary shut-downs were called by all conventional mines in Saskatchewan for maintenance, vacation and, mostly, for inventory control.

In September, the Government of Saskatchewan, through its Crown-owned corporations CIC Mineral Interests Corporation and CIC Mining Corporation, sold 7 301 133 special warrants of Potash Corporation of Saskatchewan Inc. (PCS) to investment dealers. Each special warrant, sold at C$18.75, comprised one common share of PCS and one half purchase warrant for PCS common shares. A full purchase warrant allows the holder to acquire, until October 1, 1994, one of PCS's common shares held by the Province at a fixed price of C$18.75. The special emission allowed the Province to receive close to $137 million; ultimately, the Province will hold only 1.2% of PCS if all convertible bonds and purchase warrants are exercised.

Potash Corporation of Saskatchewan Inc. (PCS) is the largest publicly held potash producer in the world. In 1991, PCS operated four mines in Saskatchewan. Potash production from all of PCS's units, including tonnage from International Minerals & Chemical Corporation (Canada) Limited, was estimated at 4.0 Mt KCl, an 8% increase over 1990. Sales improved 5% to 3.9 Mt compared to 3.7 Mt in 1990. Revenue in 1991 rose to $311.8 million while PCS's net income increased 78% to $45.2 million. Throughout 1991, PCS continued to pursue its policy of strict inventory control with intermittent shut-downs at all of its operations. In January, the Allan mine remained shut until early February while the other PCS mines resumed operation by January 6. In April, PCS called for a maintenance shut-down at its operations for two to four weeks; in the summer, all of its mines were shut down for an eight-to-nine-week period starting July 1, and in the winter, PCS mines shut down for six to seven weeks starting December 2. In September, PCS sold its 3500 t/y potassium sulphate plant at Big Quill Lake (Saskatchewan) for $755 000 to Big Quill Resources Inc., a new company formed by former employees and based in Wynyard; the experimental plant came on stream in 1987 as a pilot project to experiment with the ion-exchange process to produce industrial-grade potassium sulphate. The new owners plan to invest $1.2 million to expand the capacity of the plant to 7000 t/y K_2SO_4 in 1992. During 1991, PCS continued to recover small quantities of calcium chloride brine from its Cory operation; the brine is being marketed locally for dust control on gravel roads. PCS controls the mining rights to 609 907 acres in Saskatchewan, of which 327 639 acres are located around its current mines and contain recoverable reserves equivalent to close to 1.5 billion t of finished product (KCl). In 1991, the company had 5 620 000 t K_2O of annual installed capacity (9.23 Mt/y KCl at 60.9% K_2O equivalent), corresponding to 48% of the potash productive capacity in Canada.

In the first quarter of 1991, PCS improved its net income to $12.3 million, compared with $3.6 million in the first quarter of 1990; this resulted from higher sales, rising prices and lower operating costs. Increases in offshore sales (+54%) were due to improved levels sold to China, India, Japan and South Korea. In the second quarter, PCS's net income rose 66% to $15.7 million as the total volume sold increased 3%; however, the continuous rise of the Canadian dollar offsets the realized price increase in the U.S. markets. The third-quarter results showed a steady improvement over last year, as net income was $7.2 million higher to reach $9.6 million. Third-quarter sales in the domestic market were down while export sales were 5% higher. For the first three quarters of 1991, PCS produced 3.03 Mt KCl, a 23% increase over the same period last year; sales were up 13%, resulting in a net 20 000 t KCl addition to inventories. At year-end, total employment at PCS was: Rocanville, 336; Lanigan, 316; Allan, 302; Cory, 129; Esterhazy, 3; and Head Office, 151, for a total of 1236 persons compared to 1242 at the end of 1990. The Head Office number includes 58 persons in sales of which 27 reside in the United States.

International Minerals & Chemical Corporation (Canada) Limited (IMC Canada), which is wholly owned by IMC Fertilizer Group, Inc., extracted potash ore from two interconnected underground mines, K1 and K2, at Esterhazy in south-eastern Saskatchewan. IMC Canada controls the mining rights of more than 170 000 acres estimated to contain more than 1.3 billion t of potash ore. In 1991, IMC Canada produced about 2.8 Mt KCl of which over 500 000 t was for PCS's account. Employment at the mines was 916 jobs of which 142 were additional employees dedicated to water inflow-related problems. Throughout 1991, both K1 and K2 operated on a 10/4 (10 days out of 14) schedule; maintenance and vacation shut-downs in the summer equated to four weeks. During 1991, the K2 mine continued to experience water inflow problems. Chemical grouting with calcium chloride is ongoing; high volume pumping of brine is carried out from three basins in the "B block" mining panel. Water inflows were kept at an average rate of 3500 gallons per minute (g/m), compared to 7000 g/m when the initial inflows occurred in 1985. Pumping capacity is maintained at 8000 g/m. In 1986, as a result of the water inflows threatening the operations, IMC Canada initiated claims for a total of $565.2 million from insurers, including a sue and labour component of $315 million. These claims are for property damages, losses and efforts. The litigation is still at the discovery stage; total stated policy limits are at $250 million.

In mid-1991, IMC Canada and PCS extended their five-year-term Mining and Processing Agreement at Esterhazy; the renewed agreement gives PCS a 25% equity option to any new development (i.e., a new mine) if this option is pursued. In early 1992, IMC Canada will submit an Environmental Impact Statement (EIS) for a new replacement mine near Esterhazy. The provincial government's evaluations of the EIS are expected in the spring of 1992. The $400 million project encompasses the sinking of two shafts over a five-year plan. A new 4.2 Mt/y KCl mine would be located 8 km northeast of the existing K2 mine; present milling facilities will be used as mined potash ore will be transported to the mills through a proposed 8-km sub-surface pipeline using metal capsules propelled by compressed air. In 1991, seismic work was carried out around the three test holes drilled in 1990.

Potash Company of America (PCA), a division of Rio Algom Limited, extracts potash by solution from the old underground mine that flooded in 1987. The potash extraction process involves the pumping of diluted brine down into the mine for dissolving in-situ potash ore, and the recovery of concentrated brine into surface cooling ponds that cover more than 130 acres. During periods of cold temperature, the potash in the brine precipitates at the bottom and is dredged; the potash material is then processed through crystallization and compaction to produce crystalline standard and coarse grades. Close to 126 persons are employed at Patience Lake. In 1991, the mine produced about 240 000 t of KCl. Also during 1991, an extended summer shut-down lasted from July until October. Some of the salt volume extracted from tailings is sold to Nickel Salt Corp. owned by Sifto Canada Inc.

Central Canada Potash (CCP), a division of Noranda Minerals Inc., produced 1.03 Mt KCl in 1991. Potash is mined from the underground mine at Viscount, east of Colonsay. Shipments were slightly higher for a second consecutive year, resulting in a small reduction in inventories. The operation shut down for four weeks in the summer, effective July 12. During 1991, a communication application project was initiated to experiment with underground communication techniques and to study radiowaves propagation. In August, a small electrical fire caused damages to the mine's motor control centre. Mining operations were carried out in Blocks II and III; development work is under way in Block IV. In June, employees at CCP accepted a two-year contract for the 380 workers represented by the United Steelworkers of America; the contract includes a 10.2% wage increase over two years.

Cominco Ltd. produced 1.03 Mt KCl in 1991 in its Vanscoy mine, a slight 5% reduction from 1990 level. The operation ran on a seven-day-per-week schedule throughout the year except for a five-week maintenance shut-down in the summer and a one-week vacation period in December. Employment in 1991 was 338. Nu Salt Corp. recovers some salt from the tailings to sell it as a de-icer in the local market.

Kalium Canada, Ltd. operates a large solution mine at Belle-Plaine, west of Regina. During 1991, the company produced 1.69 Mt KCl, a 10% increase over the previous year. Sales were slightly lower, resulting in a marginal rise in inventories. The plant operated at reduced rates in April and July, and had a two-week maintenance shut-down in November. The plant is set to run continuously, 24 hours per day, 365 days per year. At Kalium, by-product salt brine is shipped to the nearby salt evaporation plant operated by Canadian Salt Co. Ltd. Some volume of salt waste has been dissolved and re-injected underground. Employment in 1991 was 321.

In March 1991, the Saskatchewan potash industry received close to $2.9 million from the Western Economic Diversification office, a federal agency, to conduct research in waste management practices and effective environmental protection technologies, advanced production methodology and mining efficiency, and on transportation, handling and product quality. The funds, to be managed by the Saskatchewan Potash Producers Association, are part of a five-year $8 million program financially shared by the producers and the federal and provincial governments.

In 1991, the Neptune Bulk Terminals, located west of the Second Narrow Bridge in the Vancouver area (British Columbia), announced an expansion plan that involves the construction of a new A-frame potash storage shed with a capacity of 100 000 t of product, the installation of a new reclaimer (3000 t/h), and a second railcar dumper. The Neptune potash-loading capacity will expand from 2.8 Mt/y to 4.3 Mt/y KCl. Construction started in May 1991, with completion expected by the end of 1992. The terminal operates on land leased from the Vancouver Port Corporation, and is owned by a consortium of companies that includes Canpotex Ltd. The other potash terminal in the Vancouver area, Vancouver Wharves, has been planning to double its 155 000 t potash storage capacity and to install a second railcar dumper.

In August, CP Rail announced plans for a $3 million program to move potash from the Saskatoon-Lanigan area through a more direct route to reach U.S. markets. Currently, potash exports to the United States are shipped eastward through Winnipeg to reach the Emerson (Manitoba) border-crossing point. With the acquisition of the U.S.-based Soo Line Railroad in 1990, CP Rail expects to achieve greater efficiency in routing potash southbound to the U.S. midwest markets through North Portal, Saskatchewan. The program involves the construction of car storage and hopper-car clearing tracks near Belle-Plaine, an expansion of inspection trackages at Moose Jaw, and an addition to the rest-house at North Portal; construction started in August for completion by early 1992.

During 1991, several trial shipments of potash were routed to the west coast via the Burlington-Northern lines to U.S.-based terminals. Reports of better rates and delays in expansion at Vancouver-based terminals prompted Canadian potash suppliers to move some tonnages to Longview (Washington) and Portland (Oregon). Further trial shipments are expected in 1992.

New Brunswick

In January 1991, the New Brunswick government introduced a new policy concerning the acquisition of potash and related mineral rights in the province. The new "potash exploration policy" allows an individual or a company with a valid prospecting licence to apply for an exploration agreement to search for potash in an area of their choice on a "first-come, first-served" basis. An agreement to search is to cover a minimum of 10 000 contiguous hectares, to a maximum of 20 000 contiguous hectares. At the time of each annual renewal, the area of search could be reduced, but not to lower than a minimum of 10 000 hectares. Escalating work requirements ($63 000 per 10 000 hectares in year one) are to apply similarly to other requirements imposed on mineral claims under the *Mining Act*. The term of the Exploration Agreement may be extended from year to year provided the holder meets certain terms and conditions. This new policy has been adopted to make potash more openly available for exploration.

In August 1991, the federal government announced its financial support for an agronomic research and education program to be conducted in Latin America in order to increase New Brunswick Canadian potash exports. The $320 000 program is to be directed by the Potash and Phosphate Institute of Canada over four years, and is funded with the assistance of the Atlantic Canada Opportunities Agency, the Western Economic Diversification program and the Province of New Brunswick.

Potash Company of America (PCA), a Division of Rio Algom Limited, operates the Penobsquis underground mine (also referred to as the Plumweseep mine) about 5 km east of Sussex, in Kings County. The mine started operating in 1983 with a nominal capacity of 380 000 t/y K_2O. In 1991, production was about 670 000 t KCl, a slight 3% increase over 1990. The mine operated throughout the year at full capacity but closed for eight days in August for maintenance. It operates on a seven-day-per-week schedule. During 1991, PCA pursued some expansion work with the installation of a new compactor fines elevator bucket, a third crystallizer, an additional boiler and a new process control room. These new additions are part of PCA's $5.8 million program for increasing productivity. The operation returns all its tailings and slimes underground, keeping a fine balance in its cut and fill process. Mining is carried out using two extraction methods: room and pillar in horizontal and salt beddings, and cut and fill with mechanical miners in dipped potash orebodies using Voest-Alpine and PCA equipment. The average "run-of-the-mill" grade varies between 23% and 24% K_2O. Common salt is also co-produced at an annual rate of 400 000 t and is sold commercially through a sales agent as de-icing material in North American markets. In 1991, PCA employed 347 workers. Potash products for export are hauled 85 km to the Courtenay Bay potash shipping terminal in Saint John, which PCA operates on behalf of the two New Brunswick potash producers.

Denison-Potacan Potash Company (DPPC) produced 1.2 Mt KCl in 1991, a 23% increase over 1990. DPPC has been mining potash since 1985 at the Cloverhill mine located 20 km southeast of Sussex, New Brunswick. Within the mining panels, potash ore is extracted on a room and pillar system utilizing mechanical cutters (Mariettas and Voest-Alpine machines) and conventional drill and blast. The ore grade averages 23% K_2O. Since 1990, the company has been returning slurried tailings underground using a hydraulic backfilling system; prior to 1990, a dry backfilling method was used but performed poorly, achieving only a maximum 60% filling rate. The new hydraulic system permits close to 92% of mill tailings to be returned underground; recovery rates have reached over 120 000 t/m since last year with the remainder being stored temporarily on the surface. Excess brine and rainfall run-offs from the surface tailings are disposed of through a 32-km pipeline in the Bay of Fundy. Alternative technologies such as deep well injection are currently under investigation through the Environmental Impact Assessment process. Small volumes of salt are recovered intermittently from the surface tailings by the New Brunswick Department of Transportation and used locally for de-icing purposes. During 1991, there was a five-day maintenance closure in September. Routine 24-hour-per-month maintenance shut-downs are also practised. Employment in 1991 was about 580 jobs, of which 510 were on DPPC payroll and the rest on contract. Early in 1991, the financially troubled Denison Mines Ltd. announced its intention to sell its 60% share in the Denison-Potacan Potash Co. following the default of providing a principal repayment of $13.1 million to a consortium of 19 banks that funded the project. On April 11, Potash Company of Canada (Potacan), which already owns a 40% share in the operation, acquired Denison's interests for $15 million in cash with the assumption of $106 million in related liabilities. The net book value of Denison's share in DPPC was reported at close to $160 million. Potacan's shareholders are Entreprise Minière et Chimique (EMC) of France, and Kali und Salz AG of Germany, each with a 50% stake in Potacan. DPPC has been renamed Potacan Mining Co. (PMC).

Manitoba

Following the purchase of Canamax Resources Inc.'s share (51%) of the Manitoba Potash Corporation in 1989, Entreprise Minière et Chimique of France continued to study the feasibility for the development of this deposit located near Russell at the Manitoba-Saskatchewan border. This reassessment will be carried out in the context of the worldwide oversupply of potash, which is likely to continue until the end of this decade.

CANADIAN POTASH TRADE

Canada is the world's largest potash trading country with a 40% share of global trade. Germany is the second largest, followed by the former U.S.S.R. Canada exports potash to more than 35 countries, although only 6 countries account for close to 80% of Canada's total exports of potash.

Canadian potash is shipped mostly to the United States (54%) and Asia (32%), with the remainder being sent to Latin America (6%), Western Europe (4%) and Oceania (4%). Exports to Europe, Africa and Latin America are sourced equally from Saskatchewan and New Brunswick. Saskatchewan accounts for the bulk of Canada's exports to the United States (95%) and Asia (93%), while New Brunswick's main destinations are Latin America and Western Europe.

On a nine-month basis, data compiled by Statistics Canada indicated that potash exports were valued at C$923.7 million, with tonnages totalling 7.9 Mt KCl, a 7% decrease compared to the same period last year. The United States remained the dominant destination with 4.6 Mt KCl, a slight 4% increase over last year. In the offshore markets, sales to Asia were steady, accounting for two thirds of Canada's offshore shipments. Improved sales were registered to China and South Korea while volumes declined in Indonesia and Japan. Shipments to Latin America decreased drastically as a result of lower sales to Brazil (-25%) and Colombia (-50%). Sales to Western Europe demonstrated a significant reduction with much-reduced shipments to France (-33%), Denmark (-50%) and the United Kingdom (-90%); gains were observed in Belgium. Exports to Africa and Oceania were marginally lower compared to last year.

In 1990, Canada was the world's leading exporter in North America and Oceania with a respective 90% and 91% market share. In Asia, Canada was the major exporter accounting for 41% of the total trade in this region, followed by the former U.S.S.R. (20%). In Western Europe, the Federal Republic of Germany maintained its prominent position with a 25% share of total imports, followed by the U.S.S.R. (16%), Israel (15%) and the former East Germany (14%), while Canada held an 8% share. In Eastern Europe and the Middle East, potash shipments from Canada were non-existent as imports were met by the

Commonwealth of Independent States, Germany and Israel. In Africa, Israel was the major supplier with a 30% share; Canada held a 15% share in this market.

INTERNATIONAL DEVELOPMENTS

For the third consecutive year, world production of potash declined substantially to an estimated 25.9 Mt K_2O in 1991, compared to 27.4 Mt in 1990. There was a significant improvement in potash demand in Southeast Asia while sales in North America and Western Europe demonstrated some maturity. The principal cause for the decline in demand was the continuing collapse in potash consumption in both Eastern Europe and the U.S.S.R. Canada continued to act as the principal residual supplier as many suppliers continued to manage recovery with operating rates varying from 50% to 90% of capacity.

Americas

Argentina

Minera Tea S.A. reached an agreement with Interamerican Investment Corp. (ITC), a subsidiary of Inter-American Development Bank, to evaluate the feasibility of a 250 000 t/y KCl solution mine near Malargue in the Mendoza Province, 960 km south of Buenos Aires. A new company, Potasio Rio Colorado S.A., has been formed and will spend more than US$6 million for further exploration work and the sinking of trial brine wells. The project is to be developed in two phases: the first phase encompasses a pilot project of a duration of 22 months for the evaluation of the technical feasibility, while the second phase, of a duration of 19 months, would include the construction and commissioning of extraction and processing facilities. Pending satisfactory results, the US$60 million project is targeted for completion in 1994 if sufficient funds can be secured. During the preliminary exploration work, close to 86 holes have been drilled delineating potash ore lenses with widths varying between 11 m and 22 m, at depths ranging between 750 m and 1150 m. Resources have been estimated at close to one billion t of high-grade silvinite ore. Beside the uncertainties that relate to technical factors still to be assessed, the transportation of potash to markets will present a major challenge.

Bolivia

A new company, Complejo Industrial de Recursos Evaporiticos del Sayar e Uyuni (Ciresu), was formed to promote the exploitation of the saline deposits at Salar de Uyuni in southwestern Bolivia. These deposits are reported to contain 0.0025% lithium, 0.54% magnesium, 0.62% potassium and 9.1% sodium; potash reserves were estimated at over 100 Mt K_2O. During 1991, the Bolivian government held public auctions to seek partners in this project.

Brazil

The Taquari-Vassouras mine in the Sergipe District of Brazil continued to operate until December 20, 1991, despite the liquidation process of Petrobras Mineraça S.A. (Petromisa) that was initiated in April 1990. Special stockholders meetings in August and October 1990 allowed the company to continue operating in order to facilitate liquidation using its own resources and extended the liquidation period to April 1991. In 1991, potash production from underground ore was estimated at 90 000 t K_2O. During 1991, contracts with contractors were rescinded; only indispensable contracts were kept.

Five hundred and twenty employees were laid off, disposable goods were auctioned, prices were restructured to reflect market conditions, and Sergipe's capacity utilization was raised. However, late in 1991, the Brazilian government officially ceased the activities of Petromisa. The mining operation was then leased for 25 years to the state-owned mining company, Comphania Vale do Rio Doce (CVRD). A 2.5% royalty on net revenues will be paid by CVRD to Petrobras. An investment of close to US$25 million will be needed to reactivate and upgrade mining and milling facilities. Potash production is targeted at 500 000 t/y KCl by 1993, and ultimately at 1.0 Mt/y KCl. Exploration work was carried out near Santa Rosa de Lima (16 km west of Taquarri-Vassouras) for delineating reserves that have been estimated at 66.9 Mt of in-situ potash ore, equivalent to 15.5 Mt K_2O. Petromisa was involved in engineering studies for evaluating the possibilities for a solution mine in carnallitic ore. During 1991, Unisais, a subsidiary of Uniao Industrias Petroquimicas S.A., pursued preliminary exploration activities for the development of a potassium sulphate (20 000 t/y) and sodium sulphate (40 000 t/y) operation near Macau. The rights to the saline deposits are owned by the Henrique Lage Salt Group. The Aguas Maes project calls for a total investment of approximately US$150 million for completion by the year 2000. Close to US$2 million has been invested in a pilot project under a loan from Finep, a government agency.

Chile

Sociedad Mineral Salar de Atacama Ltda (MinSal Ltda) continued to evaluate the feasibility of extracting potash and other salts from brines in the Atacama desert some 200 km east of Antofagasta. MinSal Ltda was created in 1986 with the participation of Amax Exploration Inc. (holding a 63.75% share in the project), Molibdenos y Metales S.A. (11.25%) and Corporacion de Fomento de la Produccion (25%). The boric-lithium-potash deposits are reported to contain 0.125% lithium, 0.91% magnesium, 1.87% potassium and 6.92% sodium. Potassic reserves were estimated at 47 Mt KCl and 21 Mt K_2SO_4. Since 1988, potash has been extracted by La Sociedad Chilena del Lithio Ltda at a 20 000 t/y K_2O facility; potassic products are transported to a KNO_3 plant operated by Soquimich at Maria Elena.

United States

Production in the United States in 1991 increased 2% to 1.69 Mt K_2O compared to 1.65 Mt in 1990. Total sales remained virtually unchanged as gains in offshore sales (+26%) were totally offset by a reduced level of shipments within North America (-12%). In the first half of 1991, domestic sales were 5% lower while exports doubled with higher sales, especially to China and Brazil. The value of production was estimated at US$300 million. Inventories at year-end grew 14% to 338 000 t K_2O. Five companies operated six mines employing 1301 workers. Based on an estimated productive capacity of 1.92 Mt/y K_2O, the U.S. potash industry ran at 88% of capacity. In 1991, Great Salt Lake Minerals & Chemicals Corporation (GSL) announced its intention to invest US$20 million for expanding its production of potassium sulphate at Little Mountain, Utah; the project plans to double the size of the evaporation ponds to 39 500 acres, with an allowance for an additional 17 000 acres. Productive capacity is to increase from 180 000 t/y to 360 000 t/y K_2SO_4 by 1994. Early in 1991, Kerr McGee Chemical Corp. sold its sodium carbonate division to an investment group headed by D. George

Harris & Associates for US$220 million; this group has formed a new company, North American Chemical Co., which also owns GSL. In January 1991, Amax Potash Corp., a wholly owned subsidiary of Amax Inc., signed a letter of intent with Horizon Gold Corp. for selling its 300 000 t/y K_2O potash mine and processing units in Carlsbad, New Mexico. Potash reserves at Amax Potash Corp. are estimated to last seven to eight years at the current rate of extraction. Following the expiration of the initial letter in August 1991, a new one was signed in December under the same terms. In 1991, Amax Potash had sales reported at US$40 million and employed close to 400 persons. Kalium Canada, Ltd. continued its experimental work at the solution mining pilot project at Hershey, Michigan; the company started a small pilot plant with a capacity of about 40 000 t/y of granular product. Potash beds occur at depths over 8000 feet. Commercial development on a larger scale is not expected before the mid-1990s.

Europe

In 1991, the European Community (EC) continued its investigation into the allegation of the U.S.S.R.'s dumping of potash into EC markets. The complaint was lodged in 1990 by the European Potash Producers Association (EPPA) on behalf of potash producers within the EC, representing 100% of the total Community's production. Results of the investigation were expected in 1991, but are likely to be finalized in 1992.

Commonwealth of Independent States

In 1991, the former U.S.S.R. remained the world's leading producer of potash and the second leading exporter after Canada. During the year, major social and economic changes affected the political landscape of the U.S.S.R. Late in 1991, the Soviet Union was dissolved and eleven Republics formed the new Commonwealth of Independent States. Most of the production, distribution and marketing functions for raw materials, such as potash, have been taken over by individual Republics. In the former U.S.S.R., potash was produced in Byelorussia at the Soligorsk complex (which accounts for 42% of total capacity), in Russia at the Sylvinit and Uralkali complexes (a combined 53% share), and in Ukraine (a 5% share). In 1991, potash production declined for a second consecutive year to an estimated 8.4 Mt K_2O, a 7.6% decrease over 1990. The decline was in response to a much-reduced demand for potash in both the domestic and central European markets. Despite cutbacks in production, Soviet potash remained highly available for export. Major gains in sales were registered in India, China, Brazil and the United States in 1991. The destabilization of the economic situation and the disintegration of the domestic transportation system continued to affect planned developments in the potash industry. The commissioning of a new processing plant at Berezniki 4 with a capacity of 625 000 t/y K_2O has been postponed beyond 1992, while expected increases in production at other mines were delayed until further improvements in world markets are realized. The potash industry could still manage to expand its output by 1.6 Mt/y K_2O by 1997 pending favourable market conditions; however, inefficient handling and transportation systems, chronic shortages of essential equipment and obsolete plant designs at some potash-processing facilities may hinder this capability. The expansion of port facilities has been envisaged at Yuzhnyy on the Black Sea, at Murmansk in northwestern Russia, and at Vanino or Vostochnyy on the Sea of Japan.

France

Production in 1991 decreased by 140 000 t to 1.15 Mt K_2O. During 1991, Mines de Potasse d'Alsace (MDPA), a subsidiary of Entreprise Minière et Chimique (EMC), extracted potash at two underground mines, Amélie and Marie-Louise, near Mulhouse in Alsace. EMC also has a 50% share in Potacan Mining Company in New Brunswick. The Société Commerciale des Potasses et de l'Azote (SCPA), also a member of the EMC group, sells potash on the domestic market on behalf of MDPA and other suppliers, including the U.S.S.R., through the Ferchimex agency. During 1991, SCPA doubled its intake from Ferchimex to 200 000 t K_2O. SCPA signed a cooperative agreement with Uralkali, a Soviet potash complex in Russia, for pursuing agronomic research. MDPA carried out development work at the Marie-Louise operation to prepare for the mining of the last big panel in the western part of the deposit at a depth of 1050 m; this development would allow the operation to run for another 10 years before shutting down permanently. MDPA installed new compactors for increasing its production of granular products and, in 1991, new long-wall shearers were acquired. EMC sought government authorization for a project of toxic waste storage in an old mine closed since 1974. During the year, EMC continued its exploration activities for potash in Congo-Brazzaville. SCPA and Dead Sea Works Ltd. of Israel signed a 10-year contract starting in 1992 under which close to 200 000 t/y KCl will be supplied from Israel for sale to the French market.

Germany

In the Federal Republic of Germany, production of potash remained virtually unchanged at 2.2 Mt K_2O. Early in 1991, Kali und Salz announced its intention to shut indefinitely the Salzdetfurth mine near Hildesheim by early 1992. The operation, which has a capacity of 310 000 t/y K_2O, has been producing magnesium chloride and potassium chloride products. The closure results from weak market conditions that prevail in Europe. In the former German Democratic Republic, production in 1991 decreased 40% to 1.65 Mt K_2O; much of the decline resulted from the closure of several mines and the drastic collapse of the East European demand for potash experienced since 1990. During 1991, the German Ministry of Finance allocated 341 million Deutsche Marks (equivalent to US$205 million) to the former East German potash industry in order to assist with the implementation of a restructuring planned in 1990/91 by MittelDeutsche Kali AG (MDK), the new holding company formed in 1990. The funds are to be made available within the next two years through Treuhandanstalt, the federal holding company of former state-owned firms. The restructuring program is to focus on mine rationalization and workforce reduction. From a previous level of 32 000 workers, less than 9000 jobs are to be maintained by the end of 1992. Since mid-1990, five mines have shut down: Bleicherode (fall 1990), Volkenroda (fall 1990), Dorndorf (spring 1991), Sollstedt (summer 1991), and Sondershausen (summer 1991); the closures removed close to 1.0 Mt/y K_2O of capacity. By the end of 1991, the productive capacity of the East German potash industry has been estimated at 2.3-2.4 Mt/y K_2O with five active mines located at Bischofferode, Merkers, Rossleben, Unterbreizbach and Zielitz. MDK has also decided to join the Vienna-based Kali Exports AG, the European potash export organization, for managing all sales of its potash products outside of the European Community and North America. KALI-Bergbau Handelsgesellschaft GmbH, a subsidiary of MDK, will continue to sell MDK's potash to other markets. The German government continued to evaluate the project of using closed potash mines in the Thuringia and Saxony-Anhalt regions as storage sites for hazardous waste. A potassium sulphate plant at Dorndorf was also shut down.

Italy

Italian production of sulphate of potash (K_2SO_4) has been estimated at 40 000 t K_2O in 1991, compared to 68 000 t in 1990. Italkali resumed its operation early in the fall of 1991 at its potassium sulphate plants in Sicily. Major works were undertaken to alleviate the water shortage that forced the shut-down of their operations in June 1990. During 1991, the water supply system was upgraded with the installation of new pipelines and the construction of a new water desalination plant began.

Spain

Production of potash in 1991 declined slightly to about 585 000 t K_2O, a 15% decrease over 1990. Part of the loss in output that resulted from the closure of the Cardona mine in May 1990 has been marginally compensated for by higher output from the Llobregat mine. During 1991, Potasas del Llobregat S.L., a subsidiary of Ercros S.A., was sold to Instituto Nacional de Industria (INI), a state-owned industrial holding company. The restructuring of the Spanish potash industry has continued since 1989 when INI acquired control of the Suria mine from Fodina (an INI subsidiary) and Minas Potasas de Suria S.A.; the acquired operation is run by Suria K S.A., a subsidiary of INI. Both the Suria and Llobregat mines are located in Catalonia. INI also holds a 50% interest in the third Spanish potash mine, Potasas de Subiza in Navarra. All of INI's potash sales continue to be handled by Comercial de Potasas SA.

United Kingdom

In 1991, Cleveland Potash Ltd. (CPL) produced close to 490 000 t K_2O compared to 488 000 t in 1990. Potash is mined from the Boulby mine in North Yorkshire at a depth of some 1100 m. The potash product is railed 32 km south from the mine site to the Teesbulk handling terminal which underwent upgrading work during 1991 with the addition of a new 750 t/h loading system. CPL announced its intention to invest about US$10 million in its operation for the installation of a new leach filtration unit to improve potash recovery from waste slimes, and for new compaction and screening facilities. Overall, recovery is expected to increase 5%.

Middle East

Israel

Dead Sea Works Ltd. (DSW) produced about 1.27 Mt K_2O in 1991, a 2.2% decrease over 1990. During 1991, the state-owned company Israel Chemicals Ltd., the parent company of DSW, approved a plan for expanding DSW operations; the productive capacity is expected to expand from 1.38 Mt/y K_2O to 1.5 Mt/y by 1992. DSW will be investing close to US$30 million to solve its problems related to "salt mushrooms" (hard crystalline salt formations) that occur in the evaporation ponds. Two modified bucket-wheel dredgers will be upgraded with dual wheel cutters and tested in 1992.

Jordan

Production in 1991 declined 3.5% to 810 000 t K_2O. Also during 1991, the Arab Potash Co. Ltd. (APC) continued its activities for expanding its productive capacity by 400 000 t/y KCl to 1.8 Mt/y. Additional production is to include both potassium chloride and potassium sulphate. Financial assistance has been secured from the Islamic Development Bank for a US$15 million loan, and from the World Bank with a US$15 million loan payable over 15 years. The US$106 million project is due for completion in 1993; a further 400 000 t/y KCl expansion is contemplated before the year 2000. APC is also involved in a project to exploit residual salt being returned to the sea as waste. Feasibility studies were completed in 1991. The cold leach crystallization project involves the partnership of the Jordan Industrial Consortium Engineering Company. Close to 200 000 t/y of potassium sulphate is to be recovered as well as bromine and sodium carbonate by the mid-1990s.

Asia

China

Potash production is derived from brines in the Qarhan Lake in the Qinghai Province situated about 4000 km west of Beijing. Two plants operated in 1991 for an estimated output of 60 000 t K_2O. The first Qinghai potash plant has an annual capacity of about 55 000-60 000 t of 90% KCl product, while the second and newer Qinghai potash plant has a designed capacity of 200 000 t/y KCl.

Japan

The Co-op Chemical Co. commissioned a fifth potassium sulphate plant at Niigata in the Higashimo Prefecture; the 20 000 t/y K_2SO_4 plant uses the Mannheim process. Close to 8000 t/y of products will be used by the company, with the remainder to be sold to Zen-Noh. Asahi Glass took a 10% share in the Association of South-East Asian Nations (ASEAN) potash project in Thailand. Zen-Noh announced its intention to establish a joint venture with a Russian agency to build a fertilizer export terminal in the Far East at Vanino, near Nahodka; the targeted storage capacity has been quoted at 1.0 Mt/y of products.

Thailand

Early in 1991, the Thai government concluded a joint agreement with six other countries of ASEAN to support the US$286 million project for establishing a new 1.0 Mt/y KCl potash operation at Bamnet Narong in the Chaiyaphum Province, about 285 km north of Bangkok. Five Thai firms hold 40% and include Charoen Pokhand Group (13.67%), Padaeng Industry (10%), Industrial Financial Corporation of Thailand (10%), International Fertilizer Corp. (5%), and Utsahakam Pu Chemi (1.33%); the Thai government holds 20%. Other ASEAN partners include Japan's Asahi Glass (10%), Indonesia (13%), Malaysia (13%), and the Philippines, Singapore and Brunei Darussalam with 1% each. The ASEAN Potash Mining Co. Ltd., formed in 1990, invited tenders in April 1991 for the construction of a service shaft and initial mining development work. The whole project includes an underground mine, which would bear one third of the total cost, and a surface processing plant. Construction at the future mine site started in 1991 with completion projected for 1995. The mine is to use a room and pillar extraction method in carnallite ore; finished potash products are to be railed some 500 km from the mine site to the deep-sea port of Map Ta Put in the Rayong Province for access to the Gulf of Thailand. Rock salt and magnesium chloride will be co-produced. The project is being developed under the auspices of ASEAN's industrial program.

PRICES

On average, potash prices in 1991 were higher than in 1990. Domestic prices were static, with a slight weakening trend by the end of the year; the strengthening of the Canadian dollar during 1991 offset the benefits of the marginal price increase obtained in the North American market. In offshore markets, producers achieved an 8%-9% price increase, f.o.b. Vancouver, on most of their sales to the Asian market.

The price, f.o.b. Vancouver, quoted in U.S. dollars, is the basis for most Canadian international offshore sales. The importance of China in world potash trade, and especially for Canada, has resulted in making the Canada-China negotiated price a benchmark in pricing indications for international contracts. In many markets, prices are also quoted on a delivered basis c.i.f. national ports. Canpotex Limited, representing all Saskatchewan potash producers, sells both f.o.b. Vancouver or c.i.f. foreign ports, or out of warehouses in Southeast Asia.

The re-emergence of China as a significant potash importer late in 1990 created some bullish expectations in the international marketplace. Entering 1991, contract prices for exports of potash from Vancouver were quoted at US$98-$101/t for standard grade in bulk shipments.

During the first quarter of 1991, no major agreements were concluded for the first-half contracts, but early quotations in 1991 were suggesting some increases in the US$10/t range. Late in April, Canpotex Limited of Canada and Sinochem of China reached a major agreement for a total 1991 tonnage of 950 000 t KCl at US$110.00/t, an increase of US$9.50/t over last year. The contract called for shipments of 500 000 t for the first half with provision for a 450 000 t option in the second half at the same price. In the May to December 1991 period, Vancouver prices for standard grade remained fairly stable at US$109-$111/t, as most other contracts for the year were settled in view of consolidating the price increase achieved in the second quarter. The marketplace is entering 1992 with relative stability; a price increase in the vicinity of US$5-$7/t was signalled during first-half negotiations.

Early in 1991, the hope for higher prices in the North American markets, contrary to some preliminary indications, was not fully realized. The sluggish demand for potash in the United States remained persistent during the whole year, despite good levels of movements that occurred in mid-April and the fall. Prices at the beginning of 1991 were quoted at US$74/ short ton (st) for standard grade, f.o.b. Saskatchewan, for the U.S. markets. A slight US$4/t increase was achieved in mid-March, consequent to the successful price increase achieved in offshore markets. Prices remained at the US$79/st level for standard grade during the rest of the year. In early July and September, Canadian producers tentatively sought marginal increases in the US$4-$5/st range, but encountered strong resistance from buyers; potash continued to be virtually available at lower prices in the low US$70s for the rest of the year. The last round of prices published by suppliers late in November 1991 indicated a slackening in prices entering 1992, at US$74/st, with provision for an increase by February 1992 to US$77/st.

OUTLOOK

In the short term, world consumption of fertilizer potash is expected to decrease 3% in the fertilizer year 1991/92, as reduced demand is likely to prevail in the Commonwealth of Independent States (C.I.S.) and Eastern Europe. However, fertilizer consumption is projected to increase by 2% in developing countries. Potash fertilizer consumption is expected to remain stable in Latin America, Oceania, Africa and Asia, while some increases are anticipated in North America. Reduced levels of potash consumption are expected in Western Europe (-4%), the C.I.S. (-4%) and Eastern Europe (-30%), in particular in Czechoslovakia and Poland.

In North America, potash consumption is set to increase as higher planted acreages for grain and corn are projected, following the reduced harvest of 1990/91 in wheat, corn and coarse grain. The 1991/92 Acreage Reduction Program for cereals has been estimated at 5%, compared to 7.5% in the previous year. Low agricultural prices and reduced farm incomes continue to trouble the agricultural sector in Canada and the United States. A 2% increase in the consumption of fertilizer nutrients has been forecast.

For the period 1988-95, world potash consumption in fertilizers has been forecast to grow at an annual rate of 0.5% to reach 29.6 Mt/y K_2O in 1995/96. Major increases in consumption are anticipated in Asia, especially in India and China, which together will account for more than 12% of total world consumption. In India, potash demand is forecast to increase from 1.3 Mt/y K_2O in 1990/91 to 1.65 Mt/y in 1994/95 due to improved application rates and practice policies established by the government. This increment in potash usage will allow reaching an optimized N:P:K ratio of 5:2:1. In China, potash consumption is to increase from 1.5 Mt/y K_2O to 1.8 Mt/y in the same period. While China is using a sufficient volume of fertilizers per hectare, the proportion of potash has yet to increase substantially to result in a proper balance in nutrient fertilization.

The demand for industrial potash is forecast to reach 1.09 Mt/y by 1999, a 3% increase from the 1988 level. There is limited trade for industrial potash as its consumption is mostly centred in developed countries, of which the United States accounts for 56% of the total.

Total world demand for potash is forecast at 29.5 Mt K_2O by 1995, and at 31.7 Mt K_2O by the year 2000, taking into account both fertilizer and industrial potash production, and distribution losses.

On the supply side, the future of potash production is clouded by uncertainties pertaining to the situation of the potash industries in the C.I.S. and the former East Germany. Major restructuring, in-depth rationalization and increasing concerns about socio-economic and environmental questions will impact severely on the viability of several operations in these countries during the next few years.

Developing countries and established producers such as Israel and Jordan are contemplating additional expansions that will serve regional markets; these developments, if realized and sustained, will result in changes to trading patterns from established traders such as Canada, the C.I.S. and Germany. For the rest of the decade, the marketplace will continue to benefit from the existing worldwide surplus of productive capacity for meeting its needs. Producing countries that have managed to operate at low capacity utilization, such as Canada, are well positioned to furnish the growing demand on a long-term basis; however, the potential surplus in the supply/demand balance for potash has been projected to decline 25% over the next four years, down to 2.8 Mt/y K_2O in 1996.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	UnitedStates Canada
3104.20	Potassium chloride	Free	Free	Free	Free
3104.30	Potassium sulphate	Free	Free	Free	Free
3104.90.00.10	Magnesium potassium sulphate	Free	Free	Free	Free
3104.90.00.90	Other potassic fertilizer	Free	Free	Free	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States 1991.

TABLE 1. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION, Potassium Chloride					
Gross weight		11 444 002	..	12 187 402	..
K_2O equivalent		6 989 481	..	7 439 006	..
SHIPMENTS					
K_2O equivalent		7 344 620	964 920	7 012 001	918 994
IMPORTS, Fertilizer Potash				(Jan.-Sept.)	
3104.20	Potassium chloride, in packages weighing more than 10 kg				
	United States	6 704	843	3 234	402
	Germany[1]	674	87	246	32
	United Kingdom	3	-	18	2
	Total	7 381	931	3 498	436
3104.30	Potassium sulphate, in packages weighing more than 10 kg				
	United States	20 192	5 195	5 323	1 654
	United Kingdom	–	–	1	4
	Netherlands	25	18	–	–
	Germany[1]	8	18	...	–
	Italy	29	14	–	–
	Total	20 254	5 247	5 324	1 658
3104.90.00.10	Magnesium potassium sulphate				
	United States	66 260	9 301	29 968	4 677
	Germany[1]	50	9	–	–
	Other countries	313	43	79	11
	Total	66 623	9 355	30 047	4 688
3104.90.00.90	Other potassic fertilizer				
	United States	1 912	924	1 946	859
	Other countries	–	–	195	171
	Total	1 912	924	2 141	1 030
	Potash Chemicals				
2815.20	Potassium hydroxide (caustic potash)	13 156	5 179	9 243	3 700
2834.21	Potassium nitrate	6 064	3 033	3 397	1 776
2835.24	Potassium phosphates	1 479	1 468	1 031	1 032
2836.40	Potassium carbonates	1 640	1 146	1 104	763
2839.20	Potassium silicates	928	680	698	535
	Total potash chemicals	23 267	11 506	15 473	7 806
EXPORTS, Fertilizer Potash[2]					
3104.20	Potassium chloride, in packages weighing more than 10 kg				
	United States	6 133 225	647 656	4 596 348	507 461
	People's Republic of China	1 322 551	148 057	915 435	114 451
	Malaysia	539 935	64 242	424 257	55 488
	Japan	584 486	75 481	339 099	47 102
	South Korea	396 746	51 379	317 842	41 522
	Brazil	388 814	43 757	251 228	26 911
	India	179 018	20 492	155 861	18 960
	Taiwan	143 668	17 320	140 941	18 413
	Australia	290 115	35 128	114 977	14 949
	Belgium	72 897	8 283	104 828	11 847
	Philippines	147 738	13 972	89 462	11 666
	New Zealand	145 310	17 452	89 462	11 211
	Chile	90 492	10 894	51 754	6 824
	Colombia	106 429	10 375	63 910	6 346
	Indonesia	218 555	23 282	46 583	5 960
	Bangladesh	38 462	4 806	46 431	4 255
	Denmark	95 576	9 701	40 388	4 233
	Thailand	30 416	3 320	22 550	2 922
	Mexico	21 983	1 978	21 552	2 427
	Jamaica	12 040	1 632	14 570	2 327
	Nigeria	29 952	3 006	20 000	1 833
	United Kingdom	124 990	11 325	13 218	1 770
	Norway	16 236	1 869	16 000	1 582

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
	Guatemala	16 874	1 769	12 700	1 222
	Costa Rica	33 837	3 563	903	106
	France	167 047	18 828	90	8
	South Africa	53 451	6 220	–	–
	Singapore	26 393	2 432	–	–
	Venezuela	21 000	2 237	–	–
	Ivory Coast	21 000	2 126	–	–
	Italy	12 271	1 640	–	–
	Other countries	12 469	1 328	15 312	1 901
	Total	11 493 976	1 265 550	7 925 701	923 697
3104.30	Potassium sulphate, in packages weighing more than 10 kg				
	United States	2 051	420	679	209
	Thailand	3 800	338	–	–
	Total	5 851	758	679	209

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; p Preliminary.
1 Where applicable, data for East and West Germany have been combined. 2 Countries are ranked in descending order of value, based on nine-month 1991 data.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, POTASH PRODUCTION AND TRADE, FERTILIZER YEARS ENDED JUNE 30, 1976-91

	Production[2]	Imports[1,2]	Exports[1]
		(tonnes K_2O equivalent)	
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	21 819	6 256 216
1980	7 062 996	20 620	6 432 124
1981	7 336 973	35 135	6 933 162
1982	6 042 623	25 437	5 400 662
1983	5 378 842	21 846	4 864 219
1984	7 155 599	17 934	6 730 733
1985	7 283 509	17 396	6 784 178
1986	6 519 777	12 837	6 479 678
1987	7 031 586	12 122	7 100 135
1988	7 839 625	14 486	7 315 318
1989	8 088 748	18 604r	7 075 122
1990r	6 773 019	20 714	6 387 857
1991	7 520 177	21 721	6 296 072

Sources: Potash and Phosphate Institute; Canadian Fertilizer Institute.
r Revised.
1 Includes potassium chloride, potassium sulphate, potassium magnesium sulphate, except that contained in mixed fertilizers. 2 Change of data source. Prior to 1978, figures were obtained from Statistics Canada.

TABLE 3. CANADA, POTASH PRODUCTION AND SALES IN 1990 AND BY QUARTERS, 1991

	Total (1990)	1991 1st Quarter	1991 2nd Quarter	1991 3rd Quarter	1991 4th Quarter	1991 Total
	(000 tonnes, K_2O equivalent)					
Production	7 000.8	2 142.0	2 010.7	1 336.7	1 906.7	7 396.1
Sales						
North America	4 026.3	887.9	1 308.8	945.0	818.2	3 959.9
Offshore	3 163.8	810.1	826.8	755.4	704.1	3 096.4
Total	7 190.1	1 698.0	2 135.6	1 700.4	1 522.3	7 056.3
Ending Inventories						
Mine site	500.0	824.1	810.8	584.4	775.4	..
Off site	772.5	864.9	823.6	717.9	810.0	..
Total	1 272.5	1 689.0	1 634.4	1 302.3	1 585.4	1 585.4

Source: Potash and Phosphate Institute.
.. Not available.

TABLE 4. CANADA, POTASH SALES BY PRODUCT AND AREA, 1989 AND 1990

		Agricultural					Industrial			Total
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	Sales
		(tonnes, K_2O equivalent)								
British Columbia	1989	–	43	5 311	29	5 383	48	13	61	5 444
	1990	646	307	6 901	36	7 890	–	–	–	7 890
Alberta	1989	129	99	31 081	1 671	32 979	1 493	185	1 678	34 657
	1990	106	40	33 695	1 851	35 692	1 725	475	2 200	37 893
Saskatchewan	1989	34	123	10 670	62	10 889	2 547	1 095	3 642	14 530
	1990	11	2 258	9 512	104	11 885	2 761	1 437	4 198	16 083
Manitoba	1989	–	3 333	17 450	1 913	22 696	30	–	30	22 726
	1990	–	3 127	16 334	2 449	21 910	–	–	–	21 910
Ontario	1989	422	86 784	47 247	1 829	136 283	6 244	394	6 637	142 921
	1990	892	114 142	67 615	1 269	183 919	7 784	407	8 191	192 110
Quebec	1989	124	2 616	66 785	50	69 575	733	–	733	70 308
	1990	–	4 953	85 675	35	90 664	752	169	921	91 584
New Brunswick	1989	–	3 524	6 864	29	10 417	997	26	1 023	11 440
	1990	–	4 583	5 124	–	9 707	–	18	18	9 725
Nova Scotia	1989	–	980	4 468	–	5 447	–	–	–	5 447
	1990	–	3 486	1 412	–	4 898	–	–	–	4 898
Prince Edward Island	1989	–	131	6 950	–	7 081	–	–	–	7 081
	1990	–	1 395	9 484	–	10 879	–	–	–	10 879
Newfoundland	1989	–	–	–	–	–	–	–	–	–
	1990	–	–	–	–	–	–	–	–	–
Total	1989	708	97 632	196 827	5 583	300 750	12 091	1 712	13 804	314 554
	1990	1 655	134 291	235 753	5 745	377 444	13 022	2 506	15 528	392 972

Source: Potash and Phosphate Institute.
– Nil.

TABLE 5. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1991

Month	Beginning Inventory	Production	Domestic Sales			Export Sales					Canadian Total Sales
						United States			Offshore Total	Exports Total	
			Agriculture	Non-Agriculture	Total	Agriculture	Non-Agriculture	Total			
						(000 tonnes K_2O)					
January	1 272.4	661.1	9.9	1.2	11.1	400.3	28.0	428.3	260.4	688.7	699.8
February	1 225.4	704.0	14.7	1.0	15.7	167.8	18.1	185.9	271.8	457.7	473.4
March	1 440.1	771.9	13.7	1.4	15.1	206.8	25.0	231.8	277.9	509.7	524.8
1st quarter subtotal		2 142.0	38.3	3.6	41.9	774.9	71.1	846.0	810.1	1 656.1	1 698.0
April	1 688.8	588.8	58.5	1.4	59.9	446.7	58.5	505.2	178.0	683.2	743.1
May	1 549.2	775.4	148.4	1.0	149.4	405.0	31.6	436.6	287.2	723.8	873.2
June	1 483.8	646.5	17.6	0.7	18.3	116.5	22.9	139.4	361.6	501.0	519.3
2nd quarter subtotal		2 010.7	224.5	3.1	227.6	968.2	113.0	1 081.2	826.8	1 908.0	2 135.6
July	1 634.8	288.0	9.2	0.6	9.8	143.6	26.0	169.6	202.4	372.0	381.8
August	1 536.2	348.6	14.4	1.2	15.6	482.6	31.6	514.2	261.1	775.3	790.9
September	1 066.8	700.1	22.1	0.9	23.0	188.4	24.4	212.8	291.9	504.7	527.7
3rd quarter subtotal		1 336.7	45.7	2.7	48.4	814.6	82.0	896.6	755.4	1 652.0	1 700.4
October	1 302.4	752.8	14.7	1.2	15.9	217.8	37.0	254.8	218.9	473.7	489.6
November	1 573.5	735.6	10.4	1.1	11.5	179.8	34.0	213.8	297.9	511.7	523.2
December	1 774.9	418.3	3.8	1.2	5.0	283.7	33.5	317.2	187.3	504.5	509.5
4th quarter subtotal		1 906.7	28.9	3.5	32.4	681.3	104.5	785.8	704.1	1 489.9	1 522.3
Total		7 396.1	337.4	12.9	350.3	3 239.0	370.6	3 609.6	3 096.4	6 706.0	7 056.3

Source: Potash and Phosphate Institute.
Inventories at the end of December 1991 were 1585.0 thousand tonnes K_2O.

TABLE 6. WORLD POTASH PRODUCTION, 1985-91

	1985	1986	1987	1988	1989	1990p	1991e
				(000 tonnes K_2O)			
Brazil	6	11	37	48	98	68	100
Canada	6 637	6 697	7 267	8 328	7 333	7 002	7 440
Chile	–	–	–	5	10	20	20
China	20	20	25	30	35	60	60
France	1 750	1 610	1 539	1 502	1 195	1 292	1 130
Germany, Dem. Rep.	3 465	3 485	3 510	3 510	3 200	2 653	1 670
Germany, Fed. Rep.	2 583	2 162	2 201	2 290	2 186	2 197	2 200
Israel	1 172	1 240	1 265	1 242	1 271	1 311	1 270
Italy	143	109	122	126	152	68	40
Jordan	45	662	722	786	792	842	810
Spain	645	702	740	766	742	686	585
U.S.S.R.	10 367	10 228	10 889	11 000	10 232	9 088	8 400
United Kingdom	337	391	429	452	463	488	495
United States	1 296	1 202	1 262	1 461	1 595	1 654	1 690
Total	28 960	28 551	30 008	31 546	29 304	27 429	25 910

Sources: Energy Mines and Resources Canada; International Fertilizer Industry Association Ltd.; U.S. Bureau of Mines.
– Nil; e Estimated; p Preliminary.

TABLE 7. CANADA POTASH, CURRENT SITUATION AND FORECAST

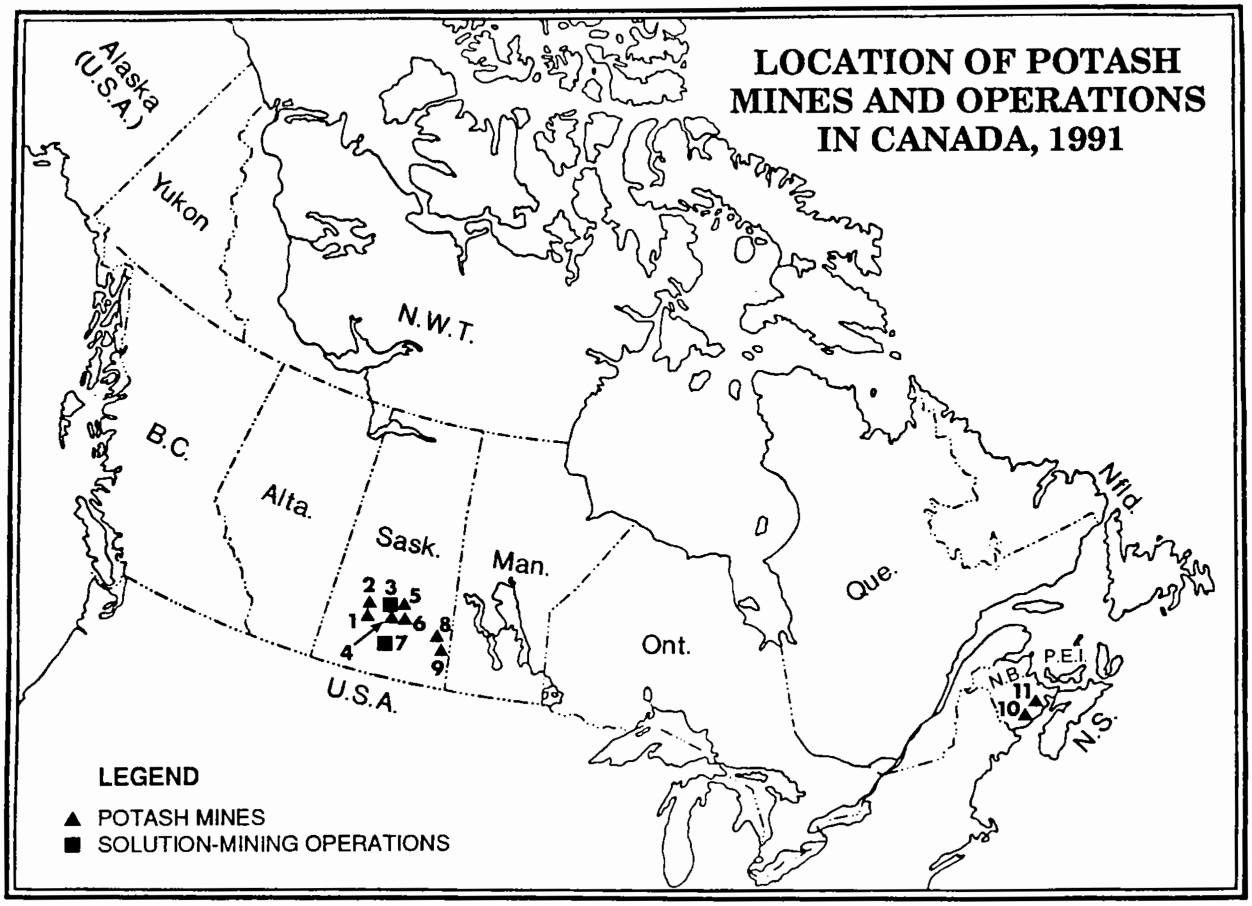
	Actual							Forecast
	1985	1986	1987	1988	1989	1990	1991p	1992e
	(000 tonnes K_2O)							
Capacity	9 780	10 580	11 020	11 430	11 550	11 800	11 800	11 800
Production	6 636	6 698	7 267	8 328	7 360	7 002	7 440	7 500
Capacity utilization (%)	68	63	66	73	64	59	63	64
Sales	6 577	7 023	7 837	8 030	7 124	7 190	7 060	7 500
of which: Domestic	434	322	480	420	315	396	350	400
United States	4 215	4 091	4 224	3 830	3 886	3 630	3 610	3 700
Offshore	1 928	2 610	3 114	3 780	2 923	3 164	3 100	3 400
Year-end stocks	1 766	1 537	1 135	1 360	1 596	1 272	1 585	1 585
World production	28 960	28 551	29 309	31 650	29 300	27 429	25 895	25 800
Canada/world production ratio (%)	22.9	23.5	24.7	26.3	25.1	25.5	28.7	29.1

e Estimated; p Preliminary.

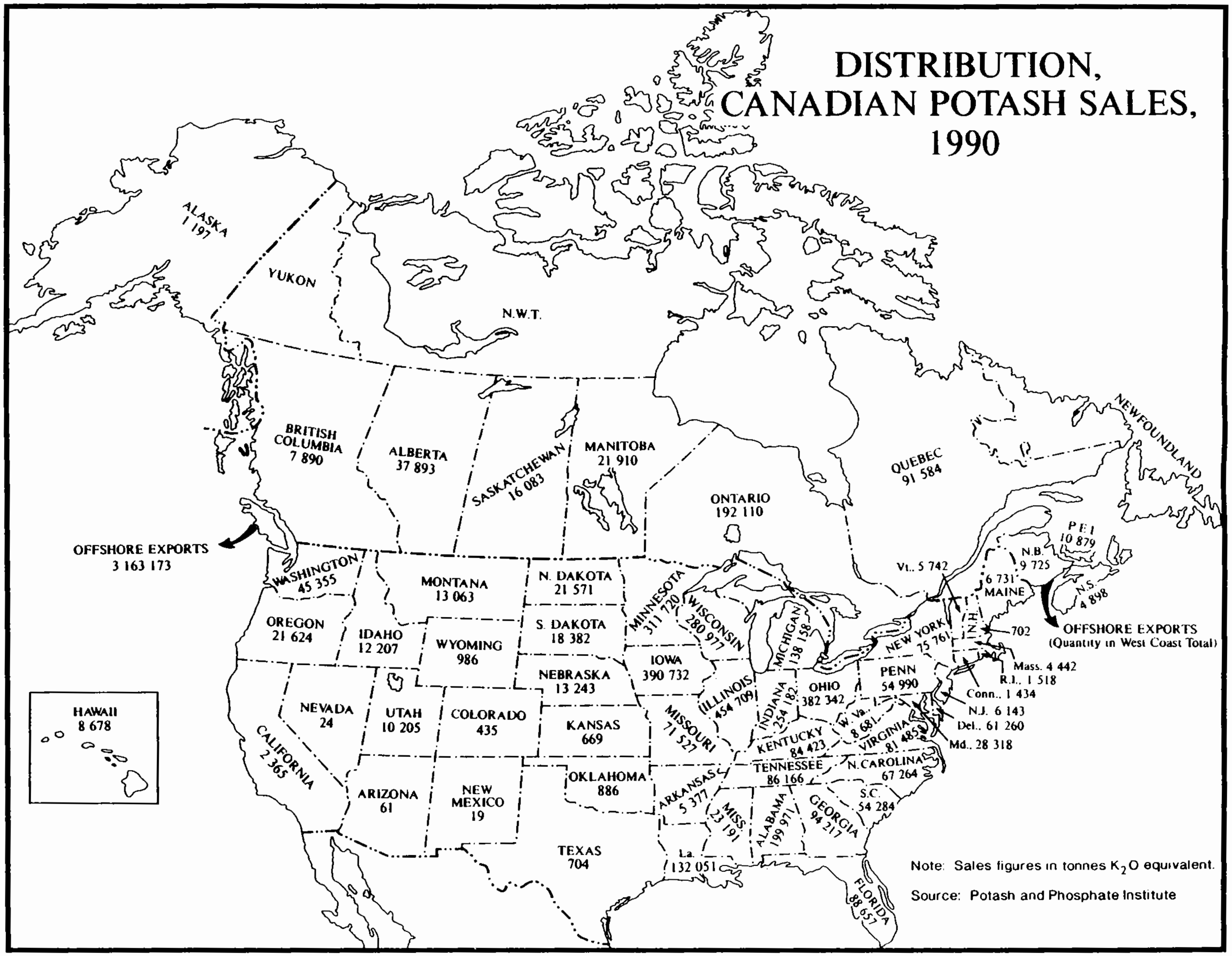
TABLE 8. CANADA, POTASH MINES, CAPACITY PROJECTIONS, 1985-95

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					(000 tonnes K_2O equivalent)						
Potash Corporation of Saskatchewan Inc.											
Allan[1]	575	575	575	575	575	960	960	960	960	960	960
Cory	830	830	830	830	830	830	830	830	830	830	830
Esterhazy (25% of IMC)	580	580	580	580	580	580	580	580	580	580	580
Lanigan	690	1 240	1 740	2 090	2 090	2 090	2 090	2 090	2 090	2 090	2 090
Rocanville	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Subtotal	3 835	4 385	4 885	5 235	5 235	5 620	5 620	5 620	5 620	5 620	5 620
Central Canada Potash	815	815	815	815	815	815	815	815	815	815	815
Cominco Ltd.	815	815	815	815	815	815	815	815	815	815	815
International Minerals & Chemical Corporation (75%)	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745
Kalium Canada, Ltd.	1 055	1 055	1 245	1 245	1 245	1 245	1 245	1 245	1 245	1 245	1 245
Potash Company of America, Inc.	630	630	100	30	150	400	400	400	400	400	400
Saskaterra Fertilizers Ltd. (Allan)[1]	385	385	385	385	385	–	–	–	–	–	–
Subtotal	5 445	5 445	5 105	5 035	5 155	5 405	5 405	5 405	5 405	5 405	5 405
Total Saskatchewan	9 280	9 830	9 990	10 270	10 390	10 640	10 640	10 640	10 640	10 640	10 640
Denison-Potacan Potash Co.	200	450	650	780	780	780	780	780	780	780	780
Potash Company of America, Inc.	300	300	380	380	380	380	380	380	380	380	380
Total New Brunswick	500	750	1 030	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Total Canada	9 780	10 580	11 020	11 430	11 550	11 800	11 800	11 800	11 800	11 800	11 800

– Nil.
[1] Potash Corporation of Saskatchewan Inc. increased its share of Allan mine from 60% to 100% in mid-1990.
Note: Capacity means "rated" capacity; under normal conditions Canadian mines can operate comfortably at about 90% of rated capacity.



1. Cominco Ltd.; Vanscoy, Sask.
2. Potash Corporation of Saskatchewan Inc., Cory Division; Saskatoon, Sask.
3. Potash Company of America (a Division of Rio Algom Limited); Saskatoon, Sask.
4. Potash Corporation of Saskatchewan Inc., Allan Division; Allan, Sask.
5. Noranda Minerals Inc., Central Canada Potash Division; Colonsay, Sask.
6. Potash Corporation of Saskatchewan Inc., Lanigan Division; Lanigan, Sask.
7. Kalium Canada, Ltd.; Belle-Plaine, Sask.
8. International Minerals & Chemical Corporation (Canada) Limited; Esterhazy, Sask.
9. Potash Corporation of Saskatchewan Inc.; Rocanville, Sask.
10. Potacan Mining Co.; Sussex, N.B.
11. Potash Company of America (a Division of Rio Algom Limited); Sussex, N.B.


DISTRIBUTION, CANADIAN POTASH SALES, 1990
ALASKA 1 197
YUKON
N.W.T.
BRITISH COLUMBIA 7 890
ALBERTA 37 893
SASKATCHEWAN 16 083
MANITOBA 21 910
ONTARIO 192 110
QUEBEC 91 584
NEWFOUNDLAND
P E I 10 879
N.B. 9 725
N.S. 4 898
OFFSHORE EXPORTS 3 163 173
OFFSHORE EXPORTS (Quantity in West Coast Total)
WASHINGTON 45 355
OREGON 21 624
CALIFORNIA 2 365
HAWAII 8 678
IDAHO 12 207
NEVADA 24
MONTANA 13 063
WYOMING 986
UTAH 10 205
ARIZONA 61
COLORADO 435
NEW MEXICO 19
N. DAKOTA 21 571
S. DAKOTA 18 382
NEBRASKA 13 243
KANSAS 669
OKLAHOMA 886
TEXAS 704
MINNESOTA 311 720
IOWA 390 732
MISSOURI 71 527
ARKANSAS 5 377
La. 132 051
WISCONSIN 280 977
ILLINOIS 454 709
MICHIGAN 138 158
INDIANA 254 182
OHIO 382 342
KENTUCKY 84 423
TENNESSEE 86 166
MISS 23 191
ALABAMA 199 971
GEORGIA 94 217
FLORIDA 88 657
S.C. 54 284
N. CAROLINA 67 264
VIRGINIA 81 485
W. Va. 8 681
PENN 54 990
NEW YORK 75 761
Vt., 5 742
N.H.
702
6 731 MAINE
Mass. 4 442
R.I., 1 518
Conn., 1 434
N.J. 6 143
Del., 61 260
Md., 28 318
Note: Sales figures in tonnes K_2O equivalent.
Source: Potash and Phosphate Institute

Primary Iron, Steel and Ferrous Scrap

Robert McInnis

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-8438

Primary iron is the raw material used to make steel and other iron products such as castings. It is defined to include blast furnace iron, direct reduced iron (DRI), and, in Canada, electric smelted iron.

Steel is made from blast furnace iron and scrap in basic oxygen furnaces at the integrated steel mills, and from scrap and/or DRI in the electric furnaces of the mini-mills.

Recycled ferrous scrap is a very important and increasingly sophisticated input to steel production. Approximately 50% of the iron units used to make steel in Canada are sourced from scrap.

In this chapter, the iron and steel information will be presented first, followed by a section on ferrous scrap.

Primary Iron and Steel

CANADIAN DEVELOPMENTS

Blast Furnace Iron

Canadian production of blast furnace iron in 1991 increased about 9% to 8.00 million tonnes (Mt), compared to 7.35 Mt in 1990. This increase was due to higher steel production at integrated producers, and to the return to production of Stelco's "E" blast furnace. It should be noted that 1990 iron production was lower because furnaces were idled by a strike.

The proportion of primary iron use in steel production increased partly as a post-strike adjustment, and partly because of the need to maintain minimum levels of production from operating blast furnaces. In periods of lowered demand, integrated producers often reduce scrap consumption in favour of iron to maintain the operating efficiency of their blast furnaces.

The Canadian steel industry has 11 blast furnaces with a total capacity of 11.5 Mt/y. Associated with these furnaces are 866 coke ovens with a capacity of 5.3 Mt/y.

Steel

The business climate was characterized by weak domestic demand in a North American market where recessionary conditions persisted, creating a very competitive and difficult pricing environment. U.S. producers with more access to the Canadian market under the Canada-U.S. Free Trade Agreement (FTA) maintained steel shipments to Canada at previously unprecedented levels. The domestic market continued to be affected by the work stoppages of the previous year as supply contracts with American producers often covered early 1991 requirements; also, sales lost are often not immediately or completely regained when product is again available. In order to maintain operating levels, many Canadian companies aggressively sought offshore orders in an extremely price-competitive market which offered minimal profits.

Canadian steel production in 1991 increased 5.8% to 12.9 Mt from the 12.2 Mt level of 1990. This increase was due partly to the fact that volumes in 1990 were distorted by a long strike at Stelco and The Algoma Steel Corporation, Limited. However, the most significant factor was trade; imports of steel mill products decreased 12% while exports increased 17%. It should be noted that the strike also distorted trade patterns. In comparison with 1989 quantities, which was a normal production year, 1991 steel production was down 15%.

Domestic demand for steel remained depressed due to a continued decline in Canadian economic activity and the loss of a significant percentage of the secondary manufacturing industry through closures or movement of plants to the United States.

Steel Mill Developments

1991 was a year of continuing change with many capital expenditure programs on the go in spite of depressed markets. Highlights by company include:

- ***The Algoma Steel Corporation, Limited:*** Algoma, which was unable to meet its requirements to pay its debt, sought and was granted protection from its creditors, under the *Federal Companies' Creditors Arrangement Act,* by the Supreme Court of Ontario. The protection, which was initially for a period of six months to July 31, was to allow the company time to restructure its $800 million debt. Protection was extended twice during the year. A number of proposals were presented to the creditors but, at year-end, no plan had been accepted and Court protection continued.

- ***Dofasco Inc.:*** Construction of a new $450 million integrated cold mill complex in Hamilton, which commenced in 1989, was finished on schedule. First commercial production occurred in December 1991. Final commissioning is scheduled for the first quarter of 1992. This complex has the capacity to process approximately 1.1 Mt/y of steel. A second major project was the joint venture with Sidbec Dosco to build a galvanizing line in Quebec; it was commissioned on schedule and commercial production began during the first half of 1991. This plant has the capacity to produce 100 000 t/y. The newest project, the construction of a hot-dip galvanizing line owned 50% by Dofasco and 50% by NKK/National Steel, proceeded on schedule. The facility, located in Windsor, Ontario, will have a capacity of 360 000 t/y; start-up is expected in 1993.

  A letter of intent was signed with Armco Inc. of the United States to form a joint venture for the production of grain-oriented electric steels. Steel used in the manufacture of electric motor and transformer laminates must have specific magnetic properties. These properties are achieved by controlling the size and orientation of the grains that make up the microscopic structure of all steel.

  In January 1991, Dofasco decided to stop providing financial support and subsequently wrote off its $713 million investment in its wholly owned subsidiary, The Algoma Steel Corporation, Limited.

- ***Stelco Inc.:*** The $198 million Z-line galvanizing facility started up in May 1991 and was in regular operation in the third quarter. This project, which is a joint venture of Stelco and Mitsubishi Canada, includes a new combination galvanizing/continuous annealing line, a pickle line upgrade at Hilton Works, and a second reheat furnace at Lake Erie Works.

The rebuild of "E" blast furnace was completed and production of hot metal began in June 1991.

The company's concentration on its core business of steelmaking resulted in decisions to divest itself of its ownership in Kautex of Canada Inc., a Windsor-based producer of plastic fuel systems for the automotive industry. To the same end, arrangements have been made to study the feasibility of having the Rochester and Pittsburg Coal Company of Indiana, Pennsylvania, acquire the Kentucky-based Chisholm coal mine and become responsible for supplying metallurgical coal to Hilton and Lake Erie Works.

The concentration on the core business also resulted in further restructuring and a decision to form a number of joint ventures. A letter of intent was signed with Oregon Steel Mills with respect to a prospective joint venture involving Stelco's pipe-making facilities in Camrose, Alberta. The McMaster Works in Contrecoeur, Quebec, was established as a wholly owned Quebec-incorporated subsidiary known as Stelco-McMaster Ltée.

Stelpipe won a $158 million order to supply large-diameter gas transmission pipe for TransCanada Pipelines Limited.

- ***IPSCO Inc.***: Capital spending was concentrated on improved productivity, lowered costs and product diversification. Capital projects completed and nearing completion included: rolling mill modernization at Regina; the installation of equipment to produce discrete plate, also at Regina; and the modernization of recently acquired pipe-making facilities at Camanche, Iowa. Future projects include the installation of an electric resistance weld mill at Regina capable of producing intermediate-size pipe at a much higher rate and, therefore, at a lower cost, with start-up scheduled for 1992. In addition, IPSCO's subsidiary company, Western Steel Limited, will modernize its Calgary steelworks to significantly reduce costs while increasing plant capacity from 140 000 t/y to 250 000 t/y.

  The company operated profitably with good levels of production. Although demand for flat steel and architectural tubing was depressed, shipments of tubular products used by the oil and gas industry were good.

- ***Co-Steel Inc.***: Co-Steel has maintained high levels of capital expenditures on acquisitions and on plant and equipment upgrading. In spite of depressed prices and markets, the company acquired 100% ownership in the Sheerness steel plant and a 60% interest in Mayer Parry Recycling, both in the United Kingdom. Control of this recycling firm resulted in a more economic scrap mix at Sheerness.

  Significant cost reductions and productivity improvements were achieved at North American operations.

- ***Slater Industries Inc.***: Slater has consolidated and modernized its operations in recent years. The corporate office and divisional organizational structures were down-sized.

SLACAN's Lachine, Quebec plant was closed, and Slater Powder Technology in Carnegie, Pennsylvania, ceased operations. A new continuous caster installed at Hamilton began operating in January 1991. At Fort Wayne, Indiana, a new ladle-refining station commissioned in 1990 was fully operational, and installation of new heat treatment facilities was completed in the first quarter of 1991. With the capability to produce higher grades of steel, the company has improved its ability to capture new markets.

- ***Sammi Atlas Inc.:*** Since the purchase of Atlas Steels in 1990, the parent company has made excellent progress in incorporating Atlas into its international organization. The Canadian operation has benefited from Sammi's international marketing and purchasing capability. A capital spending program aimed at increasing capacity and productivity is under way. At Atlas Speciality Steel Division in Welland, Ontario, the upgrading of an electric furnace to 100 t was completed with full operation achieved in 1991.

  At Atlas Stainless Steels Division at Tracey, Quebec, a $500 million modernization and expansion program is under way. The capacity of the plant will increase from 80 000 t/y to 300 000 t/y by 1995. The formalized modernization plan states that quality is the key to competitiveness, and that successful expansion and modernization requires manpower mobilization. The company has required the active collaboration of the union in implementing a total quality management program. In order to establish a partnership environment, an industrial relations joint committee was formed. The plan includes a major training program for labour that will assure the retention of existing positions, while assisting in efforts to fill 335 new jobs from the local community. The union has agreed to a six-year social contract that ensures the continuation of operations by excluding strikes and lockouts, and provides for the employment maintenance of 411 hourly paid workers.

- ***Courtice Steel:*** Courtice, which is owned by the Gerdau Group of Brazil, has increased production by about 30%. The company expects to reach its design capacity of 260 000 t/y in 1992.

Electric Smelting Iron

Another source of primary iron is the nine electric furnaces at the ilmenite smelting facility operated by QIT-Fer et Titane Inc. at Tracy, Quebec. These furnaces have the capacity to produce 900 000 t/y of iron as a co-product with titanium dioxide. The iron is used to produce three products: a range of specialty pig iron grades, which are sold mainly to the foundry industry; iron powder used by the powder metallurgy industry; and continuous cast steel billets which are sold to the steel industry for re-rolling. This facility continued to operate at capacity during 1991.

Direct Reduced Iron (DRI)

DRI is a semi-metallic product made by reducing iron ore in its solid state to approximately 95% metallics. Sidbec-Dosco Inc. has one operating Midrex DRI plant at Contrecoeur, Quebec. This plant, with a capacity to produce 750 000 t/y, operated at a level greater than its nominal capacity during 1991. DRI, steel at the company's electric furnace steel mill.

INTERNATIONAL DEVELOPMENTS

Steel

Western World steel production, as calculated by the International Iron and Steel Institute, decreased 4.5% in the first 11 months of 1991 over the same period in the previous year. This continuing decrease in production in the Western economies was attributed to lower levels of demand for consumer durables, especially automobiles, brought about by recessionary pressures which intensified during the year. In the former U.S.S.R. and Eastern Europe, massive changes involved in the breakdown of the Soviet Union devastated the economy.

Worldwide, the greatest declines in steel production occurred in the United States (11.3%), the European Community (4.2%), and the U.S.S.R. and Eastern Europe (14.8%). Japanese production averaged a slight increase for the period. Canadian production increased 5.2%; however, this increase is more of an adjustment arising from the end of a three-month work stoppage in 1990 than an indication of improved economic activity.

British steel markets showed increasing weakness throughout the year. Japan and some sectors of the continental European market showed signs of decline in the fourth quarter. In North America, there was some evidence near year-end that Canadian and U.S. markets were beginning to strengthen.

Direct Reduced Iron (DRI)

Midrex plants accounted for about 62% of world DRI production, with the HYL-1 and HYL-111 plants the second most important. Total DRI production, as calculated by the Midrex Corporation, was 19.41 Mt in 1991, an 8% increase over the 1990 level of 17.89 Mt, or about 3% of world crude steel. DRI's inherent advantages of high purity and controlled chemistry have always been valued, but low ferrous scrap prices limited the growth potential of the product. This situation has changed in recent years with scrap prices remaining high relative to historic levels, even during the 1990/91 recession.

New facilities were started up by Goldstar at Vizianagar in India, and by ASCO at Ahwaz in Iran. The Goldstar plant uses the Codir process while ASCO uses the Midrex process. These plants added an additional 0.42 Mt to world capacity. An additional 12.2 Mt of DRI capacity is under construction.

Supplies of DRI were tight in 1991 with most of the capacity of merchant producers of hot briquetted iron (HBI) sold out for the immediate future.

NEW PRIMARY IRON TECHNOLOGIES

The development of new processes that provide an alternative to the traditional blast furnace continued with even greater support than in past years. These direct smelting, or direct steelmaking, processes are reported to have economic and environmental advantages over the coke-oven blast furnace method. These stated advantages tend to derive from the fact that many of the processes do not require coke or agglomerated iron ore. Agglomerated ore such as pellets or sinter is more expensive than iron ore concentrates due to the cost of the necessary capital equipment and the energy used to indurate the iron ore. Coke production is also costly for similar reasons. The agglomeration and coking process produces high levels of undesirable emissions that, without costly process controls, may escape into the environment.

Another advantage of these processes is the much smaller minimum economic size of direct smelting plants, an important capital cost consideration that helps makes them an appropriate technology to supply hot iron for electric furnace mills.

One of the direct smelting processes, the Corex process, is now a proven commercial technology. A full-scale plant has been operating at ISCOR's steel plant in Pretoria, South Africa, since August 1988, and the hot metal from the plant meets design specifications. Additional plants are at the planning stage in several countries.

Other competing direct smelting technologies include: the XR process by Kawasaki Steel Corporation; Direct Bath Smelting of Iron Ore, a joint venture of CRA Limited of Australia and Kloeckner Slahlhorschung of West Germany; the Elkem Polar Process by Elkem A/S of Norway; and the HIsmelt process owned by CRA Ltd., Klockner Stahlwwerke, Csiro and Midrex Corp. These technologies have reached technical maturity, appear to be economically viable, and await verification at commercial scale.

High levels of research and development were expended on the new technologies by both major companies and governments. The U.S. Department of the Environment is contributing to the funding of research into a $3 million direct steelmaking project in cooperation with The American Iron and Steel Institute. The project will concentrate on in-bath smelting and refining processes. In Japan, three projects are at advanced stages of development:

- In-Bath Smelting Reduction by Nippon Steel;
- Coal Iron Gasification Process, a joint Japan-Sweden feasibility study for the international Energy Agency; and
- Direct Iron Ore Smelting Process, a joint development of Nippon Kokan KK and The Japan Iron and Steel Federation.

OUTLOOK

Iron and Steel

Canadian production of iron and steel should increase slightly by year-end 1992 as recovery from the recession is expected in both Canada and the United States. Canadian producers should also recapture more of the market lost to imported steel as a result of work stoppages in 1990. In the medium term, growth of 2%-3% is expected in 1993 and 1994. The industry is well placed to benefit from a period of economic growth since recent new capital investments should produce significant improvements in productivity. However, additional improvements in productivity will be necessary to maintain a competitive position with the greatly improved U.S. industry.

There are a number of factors that could radically change this forecast. The future of The Algoma Steel Corporation, Limited is quite uncertain and, should the company be unable to restructure its debt, it may close. Steelmaking capacity at Algoma represents about 25% of the Canadian total. Furthermore, a high percentage of Algoma's product line is not made by other Canadian producers; therefore, production lost from the closure of Algoma could not be taken up by other producers. Imports of wide flange beams and large structurals, large seamless tubing, and wide plate and sheet would all increase. Sydney Steel is also a company with an uncertain future. But perhaps of most importance, changes in the relative exchange rates between the currencies of Canada and its trading partners can dramatically influence trade patterns and, consequently, Canadian production. This forecast assumes that the Canadian steel-consuming secondary manufacturing industry will recoup a reasonable percentage of its recent losses and create new business capable of competing in North American, if not world, markets.

In the medium term (three to five years), Canadian producers should see a period of slightly increasing sales at profitable prices as the economy enters a period of growth and steel producers benefit from their improved productivity and product quality. In the longer term (five to ten years), trade under the FTA should stabilize in North America, and the Canadian industry should find its place in the North American market. One must assume that the intent of existing and proposed free trade agreements becomes the reality and that barriers to trade that exist in the form of various trade laws will be eliminated. Mexico is not self sufficient in steel and if a North American Free Trade Agreement is negotiated, both Canadian and American steel producers will have an opportunity to increase export sales.

The difference in the cost of producing steel in competing countries continues to narrow; therefore, the relative value of currencies and the cost of shipping are becoming more important factors in steel trade. The North American steel industry, of which Canada is now an integral part, will continue to rationalize and improve its competitiveness and, in the world context, will not likely have excess supply. Furthermore, over the next ten years, North American prices will not be significantly higher than world prices. During this time period, the potential to capture domestic markets from imports is excellent, giving North American producers an opportunity to maintain relatively high levels of capacity utilization. Capacity utilization is a key factor in profitability and the ability to maintain the capital expenditures necessary to maintain or improve competitiveness. However, it is important to note that continuing high levels of capital spending will be required. The rate of technological change is not likely to slow but, rather, to accelerate as new processes, such as thin slab and near net shape casting, are proven. Traditional steelmaking will have to be competitive with, or be replaced by, direct smelting or direct steelmaking processes. All of the recently proven and advanced technologies have the significant characteristic of reducing steel industry barriers to entry.

Internationally, steel demand and production had posted a steady growth for 26 or 27 months from early 1987 until mid-1989 when demand softened. Growth is expected to begin again in late 1992. U.S. output of steel is expected to grow about 5% in 1992 and to average 1%-2% during the first half of the decade. Sales increases in 1992 will be affected by the very low levels of inventory held by steel users. The European steel industry should grow

2%-3% in 1992 and average more than 1% growth per year during the 1990s. The European economy will be stimulated by the rebuilding of the economies of Eastern Europe with their great potential demand for consumer durables and the potential to provide low-cost labour. Japanese production is forecast to decrease in the short term as the recession that started in North America affects the Japanese economy. Another factor is the growing objection in the United States to Japan's longstanding and growing trade surplus. In the medium term, a period of little or no growth is likely. Steel production in the newly industrialized nations is expected to increase at over 2% per year throughout the decade.

Direct Smelted Iron

The future for iron produced by newer technologies also looks good because many direct smelting processes have reached technical maturity, appear to be economically viable, and await verification at commercial scale. High levels of spending on research into these technologies are being maintained; however, no revolutionary change is expected. It will likely be more than ten years before any significant amount of iron is produced by these technologies.

Direct Reduced Iron (DRI)

The outlook for DRI is quite positive because ferrous scrap is forecast to be in short supply and high priced in any economic upturn as electric furnace production increases. Furthermore, the availability of hot metal from blast furnaces is unlikely to increase. The resulting shortages should peak by the end of the decade because the steel industry will wait for the new reduction technologies or dramatically revamped blast furnaces to be commercially proven over the next 5-10 years. This shortfall could well be supplied by DRI. Midrex has forecast that the merchant market for DRI will increase from less than 3.5 Mt at the beginning of 1990 to 16 Mt by the year 2000. Future demand for DRI looks good for several reasons. Demand for scrap is expected to remain high for the next decade, and the availability of hot metal from blast furnaces is likely to decrease. Older equipment, especially coke ovens, will not be replaced as it reaches the end of its economic life. Efforts to install new capacity or to refurbish existing hot metal capacity will be restrained by the high costs often arising from the need for more rigorous environmental controls. During this time, new direct iron smelting or direct steelmaking technologies will not provide a solution as they are not yet commercially proven. Some of the shortfall of ferrous scrap expected in the mid-1990s could well be supplied by DRI as all available scrap will be used. The potential to rapidly increase supplies of DRI is excellent for a number of reasons: the technology is well proven; market acceptance, especially at mini-mills, is excellent; and the necessary energy in the form of natural gas is available. In many countries, large supplies of natural gas exist or are produced as a by-product, often in areas remote from markets. By-product gas is often flared off. Where such gas is available, its use in the production of DRI is profitable and often the only practical use.

Ferrous Scrap

Ferrous scrap has always been an important raw material in the production of steel. It is the major source of iron units for the world's electric furnace steel industry, which produces almost 30% of the world's steel. The amount of steel produced with electric furnaces has been increasing for many years. For example, in 1975, electric furnaces produced 106.8 Mt which accounted for 16.7% of world production. Scrap is also used in basic oxygen furnaces at up to 30% scrap per batch of steel. Ferrous scrap is a commodity for which a large international trade exists. The importance of ferrous scrap is shown by the International Iron And Steel Institute (IISI) estimates of world consumption at over 300 Mt/y during the last few years.

CANADIAN DEVELOPMENTS

In Canada, the steel industry consumed 6.62 Mt of scrap in 1991 compared to 6.55 Mt in 1990, a 1% increase. Of this total, 2.38 Mt was internally generated and 4.24 Mt was purchased. The percentage of purchased scrap used by steelmakers decreased 3.7% in 1991.

PRICES

There are few restraints to the movement of scrap across the border and, consequently, prices in the United States have a major impact on those in Canada.

The prices for ferrous scrap continued to decline during 1991. However, the decline was proportionally less than in previous recessions. The weekly steel scrap price composite, as published by the American Metal Market, was at a high of US$105/t at the beginning of the year. It dropped to $87/t in July, rose slightly in the next quarter, and fell to $86/t at year-end. The prices in Canada followed the same trends; however, Canadian imports of ferrous scrap from the United States decreased by 11.5%.

Decreasing prices for North American ferrous scrap in 1990 were attributed to a drop in steel production in the United States and to a decline of over 20% in U.S. ferrous scrap exports.

TRADE

Although a large bilateral trade exists between Canada and the United States, Canada is a net importer. Scrap supply was not a problem for Canadian steel companies in 1991, and imports decreased significantly.

During the last three years, 90% of Canadian scrap exports has gone to the United States, and virtually all Canadian imports originate in the United States.

Canada's recycling industry is efficient, quite highly mechanized, and competitive internationally. The world market for ferrous scrap is very competitive and tends to fluctuate widely from year to year. Offshore markets which have a history of buying Canadian scrap include South Korea, Spain, Italy and Japan.

CANADIAN INDUSTRY STRUCTURE

The Canadian ferrous scrap industry comprises approximately 600 firms. Most of these firms are small and are involved only in the simple collection of scrap. Dealers who are also involved in the sorting and storage of scrap are fewer in number, while those who engage in capital-intensive scrap processing total only about 15. Scrap processing requires heavy equipment such as mechanical shredders, shears, presses and bundlers.

A new, competitively sized processor would require in excess of $10 million for capital equipment.

Scrap is such an important raw material that it is common for Canadian steel producers to hold equity in scrap-processing companies in order to reduce the risk of supply problems and to assure quality control.

SCRAP CLASSIFICATION

The producers of ferrous scrap describe unprocessed scrap by its origin. "Home scrap" is produced in the manufacture of steel mill products, whereas "prompt industrial scrap" is generated by the secondary manufacturing industry. "Obsolete scrap" comes from discarded machinery, equipment and structures.

Prompt and obsolete scrap is generally processed by the recycling industry. It is sorted into a number of product classes for which standards have been written by the Canadian Association of Recycling Industries.

Scrap classification is based on factors such as size, type of material, cleanliness, and residual alloying elements. The most common grades are set out in the table opposite.

USES

Most ferrous scrap is used in electric furnace steel mills and integrated mills for the production of steel. The foundry industry is the second largest market for scrap. Minor markets include the production of iron powders, sinter, ferroalloys and abrasives.

SCRAP PRODUCTS

Class No.	Grade and Type
100	No. 1 heavy melting steel
101	No. 1 hydraulic bundles
102	No. 1 bushelling prepared
103	No. 2 heavy melting steel
104	Plate and structural steel
105	No. 2 hydraulic bundles
106	Hydraulic silicon bundles
107	No. 2 bushelling prepared
108	No. 1 Bushelling (clips)
109	Short shovelling steel turnings (crushed)
110	Machine shop turnings
111	Mixed turnings and borings
112	Cast iron borings
113	No. 1 shredded scrap
114	No. 2 shredded scrap
115	Briquetted steel turnings, alloy free
116	Briquetted steel turnings, alloyed
117	Foundry steel

Source: Canadian Association of Recycling Industries.

OUTLOOK

Historically, the trends in steel production that bear on scrap consumption have been the increasing percentages of electric furnace steel in total steel production, and the increasing use of purchased scrap by integrated producers. These trends are explained by the following facts:

- The percentage of total steel production made by the electric furnace industry increased because the cost of producing steel in electric furnaces was lower than costs at integrated mills. Cost advantages at electric furnace mills derive from lower capital costs, lower overall energy costs, lower man-hours per tonne labour inputs, flexible job responsibility practices, and the prevailing prices for scrap.

- The electric furnace mills had an additional cost advantage. The price of ferrous scrap fluctuates widely with demand, so scrap prices fell sharply in recessionary times, thereby lowering electric steel production costs. In the case of integrated steel producers, blast furnace iron costs varied little over the economic cycle and production costs did not decline appreciably.

- The increasing use of continuous casting at integrated mills reduced the amount of self-generated scrap available and, with technology that allowed the use of more scrap in basic oxygen furnaces charges, integrated mills began to purchase more scrap.

In the integrated steel industry, more or less scrap can be used depending on markets or other factors. In the case of the electric furnace steel industry, the price/ demand relationship is much more direct, and electric furnace mills can often produce steel at considerably less cost than integrated mills, especially in periods of low steel demand and low scrap prices.

Competition between electric and integrated mills will increase. Many electric mills have installed ladle refining facilities to improve the quality and range of their products. The next stage in the battle for market share will involve the use of technologies such as thin and near net casting, and the use of higher purity raw materials such as DRI or direct smelted iron. The first thin slab casting technology in a commercial plant was installed by Newcor Corp. of Charlotte, North Carolina, and it has been operating profitably since June 1990. The company has announced plans to build a second flat roll mini-mill with a capacity of 1 Mt/y in Crawfordsville, Indiana. Similar results are expected from near net casting which will allow mini-mills to produce low-cost products such as beams. These technologies will allow the electric furnace mills to compete in new markets with a likely increase in the demand for, and the price of, scrap.

Scrap usage in 1992 is expected to be close to the levels of 1988. In the medium term to 1995, usage should increase 4%-5%/y as more continuous steel is produced and a greater percentage of the steel made in North America is produced in electric furnaces. The growth rate after 1995 is forecast to slow to approximately 2%/y.

For the scrap recycling industry, the anticipated rising demand for higher quality scrap, especially in terms of low levels of tramp elements and more desirable product forms, will likely require the installation of more sophisticated process equipment. This could include x-ray spectrometers to analyze scrap, mechanical separators, and high pressure bailers and briquetting machines for the production of high-density product. There will likely also be an introduction of better shredders, which would improve the separation of ferrous metal from nonferrous metals and nonmetallic components in processing obsolete automobiles.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. CANADA, IMPORTS OF STEEL SCRAP,[1] BY PROVINCE OF ENTRY, 1989-91

		1989		1990		Jan.-Sept. 1991[p]	
		World	United States	World	United States	World	United States
Nova Scotia	tonnes	29	29	15 208	15 110	44	44
	$000	11	11	2 251	2 226	7	7
New Brunswick	tonnes	1 061	1 061	1 114	1 114	270	270
	$000	186	186	123	123	54	54
Quebec	tonnes	82 372	82 296	50 030	49 768	15 205	15 163
	$000	10 903	10 880	6 406	6 297	2 889	2 850
Ontario	tonnes	769 279	769 114	421 934	421 715	236 157	236 063
	$000	95 631	95 583	45 140	45 063	29 092	29 033
Manitoba	tonnes	101 425	101 425	47 256	47 256	16 664	16 657
	$000	14 548	14 548	6 209	6 209	1 698	1 697
Saskatchewan	tonnes	202 966	202 966	286 184	286 184	216 332	216 332
	$000	20 770	20 770	28 177	28 177	19 630	19 630
Alberta	tonnes	42 947	42 947	908	908	142	142
	$000	5 767	5 767	103	103	23	23
British Columbia	tonnes	5 395	5 395	2 000	1 804	1 523	1 447
	$000	608	608	349	337	219	210
Total, all provinces[2]	tonnes	1 205 486	1 205 244	824 640	823 877	486 337	486 118
	$000	148 437	148 365	88 779	88 556	53 627	53 529

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[p] Preliminary.
[1] Steel scrap includes H.S. classes 7204.29, 7204.30, 7204.41, 7204.49 and 7204.50. [2] "All provinces" includes the Yukon and Northwest Territories.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, EXPORTS OF STEEL SCRAP,[1] BY PROVINCE OF LADING, 1989-91

		1989		1990		Jan.-Sept. 1991p	
		World	United States	World	United States	World	United States
Newfoundland	tonnes	2 157	257	–	–	–	–
	$000	443	40	–	–	–	–
Nova Scotia	tonnes	5 275	55	18 360	2 545	18 030	17 803
	$000	867	58	4 052	763	2 020	1 898
Prince Edward	tonnes	–	–	–	–	1	1
Island	$000	–	–	–	–	3	3
New Brunswick	tonnes	514	514	1 806	1 806	2 079	2 079
	$000	293	293	410	410	410	410
Quebec	tonnes	221 137	49 308	230 152	26 792	120 990	18 816
	$000	30 297	9 051	33 280	5 686	16 854	3 915
Ontario	tonnes	294 996	278 455	540 415	502 182	332 560	316 642
	$000	53 903	48 189	72 956	67 081	42 454	38 190
Manitoba	tonnes	3 197	3 102	14 102	13 917	2 362	2 362
	$000	1 708	1 644	3 563	3 494	714	714
Saskatchewan	tonnes	201	201	44	44	108	108
	$000	270	270	84	84	13	13
Alberta	tonnes	1 689	1 233	1 450	1 020	979	820
	$000	663	469	550	388	304	261
British Columbia	tonnes	243 734	239 253	336 973	303 167	226 108	217 250
	$000	33 765	31 828	48 064	42 474	27 237	24 718
Total, all provinces[2]	tonnes	772 900	572 378	1 143 725	851 897	703 374	576 038
	$000	122 220	91 855	163 026	120 448	90 034	70 145

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; p Preliminary.
[1] Steel scrap includes H.S. classes 7204.29, 7204.30, 7204.41, 7204.49 and 7204.50. [2] "All provinces" includes the Yukon and Northwest Territories.
Note: Numbers may not add to totals due to rounding.

TABLE 3. CANADA, EXPORTS OF STAINLESS STEEL SCRAP,[1] BY PROVINCE OF LADING, 1989-91

		1989		1990		Jan.-Sept. 1991p	
		World	United States	World	United States	World	United States
Newfoundland	tonnes	1 048	–	–	–	–	–
	$000	207	–	–	–	–	–
Nova Scotia	tonnes	885	57	634	498	462	353
	$000	1 454	114	979	832	524	400
New Brunswick	tonnes	495	56	499	445	3 420	3 410
	$000	786	72	611	562	510	501
Quebec	tonnes	9 335	3 458	7 105	4 550	2 030	1 949
	$000	17 874	7 466	8 023	4 688	2 134	1 973
Ontario	tonnes	14 886	7 112	19 432	13 430	9 076	7 613
	$000	28 279	11 031	25 275	15 216	8 714	7 393
Manitoba	tonnes	1 997	1 864	3 164	3 164	457	457
	$000	2 056	1 900	1 256	1 256	545	545
Saskatchewan	tonnes	21	21	–	–	20	20
	$000	32	32	–	–	25	25
Alberta	tonnes	1 884	1 344	800	531	439	370
	$000	3 275	2 174	785	444	591	520
British Columbia	tonnes	4 470	1 687	2 730	1 424	2 683	511
	$000	4 944	425	3 173	388	2 863	396
Total, all provinces[2]	tonnes	35 021	15 599	34 364	24 042	18 587	14 683
	$000	58 911	23 217	40 106	23 390	15 910	11 756

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; p Preliminary.
[1] Stainless steel scrap includes H.S. class 7204.21. [2] "All provinces" includes the Yukon and Northwest Territories.
Note: Numbers may not add to totals due to rounding.

TABLE 4. CANADA, CRUDE STEEL PRODUCTION AND SHIPMENTS, 1989-91

	1989	1990	1991p
		(tonnes)	
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	500 000	–	–
Basic oxygen converter	11 736 900	11 736 900	11 854 400
Electric	6 393 450	6 664 640	6 891 450
Total	18 630 350	18 401 540	18 745 850
Steel castings	403 590	631 600	322 590
Total furnace capacity	19 033 940	19 033 140	19 068 440
Production			**(Jan.-Oct.)**
Steel ingot			
Basic open-hearth and basic oxygen	10 608 346	7 676 182	7 234 110
Electric	4 724 095	4 508 219	3 464 849
Total	15 332 441	12 184 401	10 698 959
Continuously cast, included in total above	11 760 472	9 423 667	8 914 719
Steel castings[2]	125 698	96 335	76 059
Total steel production	15 458 139	12 280 736	10 775 018
Shipments from plants			
Steel castings	x	89 128	72 165
Rolled steel products	13 325 808	11 563 101	9 413 902
Total shipments	x	11 652 229	9 486 067

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; x Confidential.
[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.

TABLE 5. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1989-91

	1989	1990	1991p
		(tonnes)	
Furnace capacity January 1[1]			
Blast	12 067 000	10 025 000	10 060 000
Electric	900 000	900 000	900 000
Total	12 967 000	10 925 000	10 960 000
Production			
Basic	w	w	w
Foundry iron[2]	w	w	w
Total	10 138 904	7 346 127	6 840 082a
Consumption of pig iron			
Steel furnaces[3]	10 128 221	7 441 171	6 772 897a
Consumption of iron and steel scrap			
Steel furnaces	7 789 670	6 554 354	5 504 537a

Sources: Energy, Mines and Resources Canada; Statistics Canada; Primary Iron and Steel (monthly).
p Preliminary; w Withheld to avoid disclosing company proprietory data.
a January to October.
[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] Includes pre-reduced iron.

TABLE 6. CANADA, IMPORTS AND EXPORTS, 1989-91

		1989		1990		Jan.-Nov. 1991p	
		World	United States	World	United States	World	United States
IMPORTS							
Iron and steel	(000 t)	3 033	1 182	4 031	2 515	3 875	2 755
	($000)	2 903 936	1 373 147	2 884 602	1 678 924	2 486 959	1 506 734
Rolling mill products	(000 t)	2 365	878	2 480	1 396	1 938	1 240
	($000)	1 692 776	768 185	1 734 026	1 022 434	1 411 773	888 079
Steel mill products	(000 t)	2 739	1 071	2 915	1 660	2 370	1 486
	($000)	2 240 992	1 072 256	2 309 325	1 385 407	1 956 858	1 220 975
EXPORTS							
Iron and steel	(000 t)	4 564	3 032	4 352	3 037	4 471	2 726
	($000)	2 813 688	2 110 982	2 511 712	1 934 601	2 536 867	1 790 598
Rolling mill products	(000 t)	3 330	2 141	3 408	2 243	3 607	1 990
	($000)	1 828 791	1 264 941	1 690 937	1 206 021	1 689 387	1 061 461
Steel mill products	(000 t)	3 978	2 743	3 968	2 762	4 257	2 534
	($000)	2 415 176	1 810 459	2 183 003	1 661 839	2 278 304	1 556 863

Source: Statistics Canada.
p Preliminary.

TABLE 7. WORLD RAW STEEL PRODUCTION, 1990 AND 1991

	1990[r]	1991[e]
	(000 tonnes)	
U.S.S.R.	154.4	133.6
Japan	110.3	109.6
United States	88.9	79.4
People's Republic of China	66.3	70.7
Germany[1]	38.4	42.2
Republic of Korea	23.1	26.0
Italy	25.5	25.0
Brazil	20.6	22.6
France	19.0	18.4
United Kingdom	17.8	16.5
India	15.0	16.4
Canada	12.3	13.0
Spain	12.9	12.9
Czechoslovakia	14.9	12.3
Belgium	11.4	11.3
Taiwan	9.7	11.0
Poland	13.6	10.3
South Africa	8.6	9.5
Turkey	9.3	9.3
Mexico	8.7	8.0
Romania	9.8	7.1
North Korea	7.0	7.0
Australia	6.7	6.2
Netherlands	5.4	5.2
Sweden	4.5	4.3
Austria	4.3	4.2
Luxembourg	3.6	3.4
Venezuela	3.2	3.1
Argentina	3.6	3.0
Finland	2.9	2.9
Egypt	2.2	2.5
Yugoslavia	3.6	2.3
Indonesia	2.9	2.3
Iran	1.4	2.2
Hungary	2.9	1.9
Saudi Arabia	1.8	1.8
Bulgaria	2.4	1.7
Others	20.9	15.2
Total world	769.9	734.4

Source: International Iron and Steel Institute.
[e] Estimated; [r] Revised.
[1] Including the former German Democratic Republic in 1991 only.
Note: Numbers may not add to totals due to rounding.

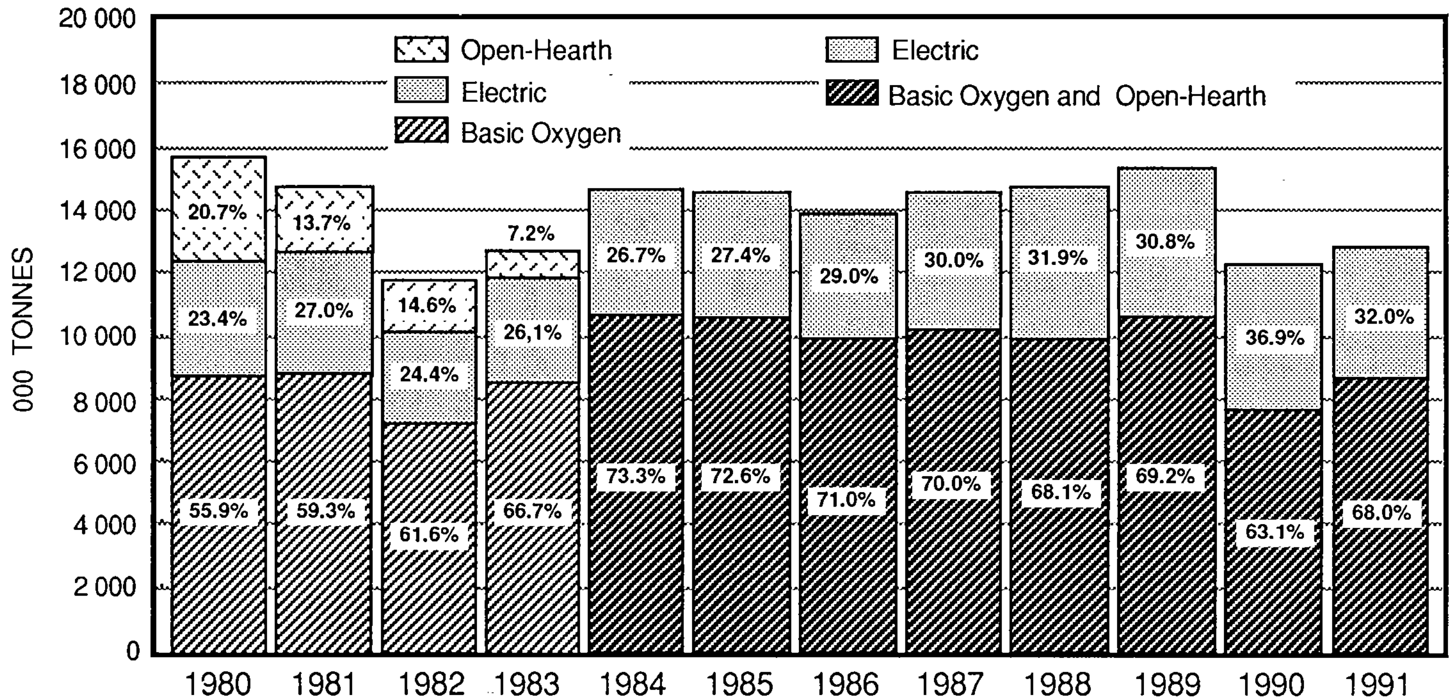
TABLE 8. CAPACITY AND PRODUCTION OF DIRECT REDUCED IRON (DRI), 1990 AND 1991

Country	Capacity		Production	
	1990	1991	1990	1991
	(Mt/y)		(Mt/y)	
Argentina	0.93	0.93	1.03	0.96
Brazil	0.31	0.31	0.28	0.29
Burma	0.04	0.04	0.02	0.02
Canada	1.00	1.00	0.73	0.56
Egypt	0.72	0.72	0.71	0.62
Germany	0.40	0.40	0.31	0.26
India	1.48	1.70	0.72	1.18
Indonesia	2.00	2.00	1.41	1.43
Iran	1.13	1.53	0.30	0.58
Iraq	1.47	1.47	0.17	. .
Libya	1.10	1.10	0.50	0.79
Malaysia	1.25	1.25	0.62	0.62
Mexico	4.03	4.03	2.47	2.49
New Zealand	0.17	. .	. .	. .
Nigeria	1.02	1.02	0.11	0.11
Peru	0.12	0.12	0.03	0.03
Qatar	0.40	0.40	0.58	0.57
Saudi Arabia	0.80	0.80	1.09	1.12
South Africa	1.36	1.06	0.90	0.90
Trinidad & Tobago	0.84	0.84	0.70	0.71
United Kingdom	0.80	0.80	. .	. .
United States	0.40	0.40	0.39	0.41
U.S.S.R.	1.67	1.67	1.69	1.70
Venezuela	5.93	5.93	3.13	4.02
Total	29.37	29.52	17.89	19.37

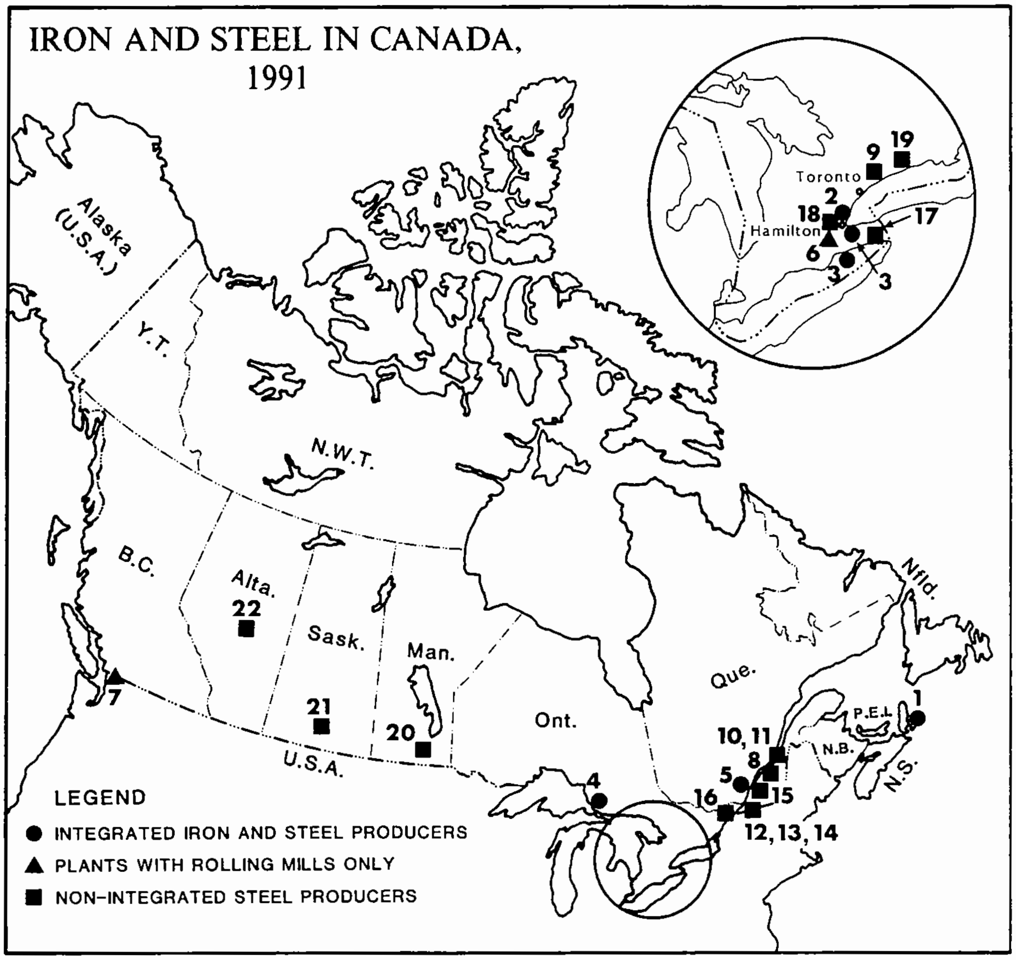
Source: Midrex Corp., North Carolina, United States.
. . Not available.

Figure 1

CANADA, PRODUCTION OF STEEL BY FURNACE TYPE, 1980-91



Primary Iron, Steel and Ferrous Scrap



INTEGRATED IRON AND STEEL PRODUCERS
(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dofasco Inc. (Hamilton)
3. Stelco Inc. (Hamilton and Nanticoke)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Inc. (Contrecoeur)

Plants with Rolling Mills Only

6. Stanley Strip Steel division of Stanley Canada Inc. (Hamilton)
7. Pacific Continuous Steel Limited (Delta)

Non-Integrated Steel Producers

8. QIT-Fer et Titane Inc. (Sorel)
9. Courtice Steel Inc. (Cambridge)
10. Stelco Inc. (Contrecoeur)
11. Atlas Stainless Steels, division of Sammi Atlas Inc. (Tracy)
12. Sorel Forge, division of Slater Industries Inc.
13. Canadian Steel Foundries, division of Hawker Siddeley Canada Inc. (Montreal)
14. Canadian Steel Wheel Limited (Montreal)
15. Sidbec-Dosco Inc. (Montreal and Longueuil)
16. Ivaco Inc. (L'Orignal)
17. Atlas Specialty Steels: division of Sammi Atlas Inc. (Welland)
18. Hamilton Specialty Bar: division of Slater Industries Inc.
19. Co-Steel Inc. (Whitby)
20. Manitoba Rolling Mills, subsidiary of The Canam Manac Group Inc.
21. IPSCO Inc. (Regina)
22. Stelco Inc. (Edmonton)

Salt

Patrick Morel-à-l'Huissier

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-3258

DOMESTIC PRODUCTION AND DEVELOPMENTS

In 1991, Canadian production of salt was estimated at 11.93 million tonnes (Mt), a 5.9% increase over 1990. Most of this increase was due to the fact that production in Ontario returned to normal after the 1990 strike that affected the Ontario operations of The Canadian Salt Company Limited. Canadian shipments of all types of salt increased moderately by 3.5% to 11.59 Mt, of which about 60% was from Ontario, compared to about 55% in 1990. Rock salt shipments accounted for 73% of total shipments, followed by salt in brines (21%) and evaporated salt (7%). The average unit value of salt shipments was estimated at $22.32/t, a 3.7% increase over 1990. Salt production capacity in Canada increased slightly to 13.25 Mt, of which rock salt accounted for 70%, followed by captive brines (23%) and evaporated salt (7%). In 1991, rock salt mines operated at 95% of capacity; captive brining plants and evaporated salt facilities operated at 78% and 83% respectively. Salt operations overall ran at an average of 90% of capacity, compared to 85% in 1990.

Sales of salt products for de-icing purposes were soft in western Canada in early 1991 due to a mild second half of the 1990/91 winter. However, an early cold 1991/92 winter has helped sales to come back to more normal levels. In eastern Canada, conditions were more favourable to the salt industry and sales of de-icing salt were strong; however, no occasional shortages in supply were reported. After the rise observed in 1990 to compensate for a drop in domestic production, imports are expected to return to levels comparable to those observed in the second half of the 1980s. Strong sales of de-icing salt were recorded in Quebec and Ontario, but sales were softer in Atlantic Canada. Shipments for the 1991/92 winter period were good and may be the signal of a strong year.

The chloralkali sector is currently under significant pressure, mainly for environmental reasons, and sales slowed a little during 1991. In 1991, one of the largest end-users for chloralkali, the Canadian pulp and paper industry, experienced one of its worst years in a long time. Pulp mill operating rates remained stable at 84% of capacity; operating rates ranging between 78% and 92% were reported during the fourth quarter of 1991. Canadian production of wood pulp rose 2% to 23 213 000 t in 1991, while pulp shipments increased 12% over 1990.

The pulp and paper industry continued its restructuring for the conversion of bleaching processes away from chlorine technology. The rate of substitution is, however, lower than initially anticipated due to the current weak Canadian economy and reduced revenues. Chlorine continued to be under scrutiny with respect to its use in solvents (chlorofluorocarbons), in drinking water disinfection and in pulp bleaching. In 1991, the production of chlorine and caustic soda declined by about 9% over 1990. The market for PVC and its feedstocks (ethylene dichloride-EDC and vinyl chloride monomer-VCM) remained firm in 1991 despite the decline in housing starts. In 1991, sales of sodium hydroxide (caustic soda) were very good with sustained demand in industrial chemical and pulp and paper markets. In North America in 1989, caustic soda was the major bleaching chemical used accounting for 49.5%, followed by chlorine at 34.8% and sodium chlorate at 12.2%. By 1995, caustic soda is forecast to represent 49.0% of bleaching chemical usage, chlorine to be reduced to 22.5%, and sodium chlorate to reach 20.9%. The imbalance between chlorine and caustic soda, two co-products from the same electrolysis process, continued and exerted upward pressure on caustic soda prices due to its restrained supply. However, prices for caustic soda declined slightly towards the end of 1991. Producers of natural soda ash are also entering the market of caustic soda, which could result in a much reduced imbalance between chlorine and caustic soda.

Sodium chlorate is considered to be the primary substitute for chlorine bleaching in pulp mills as it is the feedstock for the production of chlorine dioxide. Several sodium chlorate companies in Canada completed expansion and modernization projects during the year and new production units became operational in western Canada. Production of sodium chlorate in Canada rose by about 5% in 1991.

Atlantic Region

Salt production in the Atlantic provinces was from an underground rock salt mine at Pugwash, Nova Scotia, an underground potash and salt mine at Sussex, New Brunswick, and a brining operation near Nappan, Nova Scotia.

In New Brunswick, Potash Company of America, a division of Rio Algom Limited, produced potash and salt at its underground mine near Sussex. Salt is extracted at a rate of 400 000-500 000 t/y and is sold mainly to the eastern United States and eastern Canada. Reserves are estimated to be large enough to operate for as long as potash is extracted, which is for at least 20 years. In 1991, about 95% of the production was used in road de-icing.

In Nova Scotia, The Canadian Salt Company Limited operates an underground rock salt mine at Pugwash in Cumberland County, with a rated capacity of approximately 1.2 Mt/y. Most of the salt from this mine is used for snow and ice control. At the evaporated salt plant, saturated brine is fed to a quadruple effect vacuum pan, rated at 13 t/h, where brine solution is evaporated to produce high-quality salt crystals for use in the chemical and food industries. In 1991, the $7 million expansion and upgrading project was completed. Production at the 300-m level started as planned in the course of the year. It is expected that 1992 production will continue at the same level as in 1991. In 1990, production was higher than usual due to a shift in production to compensate for the Ontario strike. The bagging operation bought in 1989 by The Canadian Salt Company Limited from Avalon Salt of Newfoundland is used at capacity for the bagging of solar salt supplied from its facility in the Bahamas.

Sifto Canada Inc., a division of North American Salt Co., has a brining operation at Nappan in Cumberland County, Nova Scotia. Evaporated salt products are sold for table salt, fisheries and water conditioning. Again in 1991, the plant operated at a very high rate of capacity.

Quebec

The year 1991 saw no new developments at Seleine Mines Inc. in the Magdelen Islands where production was high. Reserves at the 173-m level are projected to last until the end of 1993. Each level has an average reserve life of five years, holding about 8 Mt per level. The 270 000-t covered outdoor facility completed in 1990 allows the mine to produce for 11 months instead of the previous 9 months in the past. Because of changes in priorities, the replacement of the secondary and tertiary impact crushers by rolling bar crushers was not done; however, the replacement is still planned for the near future as it should increase the recovery rate by 5% (to 85%).

Ontario

In 1991, salt was produced from two underground rock salt mines, Goderich and Ojibway, and from brining operations at Goderich, Sarnia, Windsor and Amherstburg.

At Goderich, Sifto Canada Inc. operated an underground rock salt mine. Sifto's salt is marketed mainly for ice control and is sold primarily in eastern Canada, the north-central United States (Great Lakes Basin), and regions accessible through the Mississippi River system. Salt produced at Goderich is also used by the chemical and water treatment industries. Evaporated salt is produced at the Sifto brining operation located near Goderich. The installation of a new compactor was completed in September 1991 and it is hoped this will help Sifto to develop new markets.

The Canadian Salt Company Limited produced both rock salt from the Ojibway underground mine and vacuum salt products from brine wells near Windsor. The mine capacity is 2.5 Mt/y. Rock salt is extracted from a depth of 297 m while brine is pumped from the 427-m and 457-m levels. Production at both facilities returned to normal in 1991 after the six-month strike that affected production in 1990. Development work in the southwest area of the mine progressed and production started during 1991.

In the vicinity of Amherstburg, General Chemical Canada Ltd. operated a brining operation for the manufacture of sodium carbonate and by-product calcium chloride. At Sarnia, Dow Chemical Canada Inc. extracted brines from wells for the production of caustic soda and chlorine.

Prairie Provinces

In Saskatchewan, four companies produced salt from the Middle Devonian Prairies formation. International Minerals & Chemical Corporation (Canada) Limited (IMCC) supplied by-product rock salt from its potash operation at Esterhazy. Its salt is distributed locally for road de-icing. Sifto Canada Inc. operated a brining operation near Unity for the production of fine vacuum pan salt. At the Unity plant, the only fused salt facility in existence in Canada closed down permanently in May 1991. This closure was mainly due to environmental pressures arising from air emissions from this unit's furnace. A dust collection system has been installed at the Patience Lake operation where salt is recovered by processing waste salt from a nearby potash operation. The production capacity is reported to be in the range of 50 000-60 000 t/y. The Canadian Salt Company Limited at Belle-Plaine produced evaporated salt from by-product brines sourced from an adjacent potash solution mine operated by Kalium Chemicals, a division of Kalium Canada, Ltd. Saskatoon Chemicals, a division of Weyerhaeuser Canada Ltd., produced brines from wells near Saskatoon for the manufacture of caustic soda and chlorine to be used internally.

In Alberta, two producers operated brining operations. At Fort Saskatchewan near Edmonton, Dow Chemical Canada Inc. extracted salt brines for the manufacture of chloralkali and, at Lindberg, The Canadian Salt Company Limited produced fine vacuum pan salt.

British Columbia

There was no production of salt in this province where three companies operated five chloralkali plants, a reduction of one after the closure by Canadian Occidental Petroleum Ltd. of its chlorine/caustic soda plant in Nanaimo in 1990. At the end of 1991, Canadian Occidental Petroleum Ltd. also announced the closure of the Squamish plant, leaving now only four chloralkali plants in British Columbia. These operations used solar salt imported from Mexico, the United States and Chile.

CONSUMPTION

In Canada, the apparent consumption of salt has averaged 9.0 Mt/y since the mid-1980s, a 30% increase compared to the early 1980s. In 1990, the apparent consumption of salt in Canada was estimated at 11.4 Mt, the same level that was observed in 1989. In 1990, imports accounted for about 18% of total domestic consumption. Chemical and de-icing uses accounted for between 90% and 95% of Canadian consumption, with the remainder being used for water conditioning, food processing, fisheries and other industrial usages. Most of the salt used as a de-icing agent is consumed in Ontario, Quebec and Atlantic Canada. Average yearly ice and snow control consumption of salt in Canada ranges between 3.2 Mt and 4.5 Mt.

Some 60% of world salt consumption is as a chemical raw material, followed by table salt (19%) and road de-icing salt (11%); the remaining 10% is used in animal feed and water treatment. The consumption pattern differs in North America where the chemical industry consumes about half of total production, followed by highway usage and the food industry.

The industrial chemicals industry consumes salt for the manufacture of chloralkali such as caustic soda (sodium hydroxide), chlorine and sodium chlorate. Salt for four caustic soda and chlorine plants in Canada is obtained from on-site brining and natural brines; other plants use mined rock salt or imported solar or evaporated salt. Other industrial chemicals that require significant quantities of salt include sodium bicarbonate, sodium chlorite, sodium hypochlorite, sodium carbonate (soda ash), and calcium chloride.

Chlorine, which is a major market for salt, is currently under investigation as the principal pulp-bleaching agent responsible for the presence of traces of dioxin (2, 3, 7, 8,-TCDD (tetrachlorodibenzo-p-dioxin)) and furan (2, 3, 7, 8,-TCDF (tetrachlorodibenzo-p-furan)) in certain pulp and paper mill effluents in North America. These chlorinated compounds have been identified as carcinogenic to some animals; however, their effect in small dosages on humans is controversial.

In April 1990, Environment Canada released draft regulations to impose stringent national pollution standards on the Canadian pulp and paper industry. A set of regulations, which came into effect on January 1, 1991, was prepared under the *Canadian Environmental Protection Act* and will prohibit the use and sale of defoamers containing any measurable concentrations of dioxins and furans. By 1994, the release of these chemical compounds will be banned in pulp mill effluents. An announcement on the required compliance of pulp and paper mills with new amendments to regulations under the *Fisheries Act* was issued in February 1991. These amendments, once they become law, will establish new procedures for effluent measurement and, for the first time, make **all** mills in Canada, new and old, subject to regulations governing the discharge of suspended solids and oxygen-depleting substances. To obtain an extension beyond the December 31, 1993 deadline, a company will have to demonstrate that it made all reasonable efforts to comply with these regulations. An extension will be subject to public consultation and ministerial approval. No extensions will be granted after December 31, 1995. The national average of dioxin and furan discharges from Kraft pulp mills was estimated at 6 kg/t of pulp produced. In the United States, the Environmental Protection Agency (EPA) tabled proposals to regulate the reduction of dioxin and furan released from pulp mills and to impose a concentration limit in effluents at 10 parts per quadrillion.

In April 1991, Environment Canada released a study on dioxins and furans in river and marine sediments in the vicinity of 47 pulp and paper mills using chlorine as a bleaching agent. Dioxins and furans were found at 95% of the 47 sites sampled. Sediments at coastal mills in British Columbia showed a higher degree of contamination than those near inland mills. All 47 mills will have to meet the stringent regulatory requirement by January 1, 1994. It is also worth noting that there is currently a debate, mainly in the United States, about the toxicity of dioxins. In summary, the U.S. EPA and the Center for Disease Control in Atlanta are now stating that there is new evidence suggesting that dioxin is not as strong a carcinogen as originally believed. However, these findings are unlikely to change the Canadian policy on dioxin as a study by Environment Canada found that pulp mill effluents are toxic and will endanger human life as long as chlorine is used, even if all dioxins were to be removed.

Many mills in North America have already started the conversion of their bleaching process away from chlorine technology. A target of 50% substitution is contemplated while several modifications could achieve 70% substitution. A limit of 2.0 kg/t for absorbable organic halides (AOX), which include furans and dioxins, could be readily achieved; however, a cap could be legislated at 1.5 kg/t and would require a substitution level of up to 80%-90% in older mills, and up to 60%-70% in more recent mills.

Most mills in Canada have carried out extensive process modifications and improvements in effluent treatment. Several opted for reducing chlorine usage by installing other bleaching processes such as extended lignification, oxygen delignification, sodium chlorate bleaching, integrated chlorine dioxide with hydrochloric acid recycling, and ozone and hydrogen peroxide bleaching processes.

Sodium chloride, or salt, remains the primary de-icing agent. Different de-icers are used in accordance with site requirements. On streets and highways, rock salt, calcium chloride-salt mixtures, salt brines and mechanical measures (plowing and blowing) are mostly used. On bridges, salt, sand-salt mixtures and salt alternative methods are used; pavement heating and non-corrosive chemicals with corrosion inhibitors are under investigation. On runways and airways, non-corrosive compounds are used and comprise urea, formamide and glycols. In residential and commercial areas, rock salt, potassium chloride (potash), calcium chloride and various combinations of these materials with abrasives are regularly used. Calcium chloride is the second most used de-icer, being effective at temperatures ranging between -10°C and -20°C; this chemical is usually mixed with salt at a 2%-4% rate. The use of abrasives is mostly limited to highways and residential areas; a mixture of coarse sand and small crushed stone is spread to improve the skid resistance of slippery roads.

Growing concerns over degradation of the environment and corrosion of infrastructure such as bridge decks and parking lots have led to numerous experiments with de-icing salt substitutes. Research on alternatives has focused on abrasive mixes, magnesium chloride, ammonium compounds, tetrapotassium pyrophosphates, calcium magnesium acetate (CMA), sodium formate, isopropyl alcohol, ethylene glycol and technical urea. Studies have also been conducted on non-chemical treatments, including a series of measures that are largely used in Europe such as ice-retardant pavement surfacing and roadway heating. The effects of salt-spreading on the environment depend on a variety of factors such as weather conditions, road characteristics, traffic loads, winter maintenance methods, and local topography. Environmental effects may include adverse impacts on plant growth and crop productivity in the immediate vicinity of highways, and higher salinity levels in streams and groundwater systems. For many years, provincial and regional agencies in charge of road maintenance have pursued the objective of optimizing the use and selection of ice and snow control methods. Cost, operational reliability, public safety and environmental considerations have resulted in improvements to existing methods and better road safety and rideability.

In Ontario, the Ministry of Transportation has completed its field experiments on Calcium Magnesium Acetate (CMA) on Highway 26 near Owen Sound; the final report is due in the middle of 1992. Results indicate that CMA is only effective at temperatures around -6° and -7°C. Although CMA has proven to be effective and environmentally safe, its temperature limitation and its price, which is about 30 times that of salt, will continue to limit its application.

Since mid-1987, the Transportation Association of Canada (TAC) has been coordinating an extensive project to evaluate degradation of highways and related infrastructure. The Canadian Strategic Highway Research Program (C-SHRP) is a $5 million project funded by provincial and federal governments over a five-year period. In 1990, the SHRP program in the United States initiated an $800 000 project to evaluate the testing procedure for de-icing chemicals and to develop improved sodium chloride products. The two-year program comprises two phases: field observations being carried out during the winter of 1991/92; and investigations of the effectiveness of salt and non-chloride chemicals. A preliminary report is expected by the fall of 1992 and the full report should be available before the end of March 1993.

Other sectors that consume salt include water softening, food processing and the fisheries industry, which together account for close to 5% of total consumption in Canada. Salt consumption in Canada for water softeners was estimated at 150 000-200 000 t/y. All Canadian production was consumed in the domestic market as trade in conditioning salt was estimated to be small. A typical annual consumption per household in Canada ranged between 350 kg/y and 450 kg/y of salt. The bulk of the market was reported to be located in suburban and rural areas where hard water is seldom treated on a large-scale basis. Some major municipalities in western Canada, such as Regina and Calgary, use water softeners extensively as the local water carries high calcium and magnesium concentrations. In 1990, the water treatment market in Canada was evaluated at $650 million, a 10% increase over 1989. The residential water-softening market was evaluated at $45 million, a 10% decrease compared to 1989, and salt sales in this market segment were at $20 million. This decrease in the water-softening market was mainly due to the fact that Canadians turned to bottled water where the growth was in the order of 70% in comparison with 1989. Fused salt, which was a popular product for water softening, has been replaced by compacted salt pellets, nuggets and crystals; in some instances, coarse salt is used. Growth in this market is tied to housing starts and local water characteristics. New water treatment devices that do not use salt, such as electromagnetic equipment and catalytic units, have not yet been approved in Canada.

TRADE

In 1990, salt imports were reported at 2.10 Mt, which represents a decrease of 11.2% over 1989. This number is, however, high in comparison with numbers recorded over the past decade. The main reason behind this stabilization of imports at a high value is the six-month strike that affected the Ontario operations of The Canadian Salt Company in 1990. The 1990 average unit value for imported salt rose 14% to $17.16/t. The 1990 exports declined 11.2% to 1.90 Mt valued at $37.25 million. This was below the 1984-87 average of 2.3 Mt/y, but was close to the 1987 level. The main reason for this decrease was the strike at the Ontario Canadian Salt Company operations, which reduced output and, therefore, the quantities available for export. During the first nine months of 1991, imports amounted to 955 380 t, a 40.5% decrease over 1990, primarily due to a return to normal Canadian production levels in Ontario. Imports were mainly from the United States (66%), Mexico (26%), Chile (4%) and the Bahamas (3%), for deliveries in British Columbia (48%), Ontario (34%) and Quebec (9%). Nine-month exports in 1991 increased 53% to 1.77 Mt valued at $32.9 million. Exports were shipped to over 20 countries, but the bulk was to the United States, which accounted for 99.1%. In 1991, deliveries were shipped mainly from Ontario (75%) and Quebec (22%), with the remainder coming from Nova Scotia and Saskatchewan. The unit value of 1991 exports averaged $18.56/t, a 5.3% decrease over the same period in 1990.

WORLD PRODUCTION IN REVIEW

In 1990, world production decreased 3% to 184 Mt. Although salt is produced in a great number of countries, production in that year was dominated by the United States, which accounted for 20%, followed by China (11%), the U.S.S.R. (8%) and West Germany (8%). Canada ranked fifth with 6%. In 1990, Chile doubled its production while China posted a 29% decrease.

United States

In 1991, salt production was estimated at 36.3 Mt valued at US$765 million. Thirty-two companies operated seventy plants in thirteen states. At year-end 1990, annual salt production capacity was reported at 41.1 Mt; salt producers operated at a rate of 88.3% of capacity during 1990. Apparent consumption was estimated at 40.2 Mt, about a 1% decline from 1990. Brine sales accounted for 47% of the salt sold or used, followed by rock salt (35%), evaporated salt (10%) and solar salt (8%). The chemical industry consumed about 47% of the total salt sold; road and ice control usage accounted for 25%. The average unit value for rock salt shipments decreased by about half a percent to US$16/t, while the average unit value for salt from brine rose 2% to US$5/t. Imports rose by about 2% to 6.1 Mt and were mainly from Canada, Mexico and the Bahamas. The net import reliance of the United States for 1991 was estimated at 11% of apparent consumption. Exports decreased 20% to 1.8 Mt.

In 1991, a new salt and potash operation began production of solar salt on Sevier Lake in Utah. Also in Utah, a major land exchange took place between three salt producers and a copper company. As a result of this transaction, new solar ponds on the west side of the Great Salt Lake will be constructed.

Two chloralkali facilities in Alabama and West Virginia that closed down in 1991 were responsible for the slight decline in U.S. production and consumption.

Australia

A major A$23 million expansion program of the Australian Dampier salt field was announced by Dampier Salt Ltd. Investments will be made for upgrading existing equipment, which will increase the field capacity by 500 000 t/y to 3 Mt/y. It is also reported that the company has the potential to bring its total production capacity to 7 Mt/y. This expansion will also strengthen the company's position as Australia's largest producer with a total capacity of 4.5 Mt/y. This incremental production is aimed at the growing demand from the chemical industry, especially in north and southeast Asia, as salt consumption in Asia grows at a forecasted annual rate of 2% to reach 12 Mt/y by the year 2000. Exports to Japan predominate, but it is expected that Korea, Taiwan and Indonesia will become significant customers. Gulf Holdings Pty Ltd. announced its intention to build an A$80 million solar salt facility in the region of Onslow with an anticipated capacity of 1.5 Mt/y. Production is scheduled to start in late 1992 with projected export sales at A$30 million.

INTERNATIONAL TRADE

Salt is a widespread, low-value, bulk commodity. It is relatively easy to extract and transportation represents a significant proportion of the total delivered price of salt. Consequently, international trade in salt is small relative to world production, i.e., about 20% of total world production. Trade in the Pacific area will account for one half of seaborne movements by 1992, followed by North America (24%) and northwestern Europe (20%). Australia is expected to remain the major supplier to Japan, while Mexico will continue to export mainly to Japan and North America. Imports to the European Community are expected to remain minimal as this region is essentially self-sufficient.

PRICE

The price of salt depends on factors such as production methods, purity, scale of operations, transportation costs and product availability. During those periods when a shortage occurs for reasons of strikes or technical problems, prices for salt will likely rise until alternative sources are found. In peak periods of demand, de-icing rock salt prices may increase if the current harsh winter conditions persist. Most likely, the replenishment of stocks during such periods will be subjected to higher prices.

In 1991, prices for salt products rose 3%, still at a pace below the annual inflation rate. Prices for de-icing rock salt, bulk delivery, rose 3.0%-3.5% and varied between \$48/t and \$85/t. In the agricultural products sector, the price for a 20-kg lick block was around \$4-\$8 while a 25-kg paper bag varied between \$4 and \$11. Fine evaporated salt prices varied between \$79/t and \$135/t. Water conditioning grades were sold for \$5-\$9 per 40-kg bag.

OUTLOOK

In 1992, domestic production and consumption of salt is forecast to remain stable. Imports of rock salt are likely to decline, mainly due to the closure of two chloralkali facilities in British Columbia. Rock salt prices are expected to remain stable while value-added products should achieve a marginal, inflation-like increase in 1992.

De-icing salt will continue to face mounting environmental pressures. Enhanced de-icers will become attractive alternatives where their cost can be justified, in particular in corrosion- and accident-sensitive areas such as bridge decks. The optimization of spreading rates in combination with the search for adequate abrasive mixtures will continue to be evaluated. The 1991/92 winter augurs well for Ontario and Quebec. Sales in the Maritimes are expected to be lower due to a milder winter with precipitation mainly concentrated in one or two storms.

The manufacture of inorganic chemicals will remain a major market for salt in spite of environmental concerns. In 1992, salt consumption in chemicals is forecast to increase marginally as a result of the economic recovery that is expected in North America during the year. The pulp and paper industry, the major consumer of chloralkali, is also expected to recover from the 1991 recession with operating rates in the 85%-90% range. During the 1990-94 period, demand is forecast to grow at a marginal rate of up to 1%/y, while consumption is expected to decline in the pulp and paper sector at a rate of 8%-9%/y, and in the chlorinated chemicals sector at a rate of 1.5%/y. These declines will be offset by an anticipated growth in the PVC sector, in which sales of chlorine will register an annual increase of 4%-5% up to 1994.

Demand for chlorine's co-product, caustic soda or sodium hydroxide, is forecast to be strong in the pulp and paper, detergents and pH control sectors. Consumption of caustic soda is projected to increase 1.0%-2.5%/y up to 1994. The market will likely remain firm as new capacities are installed in the growing bleach chemo-thermomechanical pulp (BCTMP) segment of Canada. A serious imbalance between caustic soda and chlorine demands should force many caustic soda consumers to look for alternatives, such as calcined trona or sodium carbonate, for use in BCTMP mills, or to reduce its consumption rate, as in Kraft mills.

The substitution rate in the conversion of bleaching processes away from chlorine will accelerate as more stringent government regulations are announced. The conversion rate, targeted at 50% by many pulp mills, will probably reach 70%-80% within the next five years and trigger a favourable market for sodium chlorate. In North America, the consumption of sodium chlorate is forecast to grow at a rate of 11%/y up to 1994. Several expansions were announced or completed in Canada during 1991. The production capacity for sodium chlorate will reach 1 004 000 t/y by 1992, a 35% increase over 1990. These increases will take place in western Canada (80%) and Quebec (20%). Further rationalization is expected in the North American chloralkali industry; some high-cost operations will likely shut down within the next three years. Up to 1995, the demand for salt in this sector should experience a smaller growth given the combination of flat chlorine sales and increasing sodium chlorate consumption.

The demand for salt in water treatment should regain strength in 1992 after a slight decrease in 1991 mainly due to the effects of the recession. The revitalization is mainly based on anticipation of moderate growth in the housing sector. It should, however, be noted that consumers seem to be turning to bottled water for their own consumption, probably at the expense of the water-softening industry, thereby limiting the potential growth of this sector. Sales of salt in the fisheries and food industries are expected to decline. Fish-processing plants have been facing adverse economic conditions and are projected to operate at reduced rates, especially in light of recent quota reductions. The food industry will continue to reduce its salt requirements due to increasing public concern about lower sodium intake. Salt substitutes are expected to make sustained gains in this market.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2501.00	Salt (including table salt and denatured salt) and pure sodium chloride, whether or not in aqueous solution; seawater				
2501.00.10	Table salt made by an admixture of other ingredients when containing 90% or more of pure sodium chloride	4%	2.5%	Free	Free
2501.00.90	Other	Free	Free	Free	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, SALT SHIPMENTS AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
SHIPMENTS					
	By type				
	Mined rock salt	7 704 499	149 821	8 402 366	164 792
	Fine vacuum salt	778 428	76 427	786 712	81 701
	Salt content of brines used or shipped	2 708 458	14 642	2 396 261	12 091
	Total	11 191 385	240 890	11 585 339	258 585
	By province				
	Nova Scotia	x	x	x	x
	New Brunswick	x	x	x	x
	Quebec	x	x	x	x
	Ontario	x	x	x	x
	Saskatchewan	602 883	29 874	533 706	26 759
	Alberta	1 325 992	14 809	1 236 747	15 410
	Total	11 191 385	240 890	11 585 339	258 585
IMPORTS				(Jan.-Sept.)	
2501.00	Salt[1]				
	United States	1 552 621	29 575	631 225	15 223
	Mexico	342 140	3 662	244 782	3 796
	Bahamas	23 568	430	29 066	497
	Chile	117 017	1 051	38 000	369
	France	3 204	102	4 117	105
	United Kingdom	11 244	154	1 938	53
	Japan	7 774	227	3 172	33
	Belgium	2 271	44	694	23
	Other countries	35 482	720	2 386	60
	Total	2 095 321	35 965	955 380	20 159
	By province of clearance				
	Newfoundland	28 432	586	11 707	264
	Prince Edward Island	–	–	–	–
	Nova Scotia	47 075	494	17 492	236
	New Brunswick	1 104	80	582	19
	Quebec	361 402	5 599	87 405	1 972
	Ontario	963 295	18 762	327 951	8 729
	Manitoba	8 785	259	10 087	220
	Saskatchewan	4 135	204	4 047	171
	Alberta	32 282	1 075	31 055	905
	British Columbia	648 811	8 906	465 054	7 643
	Total	2 095 321	35 965	955 380	20 159
EXPORTS					
2501.00	Salt[1]				
	United States	1 893 855	36 824	1 771 603	32 639
	St. Pierre and Miquelon	2 041	164	1 399	118
	Dominica	42	5	255	21
	Other countries	1 878	257	1 298	150
	Total	1 897 816	37 250	1 774 555	32 928

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil or not reported; p Preliminary; x Confidential.
[1] Includes table salt, pure sodium chloride and seawater salt.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADIAN SALIENT STATISTICS ON SALT

Company	Location/ Initial Production	Employment 1989	Employment 1990	Annual Production Capacity 1987	1988	1989	1990	1991	Remarks
						(000 t/y)			
Canadian Salt Company Limited, The	Pugwash, N.S./1959	192[b]	225[b]	1 200	1 200	1 200	1 200	1 200	Rock salt mining to a depth of 305 m.
	Pugwash, N.S./1962			110	110	110	110	110	Dissolving rock salt fines for vacuum pan evaporation.
	Îles-de-la-Madeleine, Que./1982	182	174	1 200	1 200	1 500	1 500	1 500	Rock salt mining to a depth of up to 273 m.
	Ojibway, Ont./1955	241	278	2 500	2 500	2 500	2 500	2 500	Rock salt mining at a depth of 300 m.
	Windsor, Ont./1892	86	128	150	150	150	150	150	Brining, vacuum pan evaporation.
	Belle Plaine, Sask./1969	28	43	170	170	170	170	170	Producing fine salt from by-product brine from nearby potash operation.
	Lindbergh, Alta./1968	66	67	140	140	140	140	140	Brining, vacuum pan evaporation.
Subtotal		795	915						
Dow Chemical Canada Inc.	Sarnia, Ont./1950	4[a]	4[a]	830	900	900	900	900	Brining to produce caustic soda and chlorine.
	Fort Sask., Alta./1968	3[a]	4[a]	1 400	1 400	1 400	1 400	1 400	Brining to produce caustic soda and chlorine.
Subtotal		7[a]	8[a]						
General Chemical Canada Ltd.	Amherstburg, Ont./1919	8[a]	8[a]	650	690	690	690	690	Brining to produce sodium carbonate.
International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask./1962	3	3	120	120	120	120	120	By-product rock salt from potash mine for use in snow and ice control.
Potash Company of America, a division of Rio Algom Limited	Sussex, N.B./1980	29	29	500	450	450	450	500	Rock salt produced in association with potash for use in snow and ice control.
Saskatoon Chemicals - a division of Weyerhaeuser Canada Ltd.	Saskatoon, Sask./1968	5[a]	5[a]	70	70	70	70	70	Brining to produce caustic soda, chlorine and sodium chlorate.
Sifto Canada Inc.	Nappan, N.S./1947	73	80	100	100	100	100	100	Brining for vacuum pan evaporation.
	Goderich, Ont./1959	330	335	2 800	2 800	2 800	3 300	3 300	Rock salt mining at a depth of 536 m.
	Goderich, Ont./1880	66	67	120	120	120	120	120	Brining for vacuum pan evaporation.
	Unity, Sask./1949	82	85	180	180	180	180	180	Brining vacuum pan evaporation. Fusion plant closed in 1991.
	Patience Lake, Sask./ 1987	. .	4	–	–	–	100	100	By-product rock salt from potash mine.
Subtotal		551	571						
Total		1 398	1 539	12 600	12 600	12 600	13 200	13 250	

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada, 1990; company surveys.
– Nil; . . Not available.
[a] Employment part of chemical complex. [b] Includes employment in brining operations at Pugwash.

TABLE 3. CANADA, SALT SHIPMENTS AND TRADE, 1980-91

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
	(tonnes)					
1980	4 507 416	781 428	2 134 010	7 422 854	1 151 203	1 637 601
1981	4 371 314	764 037	2 107 243	7 242 594	1 254 992	1 507 710
1982	5 223 073	773 086	1 944 172	7 940 331	1 526 879	1 721 893
1983	5 846 994	714 464	2 040 925	8 602 383	814 250	1 914 629
1984	7 030 664	754 675	2 450 060	10 235 399	1 053 217	2 530 038
1985	6 608 739	805 209	2 670 749	10 084 697	1 255 518	2 263 076
1986	6 867 287	815 044	2 649 515	10 331 846	1 328 298	2 502 518
1987	6 670 863	866 475	2 591 715	10 129 053	1 112 102	1 924 686
1988	7 126 762	783 368	2 777 050	10 687 180	1 202 219	3 030 124
1989	7 548 732r	821 284r	2 788 395	11 158 411r	2 360 432r	2 137 321
1990	7 704 499	778 428	2 708 458	11 191 385	2 095 321	1 897 816
1991p	8 402 366	786 712	2 396 261	11 585 339	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
.. Not available; p Preliminary; r Revised.

TABLE 4. CANADIAN CHEMICAL PLANTS USING SALT AS A MAJOR RAW MATERIAL: DEVELOPMENTS AND PROJECTS IN 1991

Company	Location	Parent Company	Plant Location	Type of Cells	Products	Annual Capacityr (tonnes)	Remarks
Albchem Industries Ltd.	Bruderheim, Alberta	Sherritt Gordon Limited, Vencap Equities Alberta Ltd., Alberta	Bruderheim, Alberta	Metal	Sodium chlorate	50 000	Production started in 1991.
Albright & Wilson Americas Inc.	Islington, Ontario	Tenneco, Inc., Texas, U.S.A.	Buckingham, Quebec	Metal	Sodium chlorate	132 000	
			Grande Prairie, Alberta	Metal	Sodium chlorate	45 000	A new grass-roots operation is planned for completion in the spring of 1992.
			Thunder Bay, Ontario	Metal	Sodium chlorate	53 000	
			North Vancouver, British Columbia	Metal	Sodium chlorate	72 000	
B.C. Chemicals Ltd.	Prince George, British Columbia	B.C. Chemicals Ltd., Prince George, B.C.	Prince George, British Columbia	Metal	Sodium chlorate	77 000	Expansion completed in 1991.
Canadian Occidental Petroleum Ltd.	Calgary, Alberta	Occidental Petroleum Corporation, Los Angeles, CA, U.S.A.	Amherstburg, Ontario	Metal	Sodium chlorate	50 000	
			Brandon, Manitoba	Metal	Sodium chlorate	85 000	
			Bruderheim, Alberta	Metal	Sodium chlorate	50 000	Production started in 1991.
			Nanaimo, British Columbia	Metal	Sodium chlorate	16 000	
			North Vancouver, British Columbia	Diaphragm	Caustic soda Chlorine	155 000 141 000	
			Squamish, British Columbia	Metal	Sodium chlorate	11 000	
				Mercury	Caustic soda Chlorine	75 000 68 000	Closed at end of 1991.
Canso Chemicals Limited	Abercrombie Point, Nova Scotia	ICI Inc., North York, Ontario	Abercrombie Point, Nova Scotia	Mercury	Caustic soda Chlorine	20 000 18 000	
Dow Chemical Canada Inc.	Sarnia, Ontario	The Dow Chemical Company, Michigan, U.S.A.	Fort Saskatchewan, Alberta	Diaphragm	Caustic soda Chlorine	524 000 476 000	
			Sarnia, Ontario	Diaphragm	Caustic soda Chlorine	130 000 118 000	Permanent shut-down announced for the end of 1991.
				Diaphragm	Caustic soda Chlorine	401 000 365 000	Permanent shut-down announced for the end of 1992.
Eka Nobel Canada Inc.	Magog, Quebec	Nobel Industries AB, Sweden	Magog, Quebec	Metal	Sodium chlorate	122 000	
	Valleyfield, Quebec		Valleyfield, Quebec	Metal	Sodium chlorate	105 000	
General Chemical Canada Ltd.	Amherstburg, Ontario	General Chemical Corporation, Morristown, New Jersey, U.S.A.	Amherstburg, Ontario	Metal	Calcium chloride Sodium carbonate	450 000 400 000	

Great Lakes Forest Products Limited	Thunder Bay, Ontario	Canadian Pacific Securities Limited Montreal, Quebec	Dryden, Ontario	Membrane	Caustic soda Chlorine	16 000 14 500	
ICI Canada Inc.	Montreal, Quebec	Imperial Chemical Industries plc (ICI), England	Bécancour, Quebec	Diaphragm	Caustic soda Chlorine	325 000 295 000	
			Cornwall, Ontario	Mercury	Caustic soda Chlorine	38 500 35 000	
			Dalhousie, New Brunswick	Metal	Sodium chlorate	22 000	Production started at end of 1991.
				Mercury	Caustic soda Chlorine	31 000 28 000	
PPG Canada Inc. Industrial Chemical Division	Beauharnois, Quebec	PPG Industries, Inc. Pittsburgh, Penn., U.S.A.	Beauharnois, Quebec	Metal	Sodium chlorate	40 000	
				Membrane	Caustic soda Chlorine	80 000 73 000	
St. Anne Chemicals Company Ltd.	Nackawic, New Brunswick	Parsons & Whittemore, Inc. New York, U.S.A.	Nackawic, New Brunswick	Metal	Sodium chlorate	10 000	Captive production. A 25% expansion is planned.
				Membrane	Caustic soda Chlorine	10 000 9 000	Captive production.
Saskatoon Chemicals	Saskatoon, Saskatchewan	Weyerhaeuser Canada Ltd. Kamloops, B.C.	Saskatoon, Saskatchewan	Metal	Sodium chlorate	44 000	
				Membrane	Caustic soda Chlorine	36 000 33 000	

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada, December 1991; Chemicals Directorate and Investments, Industry, Science and Technology Canada, December 1991.
r Revised.

TABLE 5. WORLD SALT PRODUCTION, 1986-90

Countries	1986r	1987r	1988r	1989p	1990e
			(000 tonnes)		
United States	33 300	32 230	35 360	35 290	36 955
China[e]	17 300	17 960	22 000	27 985	20 005
U.S.S.R.[e]	15 300	15 400	14 800	15 000	14 515
Germany[1]	16 235	16 600	15 500	16 155	15 085
Canada	10 330	10 130	10 690	11 160	11 190
India	10 120	9 900	9 205	9 600	9 500
France	7 085	7 840	7 560	7 490	7 540
United Kingdom	6 855	7 080	6 130	5 700	5 700
Mexico	6 205	6 395	6 790	6 940	7 135
Australia	6 130	6 485	7 165	7 350	7 440
Poland	5 420	6 175	6 180	4 665	4 810
Romania	5 355	5 395	5 400	6 770	6 530
Italy	4 010	4 265	4 290	4 215	4 080
Other	31 090	31 815	32 810	32 140	33 075
Total	174 735	177 670	183 880	190 460	183 560

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, 1990.
[e] Estimated; [p] Preliminary; [r] Revised.
[1] Includes data from the former East and West Germany.

Selenium and Tellurium

Elaine Koren

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-8200

(For additional information, telephone Geoff Bokovay at (613) 992-4093.)

Selenium (Se), named from the Greek word *selene* for moon, was discovered by Berzelius in 1817, who found it associated with tellurium. Selenium is found in a few rare minerals such as crooksite and clausthalite. Chemically, selenium is a member of the sulphur family and resembles sulphur both in its various forms and in its compounds. Thus, sulphides of bismuth, iron, mercury, silver, copper, lead and zinc have been found to contain selenium, occasionally at levels over 20%.

Commercial production of selenium is principally from electrolytic copper refinery slimes as well as from flue dusts of copper and lead smelters. A significant amount of selenium is recovered by secondary sources. In 1991, Canadian production of refined selenium was estimated at 395 tonnes (t). Basic information regarding the naturally occurring environmental distribution of selenium is provided in Table 4.

Tellurium (Te), named from the Latin word *tellus* for earth, was discovered by Müller von Reichenstein in 1782 and identified by Klaproth who isolated it in 1798. Tellurium is occasionally found native, but is more often found as the telluride of gold (krennerite, $(Au,Ag)Te_2$), and combined with other metals.

CANADIAN DEVELOPMENTS

Primary selenium and tellurium are recovered exclusively as by-products of other metal-winning processes (e.g., copper refining). In Canada, all copper refineries produce copper anode slimes containing by-products from the blister copper. Selenium and tellurium, as well as gold, silver and platinum group metals, are such by-products of copper refining.

Prior to 1988, there were two companies refining selenium in Canada: Noranda Inc. and Inco Ltd. In 1988, Inco discontinued selenium refining in Canada and instead began shipping crude material overseas. Hudson Bay Mining and Smelting Co. Ltd. and Kidd Creek Mines Ltd. send their anode slimes to Noranda Inc.'s Canadian Copper Refiners (CCR) Division for recovery and refining of selenium, tellurium and other by-products.

Noranda's CCR facility processes blister copper and slimes containing selenium and tellurium from the company's Horne and Gaspé smelters in Quebec, and from the Flin Flon smelter of Hudson Bay Mining and Smelting Co. in Manitoba. The selenium recovery unit at CCR also processes the high-selenium anode slimes from the Timmins, Ontario, copper refinery of Kidd Creek Mines Ltd. as well as selenium and tellurium feed contained in domestic and imported scrap from the United States. Noranda's reported selenium production capacity is 340 t/y of glass, pigment, commercial and high-purity grades. Noranda's tellurium production capacity is about 35 t/y of commercial-grade tellurium powder, stick and lumps.

Inco Ltd. operates a copper refinery at Copper Cliff where it recovers selenium and tellurium. Since 1988, Inco has been purifying the selenium and tellurium to a crude stage only (i.e., undewatered); customers complete the final process stage. Inco can produce 45 t/y of selenium cake and 4.5 t/y of tellurium dioxide cake.

Canadian selenium consumption was reported by consumers as 14 t in 1990 (preliminary data), which is comparable to the average consumption of 14 t/y for the period 1985-88 inclusive.

Tariffs for selenium and tellurium are similar for Most Favoured Nation at 9.2% while general preferential tariffs differ with selenium at 5% and tellurium at 6%. Selenium exports were 392 t in 1989, 393 t in 1990, and 313 t in the first nine months of 1991. The European Community (EC) is the principal destination for Canadian selenium exports. Selenium imports were 5 t for 1989, 9 t for 1990, and 6 t for the first nine months of 1991. Japan is the principal source for Canadian tellurium imports. Statistics for tellurium are combined with those of boron.

WORLD PRODUCTION

World refined selenium production data are incomplete as production data are not available from all major producers. The key refined selenium producers in 1991 were Japan (480 t), Canada (395 t), Belgium (250 t) and the United States (260 t). Japan obtains most of its by-product selenium from imported copper concentrates, some of which originate from Canada.

Tellurium statistics are not widely reported. Since tellurium is associated with selenium in copper ores, major selenium-producing nations also produce tellurium.

PROPERTIES AND USES

Selenium exists in several forms. Where three are generally recognized, up to six have been claimed. Selenium can be prepared with either an amorphous or crystalline structure. The colour of amorphous selenium is either red (in powder form) or black (in vitreous form). Crystalline monoclinic selenium is deep red; crystalline hexagonal selenium, the most stable variety, is a metallic grey.

Selenium exhibits both photovoltaic properties, where light is converted directly into electricity, and photoconductive properties, where the electrical resistance decreases with increased illumination. These properties make selenium useful in the production of photo cells and exposure meters for photographic use, as well as in the production of solar cells. Selenium is also able to convert alternating current (a.c.) to direct current (d.c.), and is extensively used in rectifiers.

Below its melting point, selenium is a p-type semiconductor and has many uses in solid-state applications. It is used in xerography for reproducing and copying documents, etc., and is used by the glass industry to decolourize glass and to make ruby-coloured glasses and enamels. It is also used as a photographic toner and as an additive for stainless steel.

According to the U.S. Bureau of Mines (USBM), the 1991 estimated consumption of selenium by end use was as follows: electronic and photocopier components, 35%; chemicals and pigments, 20%; glass manufacturing, 30%; and other, 15%.

Crystalline tellurium has a silvery white appearance and, when pure, exhibits a metallic lustre. It is brittle and easily pulverized. Amorphous tellurium is formed by precipitating tellurium from a solution of telluric or tellurous acid.

Tellurium is a p-type semiconductor which, depending on the alignment of the atoms, shows greater conductivity in certain directions. Its conductivity increases slightly with exposure to light. It can be alloyed with silver, copper, gold, tin or other elements.

Tellurium improves the machinability of copper and stainless steel. Its addition to lead decreases the corrosive action of sulphuric acid and improves lead's strength and hardness. Tellurium is used as a basic ingredient in blasting caps, is added to cast iron for chill control, and is also used in ceramics. Bismuth telluride has been used in thermoelectric devices.

According to the USBM, the 1991 estimated consumption of tellurium by end use was principally in iron and steel products, followed by nonferrous metal alloys, chemicals and other uses.

SUBSTITUTES

Also according to the USBM, present and potential selenium substitutes include high-purity silicon as a semiconductor in rectifiers, and silicon has, in fact, replaced selenium in high-voltage rectifiers. Inorganic semiconductor materials, such as silicon, cadmium, tellurium, gallium and arsenic, as well as organic photo-conductors, substitute for selenium in photoelectric applications. Other sub-stitutes include cerium oxide in glass manufacturing; tellurium in pigment and rubber compounding; and tellurium, bismuth and lead in the production of free-machining metals.

The chief substitutes for tellurium are selenium, bismuth and lead in metallurgical applications; selenium and sulphur in rubber compounding applications; and selenium and germanium in electronic applications.

HEALTH AND SAFETY ISSUES AND REGULATORY DEVELOPMENTS

Health, regulatory, and environmental concerns have made trace-level determinations of selenium extremely important. Selenium, as an integral part of the enzyme glutathione peroxidase, is an essential nutrient. However, high levels of certain forms of selenium have been reported as being toxic.

The U.S. Environmental Protection Agency (EPA) and Environment Canada presently regulate selenium in drinking water, with both having set a limit of 10 parts per billion (ppb) Se.

Under new regulations that are to be implemented by the U.S. EPA, discharge standards for selenium and its compounds are based on the "Best Demonstrated Available Technology" (BDAT). Solid selenium-containing wastes, as of May 1992, must be vitrified (i.e., dissolved in a molten slag or glass) for disposal with a maximum standard of 5.7 mg/L Se in the leachate, while liquid wastes must be precipitated to lower the selenium concentration below the discharge limit of 1.0 mg/L.

In addition to agricultural drainage water, wastewaters from oil refining have been identified as a major source of selenium pollution in Northern California. Elevated levels of selenium have been found in local fauna, which prompted the Regional Water Quality

Control Board to issue guidelines limiting the selenium content of discharged wastewaters from oil refineries.

PRICES (US$)

According to the Metal Bulletin, the average European free market selenium price for 99.5% material between January and May was about $5.40/lb. At the end of May, the price decreased to $5.25/lb, which lasted until the end of July when the price was further decreased to $5.10/lb. At year-end, this price was still in effect. Published prices for selenium may not reflect actual transaction prices for selenium sold by large producers. Producer prices may be higher or lower than published prices, depending on tonnage and market conditions. Prices also vary according to the grade of the material: commercial-grade selenium (99.5% Se) trades at a lower price than does pigment-grade selenium (99.8% Se) or high-purity selenium (99.99% or greater).

Average 1991 tellurium prices were estimated at about $32/lb for commercial-grade material.

OUTLOOK

By-product demand and prices are always difficult to forecast. It is expected that regulatory requirements will place more stringent criteria on the use and production of selenium and, as a result, consumption patterns will begin to shift towards substitutes. The pigment industry is currently facing this situation with environmental pressures being placed on cadmium, which has had a flow-through effect on selenium prices where the main use of selenium in pigments is to modify the colour of cadmium sulphide, a gold-yellow pigment. The only growth area seen to date is in the use of selenium in animal feed as a sort of tonic. The use of selenium to coat photocopier drums has been facing tough competition from new organic materials devised by the Japanese. If battery recycling takes off, then some growth may be seen in the battery sector, which uses selenium in the recycling of lead-acid batteries.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2804.90	Selenium	9.2%	5%	1.8%	Free
2804.50	Tellurium	9.2%	6%	1.8%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, SELENIUM PRODUCTION, TRADE AND CONSUMPTION, 1989-91

Item No.		1989		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION[1]		213	4 138	369	6 867	215	4 148
IMPORTS						(Jan.-Sept.)	
2804.90	Selenium						
	Japan	3	164	7	336	4	200
	United States	1	21	2	117	2	82
	Germany[2]	2	96	–	–	. . .	15
	Total	6	282	9	454	6	298
EXPORTS							
2804.90	Selenium						
	Netherlands	55	3 249	71	4 099	65	3 601
	United States	101	2 424	108	2 933	110	3 360
	United Kingdom	116	8 091	132	7 081	60	3 316
	People's Republic of China	–	–	30	1 122	13	761
	Other countries	120	4 206	52	1 331	65	1 907
	Total	392	17 970	393	16 566	313	12 945
CONSUMPTION[3]		15	. .	14	. .	. .	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; p Preliminary.
[1] Primary recoverable content from Canadian sources. [2] Where applicable, data for East and West Germany have been combined. [3] Available data reported by consumers.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1975, 1980, 1985-91

	Production[1]	Exports[2]	Consumption[3]
		(tonnes)	
1975	342	218	10
1980	377	307	11
1985	361	310	14
1986	354	350	14
1987	430	353	15
1988	321	428	14
1989	213	392	15
1990	369	393	14
1991p	215	313a	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
. . Not available; p Preliminary.
a For 1991, first nine months only.
[1] Until 1985, refinery output of selenium from all sources, including imported concentrates, blister and scrap, and domestic scrap; from 1986 onwards, primary recoverable output from Canadian sources. [2] Exports of selenium, metal powder, shot, etc. [3] Consumption (selenium content) as reported by consumers.

TABLE 3. CANADA, PRODUCTION AND CONSUMPTION OF TELLURIUM, 1975, 1980 AND 1985-91

	Production	Consumption
	Total Refined[1]	Refined[2]
	(tonnes)	
1975	42	w
1980	9	w
1985	19	w
1986	20	w
1987	13	w
1988	19	w
1989	8	w
1990	12	w
1991p	13	..

Source: Energy, Mines and Resources Canada.
.. Not available; p Preliminary; w Withheld to avoid disclosing company data.
[1] Refinery output of tellurium from all sources, including imported concentrates, blister and scrap, and domestic scrap, up to 1985. For 1986 onward, primary recoverable output from Canadian sources. [2] Consumption (tellurium content), as reported by consumers.

TABLE 4. SELENIUM CONCENTRATIONS IN ROCKS, SOILS, AND WATERS

Category	Range
	(in parts per million, except where noted)
ROCKS	
Shale	Up to 675
Sandstone	Up to 112
Phosphate rock	Up to 55
Carbonate rock	Up to 30
SOILS	
Non-toxic	0.02 to 2.5
Toxic	4.0 to 6.0
WATERS	
Seawater	0.09 ± 0.03 µg/L
Freshwater	< 1.0 to 400 µg/L

Source: NRCC Report No. 20643.

Silica

Michel Boucher

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-3074

SUMMARY

Demand for silica was weak in nearly all markets during 1991 as a result of the recession. Major developments during the year included the following: Syquartz Inc. was building a quartz-growing facility in Trois-Rivières, Quebec; Loma Enterprises Ltd. closed its crushing and classifying operation at Beauport, Quebec; Consumers Glass announced that it would close its Candiac, Quebec plant in March 1992; and a European silica association called "Eurosil," comprising France, Belgium, the United Kingdom, and Germany, was established at year-end.

SUPPLY

Nova Scotia

Nova Scotia Sand and Gravel Limited produces a high-purity silica from sand deposits for a variety of uses such as sandblasting, glass sand, foundry sand and fracturing sand. The mine is located near Shubenacadie.

New Brunswick

Chaleur Silica Ltd. produces silica from a quartz-rich sandstone. The company's silica is mainly used as a flux in Brunswick Mining and Smelting Corporation Limited's Belledune lead smelter, but is also used in cement plants and foundries, and as sandblasting material.

Sussex Silica Inc. mines a high-grade (+99% SiO_2) silica deposit near Sussex. The company produces lump silica and sand of various sizes. Its lump silica and coarse-grained sand are used in the manufacture of silicon metal and silicon carbide in Quebec. The fine sand is used in sandblasting, glass sand, as filter sand and decorative sand in the Maritimes, and as a flux for base-metal smelters.

Quebec

Unimin Canada Ltd., a subsidiary of Unimin Corp., is the largest producer (in terms of volume and value of production) of silica east of Ontario. Silica is mined from a quartzite deposit at Saint-Donat and from a sandstone deposit at Saint-Canut. Silica from Saint-Donat (100 000 t/y capacity) is refined at the Saint Canut plant near Montreal. Most silica produced by Unimin Limited originates from Saint-Canut where the ore is crushed, screened and beneficiated by attrition scrubbing, flotation and magnetic separation. Production capacity of the Saint-Canut plant is about 550 000 t/y of finished products. The major markets for Unimin products are glass containers, flat glass, fibreglass, and the silicon carbide industries.

Uniquartz Inc. intends to mine a silica-rich sandstone deposit near Saint Jean-Vianney, about 30 km from Matane. The deposit is reported to contain more than 25 Mt of high-purity ore. Some lump ore has been sold on a trial basis to European consumers for the production of ferro-alloys. A feasibility study on the production of lump ore for the silicon and ferro-silicon industries, and high-purity silica sand for the glass and foundry industries, was completed during the year.

Hogan Holdings Inc. (formerly Baskatong Quartz Inc.) produces high-purity lump silica from a quartzite deposit north of Saint Urbain. The silica is used mainly by SKW Canada Inc. at Bécancour for the production of ferrosilicon and silicon metal, and also by Elkem Métal Canada Inc. at Chicoutimi. Hogan Holdings also produces high-purity silica from quartz vein deposits located at Lac Bouchette south of Lac Saint-Jean; the silica is sold almost exclusively to SKW for the production of ferrosilicon. Hogan Holdings has also reported it is planning to develop a high-purity quartz vein deposit in the Eastern Townships of Quebec.

Loma Enterprises Ltd. of Beauport crushes and classifies the fines produced by SKW Canada Inc. for sale to the silicon carbide and sandblast industries. The plant was closed during the year due to low prices and reduced demand by the silicon carbide industry.

Armand Sicotte & Sons Limited mines Potsdam sandstone at Sainte-Clothilde, south of Montreal. The company's lump silica is used for the production of ferrosilicon, phosphorus and cement.

The Good Sand Company Ltd. mines silica sand and gravel at Saint-Joseph-du-Lac and at Ormstown. The material is used mainly for sandblasting, but also for fibreglass and foundries.

Temisca Exploration Inc. of St. Bruno-de-Guigues produces silica on a small scale for use in sylviculture, filtration, sandblasting, foundries and as traction sand. The company started the construction of a new plant that will increase capacity to some 50 000 t/y by mid-1993.

Société de Haute Technologie du Québec Inc. is scheduled to begin production of a 50-t/y standard-quality synthetic (cultured) quartz-growing facility at Trois-Rivières, Quebec, by mid-1992 at a cost of $8 million. Initially, high-purity quartz will be imported. Synthetic quartz is used as oscillators in communications equipment, computers, lasers, optical equipment, etc.

Consumers Packaging Inc. announced that it would permanently close its Candiac container glass plant at the end of March 1992, leaving some 380 employees out of work. The company cited reduced sales as the reason for the plant closure. The lower sales were the result of increased competition from U.S. and Mexican producers, the recession in Canada and the United States, and competition from plastics. The company consumed approximately 15 000 t/y of silica.

Ontario

Unimin Canada Ltd. is the largest producer (in terms of volume and value of production) of silica west of Quebec, with a reported total capacity of about 550 000 t/y. Lump quartzite from Badgeley Island (150 000-t/y capacity), north of Georgian Bay, is shipped by lake boat to Canadian destinations for the manufacture of ferrosilicon. The finer material produced by crushing is shipped to Unimin's plant at Midland (400 000-t/y capacity), south of Georgian Bay, where it is further processed to a glass-grade silica sand and silica flour for ceramic and other uses.

Manitoba

Marine Transport Limited of Selkirk produces high-purity silica sand from a quarry on Black Island on Lake Winnipeg, some 130 km north of Selkirk. The silica sand, mined from a poorly consolidated white sandstone, is well rounded and suitable for use in foundries, glass, fibreglass and construction, and as traction sand. The ore is washed, screened and dewatered at a plant on the island, and then shipped by barge to a processing plant at Selkirk on the Red River.

Inco Limited produces a low-grade silica from an impure quartzite at a quarry in Manasan; the silica is used at its Thompson nickel smelter. Production varies from year to year, depending on nickel production.

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited (HBMS) produces smelter flux from two pits in the Amisk Lake area of northern Saskatchewan. The silica sand is used by HBMS at its copper-zinc smelter in Flin Flon, Manitoba.

Alberta

Sil Silica, a wholly owned subsidiary of The Warren Paving and Materials Group Ltd., produces silica sand from local sand dunes in the Bruderheim area. Silica is sold mainly as fibreglass and sandblasting material. It is also sold as foundry sand, filtration sand, fracturing sand, and railway traction sand.

British Columbia

Mountain Minerals Co. Ltd. mines a high-purity, friable sandstone deposit near Golden. The rock is crushed, screened, washed, dried and separated into several sizes. These different sizes are sold for glass sand, sandblasting sand, foundry sand, filter media sand, golf course sand, and fine sand.

TRADE

Most silica sand imported into Canada comes from loosely consolidated and easily processed sandstone or lake sand deposits located near the Great Lakes region of the United States in Illinois, Wisconsin, Michigan and Indiana. The imported silica sand is used mainly by iron and steel foundries and by the glass industry of Ontario and Quebec. In 1990, imports of foundry sand were 589 162 t, and imports of sand for use in glass-making were 152 028 t. Imports of silica sand for use as foundry sand increased considerably in British Columbia in 1990 because olivine was banned due to its high nickel content.

INTERNATIONAL DEVELOPMENTS

Good quality silica is available in large quantities in many countries of the world at low prices.

A new European silica sand association was established during the year. The association, called "Eurosil," consists of silica sand trade associations and silica producers. The association's founding members are from France, Belgium, the United Kingdom, and Germany, and its administrative office is located in Paris. Eurosil was formed to promote the development and uses of silica and silica products throughout Europe as a prime raw material for industry. It also represents its members' interests with regard to existing and proposed legislation, regulations and operating standards.

OUTLOOK

No improvement is expected in 1992 in Canada in the container glass industry. In the longer term, environmental concerns and the disposal problems posed by plastic containers should encourage a greater use of glass containers, which are easier to recycle. However, the glass container industry is under growing pressure to increase recycling, which will likely mean a reduction in the consumption of industrial minerals used in glass-making. Markets for flat glass and fibreglass are not expected to improve as long as the economy remains weak.

In the longer term, competition from U.S. producers of silica for glass and foundry sand will remain strong in Ontario and Quebec because of the proximity of these provinces to the low-cost producers of the Great Lakes region in the United States. Also, due to reduced North American car production and the recycling of silica sand at foundries, no growth can be expected in the foundry sand industry in Canada. Competition from substitutes for glass containers such as paper, plastics and aluminum will continue. Sandblasting will continue to decline as a result of tighter environmental controls and substitution. The filler market is still small, but its growth will continue to be strong. On balance, producers of silica will continue to suffer from low capacity utilization and low prices.

OPPORTUNITIES

Higher-value silica products could be produced in Canada because of the low cost of electricity in certain parts of the country. Such products include:

- cultured quartz for the production of oscillators used in electronics, optical instruments and other applications;

- fused silica (minimum 99.8% SiO_2) in the form of ingots, rods, tubes and powder for the chemical and electronic industries;

- refined silicon carbide for advanced ceramics;

- monocrystalline silicon for the production of silicon chips;

- high-purity ground silica (minimum 99.5% SiO_2, 2-20 microns) for use as an abrasive for metal polishes and cleansers, and fillers in plastics and rubber; and

- chemical-grade silicon metal for the production of silicones.

With the exception of a cultured quartz facility being built in Quebec, none of these products are currently manufactured in Canada.

In addition, there are potential opportunities for:

- an integrated silicon carbide plant in western Canada, based on local raw materials and inexpensive electricity;

- a new reinforcement fibreglass plant (in Canada, there is only one plant in Ontario);

- the production of silicones[1] by reacting silicon metal powder with methyl chloride;

- amorphous silica[1] from the hydrolysis of silicon tetrachloride[2] in a flame of hydrogen and oxygen for use as a thickening agent in inks, paints, cosmetics, rubber, etc., and as specialty coatings, such as powder coatings; and

- precipitated silica and silica gel[1] by reacting sodium silicate with sulphuric acid. (These products are used for reinforcing rubber and as extenders in paints, fillers in inks, and thickening and polishing agents in toothpastes.)

Note: Information in this review was current as of January 31, 1992.

REFERENCES

[1] No production facility yet exists in Canada, although most raw materials are available.

[2] Produced through the chlorination of silicon metal or silica.

TABLE 1. CANADA, SILICA PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION	(Shipments)				
	By province				
	Quebec	770 728	15 726	. .	. .
	Ontario	668 017	7 895	. .	. .
	Alberta	120 600	4 933	. .	. .
	Manitoba	233 000	2 675	. .	. .
	Saskatchewan	159 980	1 849	. .	. .
	British Columbia	50 345	1 611	. .	. .
	Nova Scotia	x	x	. .	. .
	New Brunswick	x	x	. .	. .
	Newfoundland	–	–	. .	. .
	Total	2 081 170	37 089	. .	. .
IMPORTS[1]				(Jan.-Sept.)	
2505.10	Silica sands and quartz sands				
	United States	965 514	19 169	551 726	10 898
	Other countries	361	233	653	95
	Total	965 875	19 402	552 379	10 993
2506.10	Quartz (other than natural sands)				
	Spain	–	–	33 060	1 148
	United States	5 380	365	2 898	167
	Other countries	156	10	408	26
	Total	5 536	376	36 366	1 343
2506.21	Quartzite crude or roughly trimmed				
	United States	1 092	123	1 010	95
	Total	1 092	123	1 010	95
2506.29	Quartzite n.e.s.				
	United States	1 167	86	977	126
	Total	1 167	86	977	126
2811.22	Silicon dioxide				
	United States	9 448	18 396	6 441	13 909
	Other countries	2 107	5 477	1 040	2 391
	Total	11 555	23 873	7 481	16 300

TABLE 1 (cont'd)

Item No.		1990 (tonnes)	1990 ($000)	Jan.-Sept. 1991p (tonnes)	Jan.-Sept. 1991p ($000)
EXPORTS					
2505.10	Silica sands and quartz sands				
	United States	134 979	986	129 490	624
	Austria	–	–	672	111
	Belgium	–	–	357	67
	Other countries	8 465	363	6 996	140
	Total	143 444	1 349	137 515	942
2506.10	Quartz (other than natural sands)				
	United States	495	43	239	32
	Total	495	43	239	32
2506.21	Quartzite crude or roughly trimmed				
	United States	109	15	44	7
	Total	109	15	44	7
2506.29	Quartzite n.e.s.				
	United States	23	3	44	9
	Total	23	3	44	9
2811.22	Silicon dioxide				
	United States	828	146	67	44
	Taiwan	–	–	8	3
	Total	828	146	75	48

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; n.e.s. Not elsewhere specified; p Preliminary; x Confidential.
1 Includes sand for use in foundries and glass manufacturing, ground and flour sand, and volatized and silica flue dust.
Note: Numbers may not add to totals due to rounding.

TABLE 2. IMPORTS OF SILICA SAND (FROM THE UNITED STATES) BY PROVINCE AND BY USE, 1990

	Foundry (tonnes)	Foundry ($000)	Glass Manufacturing (tonnes)	Glass Manufacturing ($000)
Newfoundland	–	–	–	–
Nova Scotia	544	7	–	–
Prince Edward Island	–	–	–	–
New Brunswick	452	35	–	–
Quebec	27 898	486	26 529	243
Ontario	319 123	5 395	125 443	1 243
Manitoba	2 201	166	–	–
Saskatchewan	112	11	–	–
Alberta	282	17	54	4
British Columbia	238 548	2 869	2	–
Total	589 162	8 990	152 028	1 492

Source: Statistics Canada.
– Nil.
Note: Numbers may not add to totals due to rounding.

TABLE 3. CANADA, SILICA CONSUMPTION,[1] 1989 AND 1990

	1989r	1990p
	(tonnes)	
Lump	1 274 680	1 042 784
Sand	1 812 422	1 591 695
Flour	54 754	49 016
Total	3 141 856	2 683 495

Source: Energy, Mines and Resources Canada.
p Preliminary; r Revised.
1 Available data, as reported by consumers.

TABLE 4. SODIUM SILICATE PLANTS IN CANADA

Company	Plant Location
National Silicates Limited	Toronto, Ontario
	Valleyfield, Quebec
	Whitecourt, Alberta
	Nanaimo, British Columbia

TABLE 5. CANADA, REPORTED CONSUMPTION[1] OF SILICA, BY INDUSTRY, 1989 AND 1990

	1989r	1990p
	(tonnes)	
Primary glass and glass containers, and glass fibre wool	753 091	597 500
Nonferrous smelting and refining	944 316	842 665
Foundries	424 158	331 051
Abrasives	132 222	93 905
Chemicals	132 245	41 379
Other products[2]	755 824	776 995
Total	3 141 856	2 683 495

p Preliminary; r Revised.
1 Available data, as reported by consumers. 2 Includes asbestos products, asphalt roofing products, cement, ceramic products, structural clay products, cleansers, fertilizers, paint and varnish, pulp and paper and products, refractory brick, rubber products, ferroalloys, primary steel and other miscellaneous products.

TABLE 6. FLAT GLASS- AND CONTAINER GLASS-MANUFACTURING PLANTS IN CANADA

Company	Plant Location	Type of Glass
PPG Canada Inc.	Owen Sound, Ontario	Flat
AFG Glass Inc.	Scarborough, Ontario	Flat
Glaverbec Inc.	Saint-Augustin, Quebec	Flat
Consumers Glass, a division of Consumers Packaging Inc.	Scoudouc, New Brunswick	Container
	Pointe-St-Charles, Quebec	Container
	Candiac, Quebec	Container
	Etobicoke, Ontario	Container
	Milton, Ontario	Container
	Brampton, Ontario	Container
	Hamilton, Ontario	Container
	Lavington, British Columbia	Container

Source: Energy, Mines and Resources Canada.

TABLE 7. FIBREGLASS PLANTS IN CANADA

Company	Plant Location	Type of Fibre
Fiberglas Canada Inc.	Candiac, Quebec	Insulating
	Markham, Ontario	Insulating
	Edmonton, Alberta	Insulating
Manson Insulation Inc.	Brossard, Quebec	Insulating
	Scarborough, Ontario	Insulating
Manville Canada Inc.	Innisfail, Alberta	Insulating
Graham Fiber Glass Limited	Erin, Ontario	Insulating
Ottawa Fiber Inc.	Ottawa, Ontario	Insulating
Fiberglas Canada Inc.	Guelph, Ontario	Reinforcing

Source: Energy, Mines and Resources Canada.

TABLE 8. TYPICAL BATCH FORMULATIONS FOR FLAT GLASS, GLASS CONTAINERS AND FIBREGLASS

Raw Materials	Percent by Weight	Source of
FLAT GLASS[1]		
Silica sand	60	SiO_2
High calcium limestone	4	CaO
Dolomitic limestone	15	MgO and CaO
Soda ash	20	Na_2O
Salt cake or gypsum	0.5	Na_2O,CaO and SO_3
Rouge	0.5	Fe Colorant
GLASS CONTAINERS[2]		
Silica sand	60	SiO_2
Limestone	14-18	CaO,MgO
Soda ash	19	Na_2O
Alumina source		
(feldspar, nepheline syenite or aplite)	4-5	Al_2O_3,Na_2O,SiO_2
Others		
Gypsum and/or barite	1	SO_3,BaO
FIBREGLASS		
Insulating fibre[3]		
Silica	40	SiO_2
Soda ash	10	Na_2O
Feldspar or nepheline syenite	20	Al_2O_3,Na_2O,SiO_2
Borax or ulexite	15	B_2O_3
Dolomite or limestone	15	MgO,CaO
Reinforcing fibre[4]		
Silica	28-30	SiO_2
Boric acid	8-11	B_2O_3
Colemanite	11-17	CaO.B_2O_3
Kaolin	26-28	Al_2O_3,SiO_2
Limestone or dolomite	28-31	CaO,MgO
Soda ash	0-1	Na_2O

Source: Energy, Mines and Resources Canada compiled data obtained from:
[1] LOF Glass Company, Toledo, Ohio; [2] Brockway Inc., Brockway, Pennsylvania;
[3] Fiberglas Canada Inc; [4] PPG Canada Inc.

TABLE 9. SILICON CARBIDE PLANTS IN CANADA

Company	Plant Location
Norton Céramiques Avancées du Canada Inc.	Shawinigan, Quebec
General Abrasives (Canada) Ltd.	Niagara Falls, Ontario

Note: The production of one tonne of SiC requires the following raw materials, and the approximate tonnages:

Raw Materials	Tonnes
Silica sand (99.5% SiO_2)	1.5-1.6
Grounded petroleum coke	1.2
Recycled SiC	2.5
Recycled graphite	0.06
Electrical energy	8-10 000 kWh

Source: Energy, Mines and Resources Canada.

TABLE 10. SILICON AND FERROSILICON PLANTS IN CANADA

Company	Plant Location	Product
Timminco Limited	Chicoutimi, Quebec	Fe-Si
SKW Canada Inc.	Bécancour, Quebec	Si; Fe-Si
Elkem Metal Canada Inc.	Beauharnois, Quebec	Si-Mn; Fe-Mn

Note: The production of one tonne of Si requires the following raw materials, and the approximate tonnages:

Raw Materials	Tonnes
Silica (lump quartz, +98% SiO_2)	2.60
Wood chips	1.5-2.0
Petroleum coke	0.50
Low ash coal	0.37
Charcoal	0.25
Pre-baked electrodes	0.10
Electrical energy	13 000 kWh

Source: Energy, Mines and Resources Canada.

Silver

John Keating

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4409

Silver prices, which trended downwards throughout the 1980s due to a combination of soft investment demand and increased by-product production, fell to a 17-year low of US$3.58/ounce (oz) in February 1991. Prices subsequently gained support due to strengthening investor demand and lower supplies, and averaged US$4.04/oz in 1991, compared to $4.83/oz in 1990 and $5.50/oz in 1989.

CANADIAN DEVELOPMENTS

Silver production declined in 1991 to 1240 tonnes (t) from 1380 t in 1990. The drop was due to mine closures and reduced output in response to weak metal prices or the depletion of ore reserves.

Most of Canada's silver output is produced as a by-product or co-product of other mining. It is estimated that a 7% reduction in annual silver capacity resulted from the closure in 1991 of the Gays River, East Kemptville, Normetal, Estrades, Opemiska, Lyon Lake, Snow Lake and Afton base-metal mines, as well as the Blackdome, Beaverdell, Shasta, Colomac, Jolu, Renabie, Bell Creek, Eastmaque, Sleeping Giant, Lac Shortt and Hope Brooke precious-metal operations. These losses were partially offset by production from new base-metal operations such as the Sa Dena Hes (formerly Mt. Hundere), Goldstream and Norita East operations.

A further reduction of approximately 30% in Canadian capacity is expected to occur during 1992 as reserves are depleted at both the Equity Silver and Samatosum mines in British Columbia.

Reclamation work at the Equity Silver mine, Canada's largest silver producer, continued through 1991 while Equity Silver Mines Limited completed the placement of a $32 million bond to cover post-closure effluent treatment costs and a $5.5 million security for waste-dump and plant-site restoration. The mine is expected to operate at its full capacity of 10 000 t/d until open-pit reserves are depleted in June and the mine closes in the fall of 1992. However, the mine's life may be extended if a feasibility study being conducted on underground reserves proves positive. The mine opened in 1980 and produced 2 058 600 kg of silver, 14 000 kg of gold and 77 000 t of copper to the end of 1991.

Delineation drilling at the Samatosum mine during the first half of 1991 outlined 80 300 t of mineable underground reserves grading 1022 g/t silver, 1.7 g/t gold, 1.2% copper, 2.9% zinc and 1.7% lead. The 450-t/d mill, which began processing ore from underground in September, is scheduled to cease operation in October 1992 after open-pit and underground reserves are depleted. The mine, owned by Minnova Inc. (70%) and Rea Gold Corporation (30%), was opened in 1989 and has produced approximately 295 000 kg of silver, 536 kg of gold, 3700 t of copper, 4300 t of lead and 7900 t of zinc to the end of 1991.

Also in British Columbia, Treminco Resources Ltd. reduced its workforce in half and cut production by one third at the Silvana mine in response to weak metal prices. The operation produced 11 400 kg of silver, 1450 t of lead and 1700 t of zinc for the fiscal year ending in July 1991.

It is expected that the decline in Canada's annual production capacity of silver will be more than offset in the future by the opening of new mines such as the Louvicourt base-metal deposit in Quebec and the precious-metal Eskay Creek property in British Columbia. A preliminary feasibility study indicated that a 363-t/d operation at Eskay Creek could produce up to 7700 kg of gold and 311 000 kg of silver annually over an eight-year mine life.

WORLD DEVELOPMENTS

According to preliminary estimates from the Silver Institute, world silver mine production declined for the first time in five years to about 14 000 t in 1991 compared to 14 560 t in 1990. The largest producing nations by order of output were Mexico, the United States, Peru, the U.S.S.R., Canada, Australia and Poland.

Mexico's silver industry has been stricken by falling metal prices, strikes and high operating costs. Although tax cuts and more liberal foreign investment policies sparked a 7.7% growth in Mexico's mining sector during 1990, it is expected that low metal prices suppressed growth in 1991. It was reported that over 40 small- and mid-sized mines, which produce only silver, closed because of low silver prices.

Industrias Penoles SA de CV lifted the force majeure on metal shipments from its Met-Mex silver, lead and zinc complex in Torreon after a four-week strike ended on March 14. The complex produces about 1500 t/y of silver, which is approximately 13% of Western World production.

The Peruvian government began a privatization process of state-owned mining interests in an effort to rehabilitate the nation's mining sector. It was reported that state-owned Empressa Minera del Centro del Perú S.A. (Centromin Perú S.A.) dominates the silver sector with control of more than 19% of the country's output. The government also announced tax breaks for small- and medium-sized mining companies which are believed to account for 19% of annual domestic silver production. Peruvian silver output was about 1 770 000 kg in 1991 compared to 1 762 600 kg a year earlier.

In Chile, Niugini Mining shipped the first gold-silver bullion from its San Cristobal mine in January. Water for the 50 000-oz/y heap leach operation is carried by pipe for 40 km across the Atacama desert.

In June, Compania Minera Mantos de Oro, which is equally owned by Placer Dome Inc. and Consolidated TVX Mining Corporation of Toronto, commissioned a new 15 000-t/d crusher and cyanide leach plant at its La Coipa mine in Chile. Silver recoveries are expected to average about 76% for ore from the operations of three orebodies (Farellon, Ladera, and La Coipa Norte). The operation will reportedly increase Chile's annual silver output (which was 634 500 kg in 1990) by 50% and is expected to produce over 68 400 kg of gold and 4 416 600 kg of silver over a projected mine life of 14 years.

Bolivia was one of the first Latin American countries to reform its mining code with privatization reported to be well under way. State-owned Corporacion Minera de Bolivia (Comibol) placed the Bolivar silver-zinc-tin-lead mine up for sale during 1991. Tenders were reportedly received from domestic and foreign interests such as Cia. Minera del Sur S.A. (Comsur), Carnon Holdings, Tiwanacu S.A., Consolidated Gold Fields PLC, and the Metall Mining Corporation of Toronto. Probable reserves at Bolivar are quoted to be 856 000 t averaging 309 g/t silver, 16.16% zinc, 1.26% tin and 1.68% lead, and over 350 000 t of tailings grading 75 g/t silver, 3.97% zinc, 0.76% tin and 0.92% lead.

In the United States, Hecla Mining Co. celebrated its one-hundredth anniversary in 1991. The company began mining silver in the Coeur d'Alene district of Idaho. It now owns various precious-metal deposits in the United States including a 28% interest in the largest U.S. silver producer, the Greens Creek mine near Juneau, Alaska. During 1991, Hecla also acquired the Grouse Creek deposit in Idaho through a merger with owner CoCa Mines Inc. The deposit is reported to host open-pit reserves of 8.63 Mt grading 2 g/t gold and 51 g/t silver.

Coeur d'Alene Mines Corp. became the second largest silver producer in the United States behind ASARCO Incorporated, when its annual capacity increased by about 46 700 kg to 217 700 kg after it purchased Callahan Mining Corp. Callahan's primary producer is the Galena mine in Idaho.

In 1989, Congress approved a Bill to reduce the Department of Treasury's silver stockpile by 7.5 million oz over three years. The U.S. Defense Logistics Agency, which is responsible for overseeing the sale, completed the reduction during the fiscal year ending October 1, 1991.

The U.S. Department of Defense (DOD) continued to reduce its silver stockpile during 1991 through U.S. Mint coinage programs. According to the Silver Institute, over 55 million oz of silver has been sold through coinage programs since DOD stocks were first used by the Mint in November 1986. Production of the American eagle silver dollar has consumed 78% of the stocks used, while commemorative coin programs accounted for the remainder. The Silver Institute estimates that, based on an average annual consumption rate of 11.5 million oz, the stockpile will be depleted by 1998.

CONSUMPTION AND USES

Although 1991 figures are not yet available, it is expected that silver consumption increased as a result of continued growth in industrial demand, coinage programs and the unofficial importation of silver into India.

The major industrial uses for silver are in photographic materials, electrical and electronic products, sterling and electroplated ware, jewellery, and brazing alloys and solders.

Despite the fact that developments in photographic technology and an increase in recycling have drastically reduced silver requirements for this application, photography has continued to be the most important industrial market for the metal. Overall consumption in 1990 was reported at 5785 t. One of the largest single photographic applications, accounting for about 40% of total consumption, is in the production of X-ray films. In view of increasing worldwide concern for human health, the use of X-ray films is expected to grow at an average annual rate of about 4% during the early 1990s.

It is estimated that silver consumption in the photographic industry will grow by 3%/y to 1995, an increase of approximately 16% over 1990. New camera designs and greater access to film development are considered to be two aspects which will encourage growth in this sector. Automatic 35-mm cameras are increasing in popularity and the disposable camera market is reported to be growing rapidly with 20 million units sold in Japan in 1989. Also promoting the use of film is the mini-lab. These very efficient automated units can be established in areas with low demand for film development at a relatively small investment. There were estimated to be 17 000 mini-labs in the United States in 1989, with 50 000-60 000 operating worldwide.

It is expected that video cameras will continue to increase in popularity and make in-roads into traditional silver halide snapshot markets. In response to these and other new developments in imaging technology, Kodak has developed a Photo CD system. The system allows the transfer of 35-mm photo negatives or slides onto a compact disc for viewing on television sets or for interacting with personal computers to provide inexpensive access to high-quality colour photographic images. The system is expected to be available in 1993.

The second largest market for silver, representing about 25% of industrial consumption in the United States, is in contact and conductor products for the electrical and electronics industries. While these industries have grown in importance, silver consumption in this area has remained relatively constant due to improvements in utilization technologies and miniaturization.

It was reported at the end of 1989 that the U.S. Navy was testing a new silver-iron battery for undersea vehicles. The new battery, patented by Westinghouse Electric Corporation, offers a significantly longer shelf life, quicker rechargeability, and is more rugged than competing products.

Other promising uses of silver include: a silver alloy coating for the bottom of microwaveable cookware which allows for the browning or crisping of food surfaces; a silver-aluminum casting alloy (the strongest aluminum casting alloy known), which provides high strength while minimizing the weight of aircraft; a silver-coated laser card that contains a patient's medical records and health history (20 000 of the credit-card-sized records are being used in a pilot program in Japan); and in water purification systems. With respect to the latter, the U.S. Environmental Protection Agency removed silver from the U.S. Primary Drinking Water Standard List of Contaminants during 1991. This decision could result in an increase in the use of silver-copper electrodes, silver-based additives, or silver coatings on water reservoirs as methods to purify water systems in the United States. Ionics Inc., the largest U.S. supplier of silver-impregnated activated carbon for water purification, uses over 52 t/y of silver in this application.

One growing market for silver is its use in utility power generation. Luz International has constructed a number of solar-electric power plants in Southern California that use banks of silver-coated mirrors to capture the sun's energy. The company expects to complete five more plants by 1994. The new plants will serve the residential electrical demands of 810 000 people and will subsequently reduce oil imports by more than 3 million barrels annually. It is estimated that 2500 kg of silver will be used to coat the project's 650 000 mirrors. The company's newest plant is reported to generate power at a cost of US8¢/kW, which is considered to be competitive with other power systems.

The use of silver in the production of coinage has been one of the fastest growing markets for the metal in recent years.

According to the Silver Institute, silver coin consumption in 1990 rose 20% over the previous year to 980 t, its highest level since 1975. In 1990, 71 nations minted 283 issues of silver commemorative coins (accounting for 625 kg of silver) and bullion coins (355 t of silver). The most popular bullion coin was the American eagle silver dollar with over 246 t sold, while Japan's 5000 yen coin, which commemorated the International Garden and Greenery Exposition at Osaka in 1990, was the most favoured commemorative coin at over 140 t.

Although figures are not yet available, it is expected that the demand grew for some bullion coins in 1991 with sales of the American eagle silver dollar reported to be up 20% by August; however, sales of the Canadian silver maple leaf are estimated to be down by 50% in 1991 from the 528.8 t sold in 1990. With respect to commemorative coins, the Royal Canadian Mint introduced the silver coin aviation series called "Pioneers in Powered Flight: 1900 to 1949" in 1991. The 31-g coins, containing 92.5% sterling silver and having a 24-karat gold-covered cameo, will commemorate the first 50 years of powered flight in Canada. These limited-edition coins will be introduced in pairs over the next five years.

In 1992, the Royal Canadian Mint will increase the silver content in the annual commemorative silver dollar to 92.5% silver. The silver dollar was 80% silver when it was first struck in 1935, but was changed to 50% silver (and 50% copper) in 1971. The 1991 silver dollar honoured the Frontenac, Canada's first steamboat which was launched on Lake Ontario in 1816.

The U.S. Mint announced that, in 1992, it will begin marketing four million silver dollar coins in honour of the twenty-fifth Olympiad. Profits from coin sales are to go to the U.S. Olympic Committee. The United States will also mint, during 1992, a commemorative silver coin in honour of the five-hundredth anniversary of Columbus's voyage to the Americas.

India, with a population of over 800 million, has been a major consumer of silver for centuries. Although imports of silver into India have been officially banned since 1948, trade has generally continued depending on the price in international markets and the level of domestic dishording. Between 1967 and 1985, India was a net exporter of silver as international prices rose. However, India has since become a net importer with more than 1200 t imported in 1990, almost twice the amount purchased in 1989. This reversal in trade has been attributed to a 33% rise in industrial demand during 1990, as well as to strong demand for use in decorative and investment products such as in silver thread for saris, jewellery, cutlery, utensils, medallions and edible wafer-thin silver foil. The Silver Institute estimates that Indians eat over 31 t/y of silver as a means to promote good health, or as an aphrodisiac.

MARKETS, PRICES AND STOCKS

While silver is traded in the major financial centres around the world, the London Silver Market, part of the London Bullion Market Association, is the most important of the physical markets. In June 1989, the London Metal Exchange discontinued its silver contract due to low trading volumes. The most important futures market is the Commodities Exchange, Inc. (COMEX) in New York. The Handy & Harman silver price has declined from a peak of US$48.00/oz in 1980 to a 17-year low of $3.58/oz in February

1991. The price then gained support and rose to a high of \$4.53/oz in June after a detailed market analysis, prepared for the Silver Institute, projected that new silver supplies in 1991 would fall short of fabrication demand for the second year in a row. It subsequently fluctuated around the \$4.00 level for the remainder of the year as investors profited from short-term price increases. The average price for 1991 was \$4.04/oz.

Handy & Harman reported world stocks of silver bullion at the end of 1990 at 48 200 t. This included over 39 790 t of private investment stocks and about 8400 t held by governments, principally the United States, Mexico, India and Peru. At the end of 1991, COMEX stocks were reported at over 8430 t compared to 8208 t at the beginning of January.

The possibility of significant sales of the large silver stocks held by governments has continued to exert a negative influence on the silver market. While the reduction of the large U.S. stockpile through coin and bullion sales has been fairly limited to date, large disposals by the United States or other governments, such as Peru, remain a concern.

OUTLOOK

Annual silver production in Canada is expected to decline over the next few years as ore reserves are depleted at mines that primarily produce silver.

Current low prices are limiting new silver supplies while at the same time having a positive effect on industrial demand. It is believed that a supply-demand deficit may exist throughout the 1990s; however, the deficits are expected to be small when compared to the large overhang of world stocks which will continue to exert downward pressure on prices.

The silver price is forecast to range between US\$4.00 and \$4.50/oz in 1992. In the medium-to-longer term, prices are expected to average between \$4.00 and \$5.00/oz, unless major new uses are developed or a reversal in investor and speculator sentiment occurs.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
2616.10	Silver ores and concentrates	Free	Free	Free	Free	Free	Free
71.06	Silver (including silver plated with gold or platinum), unwrought or in semi-manufactured forms, or in powder form						
7106.10	Powder						
7106.10.10	Containing by weight 92.5% or more of silver	4%	Free	Free	Free	3.8%	2%
7106.10.20	Containing by weight less than 92.5% of silver	10.2%	6.5%	Free	Free	3.8%	2%
7106.91	Unwrought						
7106.91.10	Containing by weight 92.5% or more of silver	Free	Free	Free	Free-2.4%	Free	2.5%
7106.91.20	Containing by weight less than 92.5% of silver	10.2%	6.5%	2%	Free-2.4%	Free	2.5%
7106.92	Semi-manufactured						
	Containing by weight 92.5% or more of silver						
7106.92.11	In bars, sheets or plates	Free	Free	Free	2.4%	3.8%	2.5%-5.8%
7106.92.19	Other	11%	7%	2.2%	2.4%	3.8%	2.5%-5.8%
	Containing by weight less than 92.5% of silver						
7106.92.21	Containing by weight 50% or more of copper	4%	2.5%	0.8%	2.4%	1.8%	2.5%-5.8%
7106.92.22	Containing by weight less than 50% of copper	10.2%	6.5%	2%	2.4%	1.8%	2.5%-5.8%
7107.00	Base metals clad with silver, not further worked than semi-manufactured	10.2%	6.5%	2%	2.6%	4.6%	5.8%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Customs Tariff Schedules of Japan, 1991.

[1] GATT rate is shown; lower tariff rates may apply circumstantially.

Silver

TABLE 1. CANADA, SILVER PRODUCTION AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(kilograms)		(kilograms)	
PRODUCTION	**(SHIPMENTS)[1]**				
	Newfoundland	x		x	
	Prince Edward Island	–		–	
	Nova Scotia	x		x	
	New Brunswick	144 513		153 057	
	Quebec	163 509		148 306	
	Ontario	329 777		294 951	
	Manitoba	40 643		46 999	
	Saskatchewan	x		x	
	Alberta	–		–	
	British Columbia	597 930		490 178	
	Yukon	83 938		86 044	
	Northwest Territories	19 119		19 248	
	Total	1 381 257		1 239 909	
	Total value ($000)	249 746		185 261	
				(Jan.-Sept.)	
		(kilograms)	($000)	(kilograms)	($000)
EXPORTS					
2600.00	Silver contained in ores and concentrates				
	Japan	368 483	57 448	267 498	29 854
	Belgium	104 161	17 661	57 519	6 595
	United States	20 086	7 420	4 970	2 619
	Germany[2]	51 683	8 878	10 822	1 196
	United Kingdom	1 570	373	7 204	1 076
	Other countries	78 772	13 446	45 251	6 492
	Total	624 755	105 226	393 264	47 832
2603.00	Copper ores and concentrates				
2603.00.81	Silver content	473 419	73 728	312 204	33 611
2607.00	Lead ores and concentrates				
2607.00.81	Silver content	86 366	20 551	47 208	10 424
2608.00	Zinc ores and concentrates				
2608.00.81	Silver content	15 977	1 619	14 345	836
2616.10	Silver ores and concentrates				
2616.10.81	Silver content	1 582	317	–	–
2616.90	Precious metal ores and concentrates				
2616.90.81	Silver content	47 411	9 011	19 507	2 961
71.06	Silver (including silver plated with gold or platinum), unwrought or in semi-manufactured forms, or in powder form				
7106.10	Powder	454	89	155	49
	Other				
7106.91	Unwrought	1 253 863	240 529	741 977	111 833
7106.92	Semi-manufactured	15 443	3 071	14 261	2 218
IMPORTS					
2600.00	Silver contained in ores and concentrates				
	Peru	155 144	20 663	89 789	9 646
	United States	69 963	11 190	46 445	6 886
	Other countries	28 520	4 346	3 349	406
	Total	253 627	36 199	139 583	16 938
2603.00.00	Copper ores and concentrates				
2603.00.00.81	Silver content	8 653	1 495	10 454	1 628
2607.00.00	Lead ores and concentrates				
2607.00.00.81	Silver content	146 788	19 326	28 819	3 282

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(kilograms)		(kilograms)	
IMPORTS (cont'd)					
2608.00	Zinc ores and concentrates				
2608.00.00.81	Silver content	60 878	9 956	40 569	6 193
2616.10	Silver ores and concentrates				
2616.10.00.81	Silver content	37 308	5 422	59 734	5 834
2616.90	Precious metal ores and concentrates				
2616.90.00.10	Silver content	–	–	7	1
71.06	Silver (including silver plated with gold or platinum), unwrought or in semi-manufactured forms, or in powder form				
71.06.10	Powder	4 168	963	2 734	604
	Other				
7106.91	Unwrought	96 263	19 231	112 206	11 897
7106.92	Semi-manufactured	10 233	2 115	7 196	1 681
7107.00	Base metals clad with silver, not further worked than semi-manufactured	4 094	405	3 444	165

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; n.e.s. Not elsewhere specified; p Preliminary; x Confidential;
[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] Where applicable, data for East and West Germany have been combined.

disappearance, exports to the United States in 1991 decreased by about 4% over 1990.

Ormiston Mining and Smelting Co. Ltd. produced salt cake-grade material from brines of Horseshoe Lake. Millar Western Industries Ltd. produced salt cake from Whiteshore Lake. Saskatchewan Minerals, a wholly owned division of Dickenson Mines Limited, produced detergent- and kraft-grade material from the Ingebrit Lake and Chaplin Lake (kraft grade).

In the light of vanishing markets for sodium sulphate, Ormiston Mining and Smelting Co. Ltd. has developed and licenced a new process to produce sodium carbonate (soda ash) from sodium sulphate. Some small amounts were produced and the company is now looking to develop markets before commencing industrial production.

All remaining Canadian producers of natural sodium sulphate are looking at diversification of their product lines in order to compensate for the sharp decline in the pulp and paper industry. This is necessary for the sodium sulphate industry if it wishes to survive.

There is only one producer of synthetic sodium sulphate in Canada, which is located in Cornwall, Ontario. There, Courtaulds (Canada) Inc. produces a detergent-grade as a by-product of viscose rayon production at a rate slightly in excess of 20 000 t/y. The reported 27 000-t/y capacity of this plant will be raised in the coming year.

Deposits

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 ($Na_2SO_4 \cdot 10H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated. Deposits in Saskatchewan are deemed to contain close to 100 Mt of anhydrous sodium sulphate.

Recovery and Processing

Because most of the sodium sulphate is recovered by the evaporation of concentrated brines or by dredging the permanent beds of crystals, weather is as important for the 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 constituents 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 using conventional earth-moving equipment. The harvested crystal is stockpiled adjacent to the plant.

Some operators use floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported by pipeline to a screening house at the plant. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

Since 1984, one company uses solution mining in lake beds that are 3-11 m thick. It pumps a concentrated brine to an air-cooled crystallizer at the plant where sodium sulphate is separated from other more soluble salts.

Processing of the natural salt consists of dehydration (Glauber's salt contains 55.9% water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, and submerged combustion and multiple-effect evaporators. Subsequent crushing and screening results in a product with uniform grain size and good flow characteristics. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97% Na_2SO_4. Detergent-grade material analyzes up to 99.7% Na_2SO_4. Uniform grain size and free-flow characteristics are important in material handling and use.

Of the original seven plants in the Prairies, four were capable of producing detergent-grade sodium sulphate. Three plants have the capacity to produce 80% or more of their output as a high-grade product.

USES

The main end uses for sodium sulphate are in the pulp and paper, detergent, glass and dyeing industries.

In the chemical pulping of wood, the digestion reagents consist of about two thirds caustic soda and one third sodium sulphide obtained by using sodium sulphate as make-up. About 33% of sulphur input is retained in the organic chemicals recycled in the process. Lately, technical improvements in the process have significantly reduced the consumption of sodium sulphate per tonne of pulp produced to slightly less than 20 kg/t. The reduction is also due to the increasing use of chlorine dioxide as a bleaching agent. This bleaching chemical is manufactured internally and a sodium sulphate slurry is its by-product in many mills. Caustic soda and emulsified sulphur can be substituted for salt cake. Partial substitution reduces sulphur emissions, thereby facilitating compliance with stricter environmental controls. The U.S. pulp and paper market accounts for about 35% of sodium sulphate usage.

Sodium sulphate is used as a builder, or more correctly as a diluent, in detergents (supplying the "bulk"). It is claimed to improve detergency through its effect on the colloidal properties of the cleaning system, but it is essentially inert. The curtailment in the usage of sodium tripolyphosphate (STPP), on grounds of pollution control, also contributed to a decline in sodium sulphate production. The average sodium sulphate content of powder detergents is now between 20% and 25% in North America and Japan, about 25% in Western Europe, and above 50% in Eastern Europe. In the United States, detergents represent 45% of the market for sodium sulphate, but rapid growth in liquid detergents has had a negative impact on demand. Liquid detergents now represent 35%-40% of the market but appear to have reached a plateau as substitutes.

Some sodium sulphate is used by the glass industry as a source of Na_2O to speed up melting and prevent scum from forming on the surface of the melt. For typical container glass, the sodium sulphate used is 0.36% of the weight of the glass produced, while flat glass requires 5-10 parts of sodium sulphate per 1000 parts of silica sand. However, calcium sulphate and soda ash can partially replace sodium sulphate, particularly in the manufacture of flat glass and specialty glasses. Both natural and synthetic salt cake can be used providing the Fe_2O_3 content is less than 0.15%. Sodium sulphate in glass accounts for 5% of U.S. consumption.

Sodium sulphate is also used in the textile industry in the dyeing process, particularly in the dyeing of wool. In addition, sodium sulphate is used in the manufacture of a number of chemicals such as potassium sulphate, sodium sulphide, sodium silicate, sodium hyposulphite and sodium aluminum sulphate. Sodium sulphide is quantitatively the most important, and is used for de-hairing hides in the tanning process.

Other end uses include the manufacture of viscose sponges, feed supplements, boiler feed water treatments, veterinary medicines, sulphonated oils and printing inks, and in applications in the ceramics and photographic industries.

PRICES

Canadian list prices for natural sodium sulphate, f.o.b. western plants, were approximately \$65-\$75 and \$85-\$91/t respectively for salt cake and detergent-grade in 1991. Small quantities were sold near the list price while large lots were sold at substantial discounts. One-year contracts at firm prices are common. In 1992, prices are expected to remain stable for salt cake and to improve slightly for detergent-grade. Prices for detergent-grade by-product sodium sulphate were in the order of \$175-\$180/t delivered in Ontario in bulk shipment. For bagged product, the quote on December 31, 1991, was \$215/t, f.o.b. plant (e.g., Cornwall).

OUTLOOK

On balance, the North American natural sodium sulphate industry is expected to experience a flat growth in consumption over the next few years; some analysts expect a slight negative trend.

Canadian shipments in 1991 were sharply below those of 1990 mainly due to the closure of the three Agassiz Resources Ltd. plants. In the North American pulp and paper industry, consumption of sodium sulphate continued at steady levels, since substitution by caustic soda and emulsified sulphur ran its course. However, conditions in Canada were less positive than in the United States, mainly because of the impact of the recession on the pulp and paper sector and a faster move away from sodium sulphate. In the future, new processes will be introduced using much less sodium sulphate; therefore, the average consumption per tonne is likely to decline substantially and will only be partially offset by a higher output of pulp and paper. It is expected that the market for sodium sulphate in the Canadian pulp and paper industry will drop by about 50% to around 70 000 t by 1995.

In the detergent industry, a worldwide growth rate of about 2% is envisaged due to potential market growth in Asia (Pacific Rim countries) and Eastern Europe. In North America, the increased use of compact detergents and liquid detergents has resulted in a continuing decline in demand. Compact powders are currently being introduced in Europe and, even though they appear to receive less acceptance than in North America, it is expected that, in the long term, they will replace the more traditional powders. The closure of a major Colgate plant in Toronto will result in a drop in internal consumption, which will be only partially offset by the move of a production unit from the United States to Canada.

Consumption of sodium sulphate in the United States in 1991 is estimated to have decreased by 16.5% over 1989. American exports rose by about 77% to 110 000 t due to the sale of a California facility to a consortium, which includes investors from the Republic of Korea where some of the production is shipped to satisfy domestic requirements. The United States, which accounts for about 14% of world consumption of sodium sulphate, had an import reliance factor of 6% in 1991, which has been steadily decreasing since 1989. In 1991, U.S. production of natural sodium sulphate remained stable while the production of synthetic sodium sulphate is estimated to have decreased by 17.6%. Canadian exports to the United States are expected to stagnate at current levels or even decline slightly.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2833.11.00	Disodium sulphate	9.2%	Free	1.8%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, NATURAL SODIUM SULPHATE PRODUCTION AND TRADE, 1989-91

Item No.		1989		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION							
Shipments							
	Saskatchewan	x	23 177	x	23 904	x	20 589
	Alberta	x	3 167	x	3 184	x	1 212
	Total	327 444	26 344	346 607	27 089	284 741	21 800
IMPORTS						(Jan.-Sept.)	
2833.11	Disodium sulphate						
	United States	1 318	152	353	52	521	70
	United Kingdom	3 769	173	26	3	24	3
	Germany[1]	64	9	26	3	19	2
	Total	5 152	335	405	60	563	77
EXPORTS							
2833.11	Disodium sulphate						
	United States	163 191	13 639	159 279	15 480	115 329	11 920
	New Zealand	1	11	–	–	1 918	192
	United Kingdom	–	3	–	–	21	29
	Other countries	8 165	455	6 895	576	242	681
	Total	171 358	14 108	166 174	16 056	117 509	12 822

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; p Preliminary; x Confidential.
[1] Where applicable, data for East and West Germany have been combined.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1991

	Plant Location	Source Lake	Annual Capacity
			(tonnes)
ALBERTA			
Agassiz Resources Ltd.[1]	Metiskow	Metiskow	55 000
SASKATCHEWAN			
Agassiz Resources Ltd.[1]	Cabri	Snakehole and Verlo	60 000
Agassiz Resources Ltd.[1]	Hardene	Alsask	45 000
Millar Western Industries Ltd.	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals[2]	Chaplin	Chaplin	90 000
Saskatchewan Minerals[2]	Fox Valley	Ingebrigt	180 000
Total			629 700

Source: Company reports.
[1] Francana Minerals Inc. closed in May 1991. [2] A division of Dickenson Mines Limited.

TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, AND 1980-91

Year	Production[1]	Imports[2]	Exports	Consumption[3]
		(tonnes)		
1970	445 017	26 449	108 761	291 439
1975	472 196	22 638	178 182	256 385
1980	496 000	20 211	245 831	232 045
1981	535 000	12 481	284 284	216 298
1982	547 000	17 293	367 931	191 988
1983	453 939	22 479	265 753	190 625
1984	389 086	20 562	233 776	235 504
1985	366 217	33 409	210 851	241 143
1986	370 726	17 551	233 397	228 360
1987	342 076	17 194	168 097	188 626
1988[4]	330 971	6 567	150 569	187 846r
1989	327 444r	5 152	171 358	223 135
1990	346 607	405	166 174	184 045
1991p	284 741	. .	. .	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
. . Not available; p Preliminary; r Revised.
[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake. [3] Available data as reported by consumers. [4] As of 1988, trade figures represent disodium sulphate only.

TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION,[1] 1988-90

	1988	1989	1990p
		(tonnes)	
Paper pulp, paper and paper products	144 813r	180 044	143 040
Cleansers	34 278	36 200	35 904
Primary glass and glass containers	8 068	6 242	4 321
Other products[2]	687	649	780
Total	187 846r	223 135	184 045

Source: Energy, Mines and Resources Canada.
p Preliminary; r Revised.
[1] Available data as reported by consumers. [2] Chemicals, feed industry and other minor uses.

Stone

Oliver Vagt

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-2667

The volume of all types of stone produced in Canada in 1991 was about 23% lower than the previous year, according to preliminary figures. As characterized by end use, production included dimensional stone, chemical and metallurgical grades of stone, and pulverized and crushed stone. Similarly, the total value of production decreased more than 20% to $513 million.

Additional detailed information, particularly on normal aggregates, including crushed stone and sand and gravel, as well as on numerous lightweight aggregates, is included in a separate chapter entitled "Mineral Aggregates."

Dimension stone relates to a variety of rock types that may be cut, shaped or simply selected for a broad range of construction/ engineering, architectural or monumental requirements. The types of stone available are dependent on local geology, but mainly include granite, limestone, marble, sandstone and slate, as summarized in Tables 3-8. The term "granite," as commercially applied, includes true granite, granodiorite, gneiss and other medium-to-coarse-grained igneous rocks. However, "black granite" includes anorthosite and other dark-coloured igneous rocks. Limestone and marble are often confused; marble is the metamorphosed equivalent of the former and usually includes both dolomitic and calcitic varieties. As an industrial term, marble is used for recrystallized calcareous rock capable of taking a polish.

CANADIAN DEVELOPMENTS

Production of dimension stone, along with exports of rough block (mainly granite from Quebec), continued to be relatively strong in 1991. However, there was less emphasis on quarry development to support the manufacture of tiles, custom-cut panels and slabs as demand weakened in the domestic and export markets. In 1991, one new fabricating plant opened in Quebec; two plants that opened in that province during 1990 continued operations. In Ontario, Jarvis Resources Ltd. began development of a marble property in the Sudbury area. The company intends to extract block for processing into slabs, tiles and bricks.

Canadian companies, with up-to-date technology and aggressive marketing, have become an important part of the international stone industry. A wide variety of granite, particularly for construction uses, has become important, with most activity centred in Quebec (80%-90%) and Ontario. Limestone, marble, sandstone and slate are also important in several parts of Canada (Figure 1).

The 1980s saw considerable growth in the volume and value of granite produced in Canada for use in the construction sector, rising from 27 000 tonnes (t) valued at less than $1.2 million in 1978 to more than 113 000 t valued at $17.1 million in 1989 (Figure 2 and Table 5). Based on estimates for 1990, production reached a peak of 128 000 t valued at nearly $20 million in 1990. Output in 1991 for construction uses declined to 112 000 t, according to preliminary statistics (Figure 3).

Value added by further processing in the Canadian granite industry is substantial; for example, the total value of thin-cut tiles (1.3 cm and 1.0 cm), custom-cut panels, slabs, monuments and furniture was an estimated $110 million in 1990.[1] More than 90% of this output was from Quebec, with panels and thin tiles accounting for approximately 70% ($50 million and $25 million, respectively) and monuments accounting for the remainder. This further processing is based on both domestic and imported block, demonstrating the importance of international trade in this sector.

Granite used for monumental and ornamental purposes has declined in relative importance during the past few years; however, output has tended to remain stable.

The use of limestone and marble in construction has also increased in the last few years. Reflecting in part the growing importance of the Canadian stone industry, the Marble Institute of America held its 47th annual meeting in Québec City in 1991. The associated exposition, which included types of stone from as far away as India and Australia, attracted 75 exhibitors and about 1000 delegates from around the world.

Many provincial authorities continued assessments of their stone resources and, with the rejuvenated interest in much of the historical record, early works such as those by W.A. Parks[2] and M.F. Goudge[3] have proven to be classics on the subject. Promotional literature and display samples have been part of this work, often within the context of federal/provincial Mineral Development Agreements.

Atlantic Provinces

Limestone

Occurrences of limestone in the Atlantic provinces are common and have been systematically catalogued in the past.[4,5,6] Deposits of commercial importance are being worked in three of the four provinces.

In Newfoundland, outside of requirements for aggregate for highways, the most important operation is the manufacture of cement by North Star Cement Limited at Corner Brook.[7] Recently, the Iron Ore Company of Canada (IOC) brought into production in western Labrador a dolomitic marble for use in self-fluxing "dolomitic-type" iron ore pellets.[8] Newfoundland Resources & Mining Company Limited, as described in the "Mineral Aggregates"chapter, increased shipments of crushed limestone from its tidewater property on the Port-au-Port Peninsula.

In Nova Scotia, limestone for numerous uses is quarried in the central and eastern parts of the province. In New Brunswick, quarries operate at three locations: Brookville, Elm Tree and Havelock.

Granite

Occurrences of granite in the Atlantic region have been described by Carr.[9] In Nova Scotia, a blue-grey granite produced near Nictaux is used mainly in the monument industry. Activity relating to granite, as well as to other types of stone, was summarized in two recent publications.[10,11] Construction Aggregates

Ltd., owned by Lone Star Industries, Inc., of Greenwich, Connecticut, continued shipping high-quality granite aggregate from the company's Porcupine Mountain quarry on the Strait of Canso. Plans to develop a quarry at Kelly's Mountain on Cape Breton Island to produce crushed granite were on hold pending an environmental review.

Granite is quarried intermittently from a number of deposits in New Brunswick.[12] A red fine-to-medium-grained granite is produced near St. Stephen and fine-grained pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. A brown-to-grey coarse-grained granite in the Bathurst area, a salmon-coloured medium-grained granite near Antinouri Lake, and a black ferro-magnesian rock in the Bocabec River area are all quarried on demand. Red granite is available in the St. George district.

On the northern Labrador coast, development started on a large complex that hosts occurrences of a uniform medium-grained light grey chatoyant labradorite.[8] The deposit is being developed by the Labrador Inuit Development Corporation and an Italian company (to cut and market the stone).

In central Newfoundland, exploration has focused on the Mount Peyton "black granite," the Deadman's Bay megacrystic pink granite, and the Pass Island pink-to-red granite. Blocks have been shipped to fabricators for cutting and polishing tests.

Sandstone and Slate

Production of slate by Newfoundland Slate Inc. (originally Island Tile & Slate Limited, and later changed to Random Slate Inc.), has been intermittent since start-up in 1986. The quarry is situated at Nut Cove in Trinity Bay, Newfoundland, where extensive, good quality green- and purple-coloured slate has been outlined. However, initial expectations concerning high-volume sales have not materialized, apparently as a result of combined technical, transportation and delivery problems.

In Nova Scotia, medium-grained buff sandstone at Wallace is quarried for use as heavy riprap and dimension stone. This stone enjoyed widespread architectural use in the past in central and Atlantic Canada and, as a result, is seeing growing use for renovation and restoration work.

In New Brunswick, a red fine-to-medium-grained sandstone has been quarried in Sackville for use in construction. Deposits are exploited on demand throughout Kent and Westmorland counties.

Quebec

Limestone

Limestone occurs in the St. Lawrence and Ottawa River valleys and in the Eastern Townships. However, blocks and other shapes are produced at only a few locations. Marble has been produced in the Eastern Townships and the Lac St-Jean areas.

Granite and Marble

About 25 companies now quarry granite, mainly in the Rivière-à-Pierre, Lac-St-Jean, St. Lawrence North Shore, and Appalachian regions. Activity has increased substantially since detailed reports became available.[13,14] These companies now account for about 50 quarries classified as producers of granite for construction, monuments and/or furniture.

Granicor Inc./Columbia Granite Inc. quarries numerous types of rough granite for its fabricating plants as well as for export markets. In addition, member companies of the Quebec Granite Producers Association, including Groupe Polycor Inc., A. Lacroix Ltée, Dumas et Voyer Ltée, Granilac Inc., and others, continue regular operations and undertake new site development where demand warrants it.

In 1990, Groupe Polycor became the parent company of the long-time fabricator Granit Bussière Inc. and the quarrier Société Minière Polycor (SMP), established in 1987. Carrières Norgranit Inc., which has several granite deposits on the north shore of the St. Lawrence River and has been owned by SMP, is now also part of Groupe Polycor.

Tulinor Inc. continued to produce granite tiles at its new manufacturing plant at Grande-Bergeronnes; design capacity of the plant is about 60 000 m^2/y. Similarly, Granitslab International Inc. of Stanstead, Quebec, continued to operate its cutting and polishing plant. Granite slab is supplied to distributors, contractors and fabricators across Canada and the United States.

Granirex Inc. began operations in Thetford Mines, Quebec. Built at a cost of about $20 million, and using fully automated Italian technology, the plant produces quartz- and marble-agglomerated tiles and slabs. Specifications relating to the use of white or translucent aggregates are fundamental to colour control of the finished products. Mineral pigments, along with polyester resins used as cementing agents, result in durable granite-like custom products having polished, honed or textured surfaces.

Sandstone

Lès Carrières Ducharmes Inc., in Hemmingford, Huntingdon County, produces flagstone and construction blocks. This operation is the only company in Quebec producing this type of dimension stone.

Ontario

Limestone

Although limestones in Ontario range in age from Precambrian through Devonian, major production is from Ordovician, Silurian and Devonian deposits. A provincially funded three-volume study entitled "Limestone Industries of Ontario" was completed in 1989. This work thoroughly assesses the geological resources, economic factors and related industries associated with limestone, dolostone and marble.[15]

Arriscraft Corporation quarries a blue-grey-to-buff-coloured dolomitic limestone from the Amabel formation near Wiarton. Sold under the name of Adair marble, this attractive stone has been used increasingly for up-scale construction projects, including the new Canadian Chancery in Washington, D.C. Also in Washington, Adair marble was chosen as one of the types of stone used for the National Law Enforcement Officers Memorial built in 1991. The Adair stone was chosen because of its colour compatibility with the surroundings as well as its workability.

Marble

In the past, only a few uses for local construction-quality marble have been reported.[16]

Jarvis Resources Ltd. started developing a marble property located approximately 35 km north of Sudbury. Extensive exploration has delineated proven and probable reserves of approximately 5.5 Mt, according to the company. Based on the quality and variety of multicoloured marble available, the company plans to establish a slab and tile manufacturing line.

Two Island Marble Corporation operated intermittently in 1991. The company started its small-scale quarrying and cutting operation in 1990 in the Renfrew area of eastern Ontario.

Steep Rock Calcite, a wholly owned subsidiary of Pleuss-Staufer AG of Switzerland, operating at Tatlock and Perth, is the main producer of high-purity carbonate fillers in Ontario. The quarry at Tatlock is in a section of one of the late Precambrian marble belts which comprise a large part of the Grenville metasedimentary rocks.

Granite

Granites occur in northern, northwestern and southeastern Ontario.[17,18,19,20,21,22,23] In northwestern Ontario, Nelson Granite Limited continued to expand access to granite to complement present needs mainly for the manufacture of monuments by affiliates in Ontario and New Brunswick. The company is the largest quarrier and operates near Vermilion Bay where there are exceptionally large reserves of pink granite. Canital Granite Ltd. of Winnipeg has quarried a yellow-brown granite north of Kenora in northwestern Ontario. Canadian Shield Quarries Ltd., a member of Société d'Exploration Minière Vior Inc., has been active in the Sudbury area where deposits of gabbroic anorthosite (or "black granite") are attracting much attention. Positano Granite, a division of Poscan Ltd., has quarried a white and black gabbro east of Sudbury in northern Ontario. Detailed activity throughout the province is highlighted in an annual directory.[24]

Sandstone

Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone.[25] Medina sandstone is fine-to-medium-grained and varies from grey, through buff and brown to red, with some mottled units. Potsdam stone is medium-grained and varies from grey-white through salmon-red to purple, and is mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone, and as a source of silica for ferrosilicon and glass.

Western Provinces

Limestone

From east to west through the southern half of Manitoba, rocks of Precambrian, Ordovician, Silurian, Devonian and Cretaceous ages occur. Limestones of commercial importance occur in the three middle periods and range from magnesian limestone through dolomite to high-calcium limestones.[3,26] A provincial publication reports on limestone as well as on other types of stone.[27]

Sandstone

Sandstone for building and ornamental uses quarried near Banff, Alberta, is hard, fine-grained, medium-grey, and is referred to as "Rundal Stone."

SPECIFICATIONS

Several test methods apply to dimension stone but generally begin with compressive strength (ASTM C170) and absorption (ASTM C97). The compressive strength is defined as the maximum load per unit area that can be applied before the rock fails, reported in pounds per square inch (psi) and in megapascals (MPa). Absorption is defined as the percentage of water by weight that is absorbed over a 48-hour period.

CONSUMPTION AND MARKETS

Most dimension stone, including granite, limestone, marble, sandstone and slate, is used in construction-oriented projects. Limestone also has chemical-related uses, along with its large-scale use in the cement, lime, glass and metal-smelting industries.

Granite, as a dimension stone, is processed mainly for interior and exterior floor- and wall-cladding, modular block panelling, and monuments. Increasingly, a broader range of colour and texture is being sought by developers and architects. Detailed consumption data for rough and finished granite, as well as for other types of stone, are not available. However, trends can be established based on production, imports, and less well-defined export data. During the 1980-90 period, Canada's production of rough granite approximately doubled and imports of roughly trimmed and cut granite block (codes 2516.11 and 2516.12) more than doubled according to recent estimates and revisions (Table 9). Exports of rough granite have increased about eightfold in terms of volume since 1985 in response to demand in Japan, the United States and Italy. Exports of granite monumental or building stone (code 6802.23–cut or sawn, and code 6802.93–worked) were mainly to the United States; since 1983, this large market has been the main reason for the installation of increased fabricating capacity.

Some specific uses for stone in the chemical field are: the neutralization of acid waste liquors; the extraction of aluminum oxide from bauxite; the 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.

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 by Haley Industries Limited 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 Quarry Products Inc. A magnesite deposit at Eon Mountain in British Columbia has been quarried by Baymag Mines Co. Limited since 1982. The final product is

[18] Verschuren, C.P., van Haaften, S., and Kingston, P.W., Building Stones of Eastern Ontario, Southern Ontario–1985; Ontario Geological Survey, Open File Report 5556, 116 pp.

[19] Beard, R.C., and Kennedy, M.C., Building and Ornamental Stone in Northwestern Ontario, Canadian Institute of Mining and Metallurgy, unpublished, 1987.

[20] Verschuren, C.P., and Kingston, P.W., 1987, Criteria for Quarry Development in Southeastern Ontario, Canadian Institute of Mining Bulletin, pp. 55-60, February issue.

[21] Lebaron, P.S., Verschuren, C.P., Papertzian, V.C., and Kingston, P.W., 1989, Building Stone Potential in Eastern Ontario, Ontario Geological Survey, Open File Report 5706, 539 pp.

[22] Fouts, C.R., and Marmont, C., 1989, Gneisses in the Parry Sound-Muskoka Area: Flagstone Resources, Open File Report 5725, in press.

[23] Lacy, J.K., 1989, Building Stone Inventory of the Sudbury Resident Geologist's Area, OGS Open File Report 5721.

[24] Ontario Building Stone Producers, Directory, 1990, Ministry of Northern Development and Mines, Mines and Minerals Division.

[25] Hewitt, D.F., Building Stone of Ontario, Part IV, Sandstone, Ontario Department of Mines, Toronto, Industrial Mineral Report No. 17, 1964.

[26] Bannatyne, B.B., High-Calcium Limestone Deposits of Manitoba, Manitoba Department of Mines, Resources and Environmental Management, Mineral Resources Division, Exploration and Geological Survey Branch, Winnipeg, Publication 75-1, 1975.

[27] Gunter, R. and Segard, S., Industrial Minerals of Manitoba, Manitoba Energy and Mines, Minerals Division, Open File Report OF 85-7.

[28] Holter, M.E., Limestone Resources of Alberta, Transactions, Canadian Institute of Mining and Metallurgy, Bull. V.76, 1971.

[29] McCammon, J.W., Sadar, E., Robinson, W.C., Robinson, J.W., Geology Exploration and Mining in British Columbia, 1974, British Columbia Department of Mines and Petroleum Resources.

[30] Manitoba Energy and Mines, Industrial Minerals Division, 1990, Documentation of Dimension Stone Resources in the Medika Area, (NTS 52E).

[31] Thomas, M.W. (1988a): Geological Assessment of Building Stone Potential, Wilson Lake and Bridgeman Lake Plutons - Northern Saskatchewan (NTS 73P/16 and 73P/10): in Summary of Investigations 1985, Sask. Geol. Surv., Misc. Rep. 88-4, pp. 119-124.

[32] _______ (1988b): Building Stone Reconnaissance Project 1988: Geological Traversing in Six Precambrian Plutons, Northern Saskatchewan; unpublished report, in Saskatchewan Geological Survey, Industrial Mineral File No. S-35a, 58 pp.

TARIFFS (cont'd)

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
25.17	Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, for road metalling or for railway or other ballast, shingle and flint, whether or not heat-treated; macadam of slag, dross or similar industrial waste, whether or not incorporating the materials cited in the first part of the heading, tarred macadam; granules, chippings and powder, of stones of heading No. 25.15 or 25.16, whether or not heat-treated				
2517.10.00	Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, etc.	Free	Free	Free	Free
2517.20.00	Macadam of slag, dross or similar industrial waste	Free	Free	Free	Free
2517.30.00	Tarred macadam	10.2%	6.5%	Free	Free
	Granules, chippings and powder, of stones of heading No. 25.15 or 25.16, whether or not heat-treated				
2517.41.00	Of marble	Free	Free	Free	Free
2517.49	Other				
2517.49.10	Limestone roofing granules	Free	Free	Free	Free
2517.49.90	Other	10.2%	6.5%	2%	Free
6801.00.00	Setts, curbstones and flagstones of natural stone (except slate)	5.5%	Free	1.1%	1.6%
6802.10	Tiles, cubes and similar articles, whether or not rectangular (including square), not more than 7 cm; artificially coloured granules, chippings and powder				
6802.10.10	Roofing granules, artificially coloured	Free	Free	Free	2.7%
6802.10.90	Other	12.5%	8%	2.5%	2.7%
	Other monumental or building stone and articles thereof, simply cut or sawn, with a flat or even surface				
6802.21	Marble, travertine and alabaster	5.7%	3.5%	1.1%	0.8%-2.4%
6802.22.00	Other calcareous stone	8%	5%	1.6%	2.4%
6802.23.00	Granite	5.5%	Free	Free	Free
6802.29.00	Other stone	8%	5%	1.6%	3%
	Other				
6802.91	Marble, travertine and alabaster	9%	Free	1.8%	1.1%-2.4%
6802.92.00	Other calcareous stone	9.9%	6.5%	1.9%	2.4%
6802.93.00	Granite	10.2%	6.5%	Free	Free
6802.99.00	Other stone	10.2%	6.5%	2%	2.6%
6803.00	Worked slate and articles of slate or of agglomerated slate				
6803.00.10	Roofing slate	Free	Free	Free	2.6%
6803.00.90	Other	10.2%	6.5%	2%	1.4%
6804.10.00	Millstones and grindstones for milling, grinding or pulping	10.2%	Free	6.1%	Free
6804.23.00	Of natural stone	10.2%	Free	6.1%	Free

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, STONE EXPORTS AND IMPORTS, 1989-91

Item No.		1989		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS							
2514.00	Slate, whether or not roughly trimmed or merely cut, etc.	330	133	4	. .	6	2
2515.11	Marble and travertine, crude or roughly trimmed	179	72	34	33	8	2
2515.12	Marble and travertine, merely cut, by sawing or otherwise into blocks, etc.	21	24	44	39	120	27
				(cubic metres)		(cubic metres)	
2516.11	Granite, crude or roughly trimmed	31 852	5 759	27 929	16 914	24 473	16 258
2516.12	Granite, merely cut, by sawing or otherwise, into blocks, etc.	75 253r	11 498r	4 236	2 456	3 800	1 081
2516.21	Sandstone, crude or roughly trimmed	–	–	50	2	–	–
				(tonnes)		(tonnes)	
2516.22	Sandstone, merely cut, by sawing or otherwise, into blocks, etc.	20	3	51	48	45	58
2516.90	Monumental or building stone, n.e.s.	247	214	1 149	148	1 314	380
2517.10	Pebbles, gravel broken or crushed stone used for aggregates, etc.	1 023 851r	9 336r	1 330 967	8 768	867 451	6 102
2517.41	Marble granules, chipping and powder of 25.15 or 25.16 heat-treated or not	–	–	220	36	281	50
2517.49	Granules, chippings and powder n.e.s. of 25.15 or 25.16 heat-treated or not	49 996	703	20 197	388	9 030	176
6801.00	Setts, curbstones and flagstones of natural stone (except slate)	–	–	. .	6	. .	146
6802.10	Tiles, etc., rectangular or square not more than 7 cm, etc., artificially coloured granules, chippings and powder	. .	143	. .	152	. .	30
6802.21	Monumental or building stone, cut or even, marble, travertine and alabaster	. .	17	. .	98	. .	8
6802.22	Monumental or building stone, cut or sawn, flat or even, other calcareous stone	–	–	–	–	. .	1
6802.23	Monumental or building stone, cut or sawn, flat or even, granite	. .	8 637	. .	3 186	. .	1 904
6802.29	Monumental or building stone, cut or sawn, flat or even, n.e.s.	. .	314	. .	44	. .	157
6802.91	Worked monumental or building stone, n.e.s., marble, travertine or alabaster	. .	336	. .	908	. .	1 152
6802.92	Worked monumental or building stone, n.e.s., calcareous stone, n.e.s.	–	–	. .	13	. .	797
6802.93	Worked monumental or building stone, n.e.s., granite	. .	17 505	. .	25 965	. .	16 708
6802.99	Worked monumental or building stone, n.e.s.	. .	81	. .	1 357	. .	3 316
6803.00	Worked slate and articles of slate or agglomerated slate	–	–	. .	3	–	–
6804.10	Millstones and grindstones for milling, grinding or pulping	. .	10 117r	. .	8 882	. .	4 805
6804.23	Millstones, grindstones, etc. of natural stone	. .	288	. .	1 030	. .	377
IMPORTS							
2514.00	Slate, whether or not roughly trimmed or merely cut, etc.	2 497	909	1 876	644	1 761	453
2515.11	Marble and travertine, crude or roughly trimmed	2 263	680	1 971	433	520	190
2515.12	Marble and travertine, merely cut, by sawing or otherwise, into blocks, etc.	3 701r	1 532r	2 038	1 185	2 074	1 655

TABLE 1 (cont'd)

Item No.		1989		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
2516.11	Granite, crude or roughly trimmed	50 903r	10 739r	45 129	10 466	23 626	5 141
2516.12	Granite, merely cut, by sawing or otherwise, into blocks, etc.	1 434r	995r	1 034	778	1 858	1 144
2516.21	Sandstone, crude or roughly trimmed	2 168	239	2 612	362	1 264	152
2516.22	Sandstone, merely cut, by sawing or otherwise, into blocks, etc.	12 940r	2 622r	9 396	1 914	5 281	1 093
2516.90	Monumental or building stone, n.e.s.	8 107	1 714	9 401	1 607	6 183	1 080
2517.10	Pebbles, gravel broken or crushed stone used for aggregates, etc.	739 220	4 292	996 051	5 509	826 080	5 108
2517.41	Marble granules, chipping and powder of 25.15 or 25.16 heat-treated or not	34 324r	4 320r	45 817	5 598	39 603	4 937
2517.49	Granules, chippings and powder n.e.s. of 25.15 or 25.16 heat-treated or not	123 475r	1 535	132 486	1 448	106 074	1 020
6801.00	Setts, curbstones and flagstones of natural stone (except slate)	..	1 059	..	739	..	609
6802.10	Tiles, etc. rectangular or square not more than 7 cm, etc., artificially coloured granules, chippings and powder	31 238	4 390r	32 895	4 456	26 575	3 238
6802.21	Monumental or building stone, cut or even, marble, travertine and alabaster	..	2 738r	..	3 170	..	2 197
6802.22	Monumental or building stone, cut or sawn, flat or even, other calcareous stone	..	264	..	471	..	150
6802.23	Monumental or building stone, cut or sawn, flat or even, granite	..	1 128	..	2 183	..	1 276
6802.29	Monumental or building stone, cut or sawn, flat or even, n.e.s.	..	477	..	427	..	247
6802.91	Worked monumental or building stone, n.e.s., marble, travertine and alabaster	..	51 680r	..	46 848	..	21 377
6802.92	Worked monumental or building stone, n.e.s., calcareous stone, n.e.s.	..	568r	..	1 135	..	1 297
6802.93	Worked monumental or building stone, n.e.s., granite	..	25 488r	..	32 301	..	23 390
6802.99	Worked monumental or building stone, n.e.s.	..	838r	..	1 291	..	929
		(sq metres)		**(sq metres)**		**(sq metres)**	
6803.00	Worked slate and articles of slate or agglomerated slate	30 191	3 404	29 079	3 891	..	2 239
6804.10	Millstones and grindstones for milling, grinding or pulping	..	1 956r	..	1 617	..	974
6804.23	Millstones, grindstones, etc. of natural stone	..	2 596r	..	1 939	..	1 299

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; n.e.s. Not elsewhere specified; p Preliminary; r Revised.

TABLE 2. CANADA, TOTAL PRODUCTION OF STONE, 1989-91

	1989		1990		1991p	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE[1]						
Newfoundland	862	5 364	1 501	9 952	987	5 015
Nova Scotia	6 732	33 718	7 271	39 459	4 177	23 576
New Brunswick	2 336	14 277	2 711	18 098	2 770	18 398
Quebec	42 605	230 455	40 634	243 573	34 979	206 173
Ontario	59 417	339 380	50 418	300 561	37 331	222 374
Manitoba	2 861	13 099	3 737	15 193	1 693	7 948
Saskatchewan	–	–	–	–	–	–
Alberta	374	3 619	313	2 702	300	2 892
British Columbia	3 421	22 922	3 271	24 327	3 040	22 725
Northwest Territories and Yukon	727	4 344	1 495	9 079	508	3 735
Total	119 335	667 178	111 352	662 945	85 785	512 837
BY USE[2]						
Dimensional stone			..	..	..	..
Rough	254	23 423	..	..	..	..
Monumental and ornamental stone (n.f.)	68	8 212	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	38	3 210	..	..	..	..
Chemical and metallurgical						
Cement plants, Canada	13 899	31 805	..	..	..	..
Cement plants, foreign	807	2 444	..	..	..	..
Lining, open-hearth furnaces	–	–	..	..	..	..
Flux in iron and steel furnaces	1 270	6 203	..	..	..	..
Flux in nonferrous smelters	52	1 258	..	..	..	..
Glass factories	258	4 930	..	..	..	..
Lime plants, Canada	2 162	13 386	..	..	..	..
Lime plants, foreign	237	1 397	..	..	..	..
Pulp and paper mills	216	1 928	..	..	..	..
Sugar refineries	40	318	..	..	..	..
Other chemical uses	1 316	7 780	..	..	..	..
Pulverized stone						
Whiting (substitute)	54	3 929	..	..	..	..
Asphalt filler	143	903	..	..	..	..
Dusting, coal mines	2	75	..	..	..	..
Agricultural purposes and fertilizer plants	1 031	14 238	..	..	..	..
Other uses	397	14 291	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	7	63	..	..	..	..
Roofing granules	328	6 379	..	..	..	..
Poultry grit	59	1 453	..	..	..	..
Stucco dash	10	1 120	..	..	..	..
Terrazzo chips	3	161	..	..	..	..
Rock wool	–	–	..	..	..	..
Rubble and riprap	1 605	9 167	..	..	..	..
Concrete aggregate	11 513	68 969	..	..	..	..
Asphalt aggregate	9 487	55 599	..	..	..	..
Road metal	55 496	260 780	..	..	..	..
Railroad ballast	2 743	17 838	..	..	..	..
Other uses	31 901	151 111	..	..	..	..
Total	135 395	712 370	..	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; n.f. Not finished or dressed; p Preliminary.
[1] Data exclude stone used in the Canadian cement and lime industries. [2] Data include stone used in the Canadian cement and lime industries.
Note: Numbers may not add to totals due to rounding.

TABLE 3. CANADA, PRODUCTION OF LIMESTONE, 1988-90

	1988		1989		1990	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE[1]						
Newfoundland	768	5 221	413	2 713	800	4 595
Prince Edward Island	–	–	–	–	–	–
Nova Scotia	156	1 891	177	1 934	185	2 044
New Brunswick	724	6 403	525	6 030	509	6 229
Quebec	35 440	157 562	32 752	152 910	30 801	154 493
Ontario	53 192	274 709	56 136	306 278	48 252	266 557
Manitoba	2 321	8 831	2 396	10 138	2 951	12 208
Saskatchewan	–	–	–	–	–	–
Alberta	261	2 565	328	3 365	243	2 527
British Columbia	1 910	11 692	1 823	12 855	1 810	14 573
Northwest Territories and Yukon	14	220	309	1 918	967	7 424
Total	94 787	469 094	94 859	498 141	86 519	470 649
BY USE[2]						
Dimensional stone						
Rough	53	2 220	57	2 563	. .	. .
Monumental and ornamental stone (n.f.)	. . .	40	. . .	52	. .	. .
Other (flagstone, curbstone, paving blocks, etc.)	23	1 875	30	2 405	. .	. .
Chemical and metallurgical					. .	. .
Cement plants, Canada	12 318	25 044	13 671	31 211	. .	. .
Cement plants, foreign	575	1 495	805	2 407	. .	. .
Lining, open-hearth furnaces	–	–	–	–	. .	. .
Flux in iron and steel furnaces	1 232	5 543	1 270	6 203	. .	. .
Flux in nonferrous smelters	53	1 161	52	1 258	. .	. .
Glass factories	198	3 734	258	4 930	. .	. .
Lime plants, Canada	2 346	14 141	2 162	13 386	. .	. .
Lime plants, foreign	455	2 051	237	1 397	. .	. .
Pulp and paper mills	226	1 932	216	1 928	. .	. .
Sugar refineries	33	230	40	318	. .	. .
Other chemical uses	1 452	9 828	1 316	7 780	. .	. .
Pulverized stone						
Whiting (substitute)	39	2 346	54	3 929	. .	. .
Asphalt filler	64	526	75	706	. .	. .
Dusting, coal mines	2	85	2	75	. .	. .
Agricultural purposes and fertilizer plants	1 077	13 747	980	13 409	. .	. .
Other uses	68	1 134	104	1 818	. .	. .
Crushed stone for						
Manufacture of artificial stone	–	–	1	5	. .	. .
Roofing granules	87	1 373	59	504	. .	. .
Poultry grit	37	740	57	1 208	. .	. .
Stucco dash	24	1 588	10	1 120	. .	. .
Terrazzo chips	–	–	–	–	. .	. .
Rock wool	–	–	–	–	. .	. .
Rubble and riprap	756	4 515	858	4 293	. .	. .
Concrete aggregate	8 032	42 821	9 510	55 817	. .	. .
Asphalt aggregate	5 342	27 860	6 720	39 854	. .	. .
Road metal	54 459	247 519	48 515	230 269	. .	. .
Railroad ballast	625	3 061	560	2 820	. .	. .
Other uses	19 873	91 669	23 072	111 074	. .	. .
Total	109 450	508 280	110 692	542 738	. .	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.f. Not finished or dressed; p Preliminary.
[1] Data exclude stone used in Canadian cement and lime industries. [2] Data include stone used in the Canadian cement and lime industries.
Note: Numbers may not add to totals due to rounding.

TABLE 4. CANADA, PRODUCTION OF MARBLE, 1988-90

	1988		1989		1990	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE						
Newfoundland	–	–	–	–	–	–
Nova Scotia	3	163	. . .	21	3	253
New Brunswick	–	–	–	–	–	–
Quebec	542	7 069	484	7 791	537	8 154
Ontario	218	11 335	254r	11 162r	231	11 547
Manitoba	–	–	–	–	–	–
Saskatchewan	–	–	–	–	–	–
Alberta	–	–	–	–	–	–
British Columbia	–	–	–	–	–	–
Northwest Territories and Yukon	–	–	–	–	–	–
Total	763	18 567	739r	18 974r	771	19 955
BY USE						
Dimensional stone						
Rough	28	1 262	22	999	. .	. .
Monumental and ornamental stone (n.f.)	–	–	–	–	. .	. .
Chemical process stone					. .	. .
Flux in nonferrous smelters	–	–	–	–	. .	. .
Pulp and paper mills	–	–	–	–	. .	. .
Other chemical uses	–	–	–	–	. .	. .
Pulverized stone						
Whiting	–	–	–	–	. .	. .
Agricultural purposes and fertilizer plants	65	1 057	51	829	. .	. .
Other uses	272	11 201	293	12 473	. .	. .
Crushed stone for						
Artificial stone	52	1 017	–	–	. .	. .
Roofing granules	3	66	2	37	. .	. .
Poultry grit	. . .	17	. . .	17	. .	. .
Stucco dash	4	186	–	–	. .	. .
Terrazzo chips	9	571	3	161	. .	. .
Concrete aggregate	61	619	145	1 488	. .	. .
Road metal	73	355	139	645	. .	. .
Other uses	196	2 215	84	2 325	. .	. .
Total	763	18 567	739	18 974	. .	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.f. Not finished or dressed; r Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 5. CANADA, PRODUCTION OF GRANITE, 1988-90

	1988		1989r		1990	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE						
Newfoundland	151	1 309	217	1 398	176	1 803
Nova Scotia	5 364	27 450	5 570	27 122	5 945	32 090
New Brunswick	1 535	8 186	1 658	7 820	2 039	11 364
Quebec	7 077	53 076	6 570	53 179	7 007	66 406
Ontario	1 885	18 852	1 731	18 410	1 927	21 097
Manitoba	441	3 714	353	2 938	659	2 959
Saskatchewan	–	–	–	–	–	–
Alberta	–	–	5	158	–	–
British Columbia	1 655	9 426	1 593	9 902	1 451	9 654
Northwest Territories and Yukon	10	49	307	2 252	317	1 267
Total	18 120	122 061	18 004	123 178	19 520	146 639
BY USE						
Dimensional stone						
Rough	100	15 759	113	17 055	..	..
Monumental and ornamental stone (n.f.)	46	8 121	43	7 156	..	..
Other (flagstone, curbstone, paving blocks, etc.)	7	538	6	572	..	..
Chemical and metallurgical						
Lining, open-hearth furnaces	–	–	–	–	..	..
					..	..
Pulverized stone						
Asphalt filler	73	201	67	196	..	..
Crushed stone for						
Artificial stone	5	55	5	53	..	..
Roofing granules	291	5 979	267	5 839	..	..
Poultry grit	1	113	1	119	..	..
Stucco dash	–	–	–	–	..	..
Rubble and riprap	875	5 371	724	4 809	..	..
Concrete aggregate	1 615	10 005	1 527	9 526	..	..
Asphalt aggregate	2 683	14 315	2 445	13 771	..	..
Road metal	5 535	25 901	5 445	24 995	..	..
Railroad ballast	2 004	13 657	2 183	15 018	..	..
Other uses	4 883	22 047	5 176	24 071	..	..
Total	18 120	122 061	18 004	123 178	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; n.f. Not finished or dressed; r Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 6. CANADA, PRODUCTION OF SANDSTONE, 1988-90

	1988		1989		1990	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE						
Newfoundland	177	844	228	1 238	518	3 528
Nova Scotia	1 007	4 902	973	4 611	1 101	4 972
New Brunswick	92	57	90	52	69	38
Quebec	1 706	12 327	1 501	12 067	1 269	10 481
Ontario	176	1 559	118	1 086	7	1 355
Manitoba	–	–	–	–	–	–
Saskatchewan	–	–	–	–	–	–
Alberta	3	151	...	28	1	60
British Columbia	6	147	6	165	10	100
Northwest Territories and Yukon	–	–	–	–	–	–
Total	3 167	19 986	2 917	19 247	2 975	20 534
BY USE						
Dimensional stone						
Rough	48	2 793	62	2 805	..	..
Monumental and ornamental stone (n.f.)	19	782	24	1 005	..	..
Lining, open-hearth furnaces	3	335	–	–	..	..
Other (flagstone, curbstone, paving blocks, etc.)	–	–	2	234	..	..
Chemical process stone					..	..
Cement plants, foreign	3	54	2	38	..	..
Crushed stone for						
Poultry grit	...	97	1	109	..	..
Stucco dash	–	–	–	–	..	..
Rock wool	–	–	–	–	..	..
Rubble and riprap	4	11	23	65	..	..
Concrete aggregate	456	2 624	330	2 138	..	..
Asphalt aggregate	137	747	231	1 438	..	..
Road metal	573	2 996	449	2 420	..	..
Railroad ballast	–	–	–	–	..	..
Other uses	1 924	9 547	1 792	8 995	..	..
Total	3 167	19 986	2 917	19 247	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; .. Not available; ... Amount too small to be expressed; n.f. Not finished or dressed.
Note: Numbers may not add to totals due to rounding.

TABLE 7. CANADA, PRODUCTION OF SHALE, 1988-90

	1988[3]		1989		1990	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
BY PROVINCE[1]						
Newfoundland	31	114	4	15	7	26
Nova Scotia	37	47	11	29	37	101
New Brunswick	94	621	62	375	93	468
Quebec	1 684	4 741	1 297	4 508	1 020	4 039
Ontario	1 201	2 576	1 178r	2 444r	1	5
Manitoba	115	22	113	23	127	26
Saskatchewan	–	–	–	–	–	–
Alberta	35	58	41	69	68	116
British Columbia	–	–	–	–	–	–
Northwest Territories and Yukon	93	105	110	175	211	389
Total	3 289	8 285	2 817r	7 637r	1 566	5 169
BY USE[2]						
Dimensional stone	. .	61	–	–	. .	. .
Chemical and metallurgical					. .	. .
Cement plants, Canadian	221	578	227	594	. .	. .
Crushed stone for						
Roofing granules	2	11	–	–	. .	. .
Rubble and riprap	10	2	–	–	. .	. .
Concrete aggregate	14	67	–	–	. .	. .
Road metal	850	2 490	949	2 451	. .	. .
Other uses	2 412	5 654	1 869	5 186	. .	. .
Total	3 510	8 863	3 045	8 232	. .	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; r Revised.
[1] Data excludes stone used in the Canadian cement and lime industries. [2] Data includes stone used in the Canadian cement and lime industries. [3] Includes slate.
Note: Numbers may not add to totals due to rounding.

TABLE 8. CANADA, PRODUCTION OF STONE BY TYPES[1], 1980, 1985, 1989 AND 1990

	1980[2]		1985[2]		1989r		1990	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Granite	39 983	140 914	17 219	95 424	18 004	123 178	19 520	146 639
Limestone	58 191	185 085	77 874	317 862	94 859	498 141	86 519	470 649
Marble	316	1 807	571	13 966	739	18 974	771	19 955
Sandstone	3 064	11 540	3 011	15 310	2 917	19 247	2 975	20 534
Shale	1 812	1 810	1 561	3 059	2 817	7 637	1 566	5 169
Total	103 366	341 156	100 236	445 622	119 335	667 178	111 352	662 945

Sources: Energy, Mines and Resources Canada; Statistics Canada
r Revised.
[1] Data exclude stone used in the Canadian cement and lime industries. [2] Includes slate.
Note: Numbers may not add to totals due to rounding.

TABLE 9. CANADA, ROUGH GRANITE–SUMMARY OF PRODUCTION AND TRADE

	Quantities / Value	Production[1]	Imports[2]	Exports[2]
1980	t	81 000	24 130	5 019[a]
	$ millions	5.6	1.9	0.7
1985	t	104 000	34 468	12 511[a]
	$ millions	12.8	6.2	1.7
1986	t	121 000	33 994	18 450[a]
	$ millions	15.7	6.6	2.7
1987	t	112 000	46 370	37 450[a]
	$ millions	16.1	7.9	6.0
1988	t	153 000	46 282	86 940[r]
	$ millions	24.4	11.2	16.2[r]
1989	t	162 000	52 337	107 105
	$ millions	24.8	11.7	17.3
1990	t	166 000[e]	46 163	88 775
	$ millions	26.0[e]	11.2	19.4
1991	t	148 000	35 035	101 836
	$ millions	22.6[e]	8.5	22.6

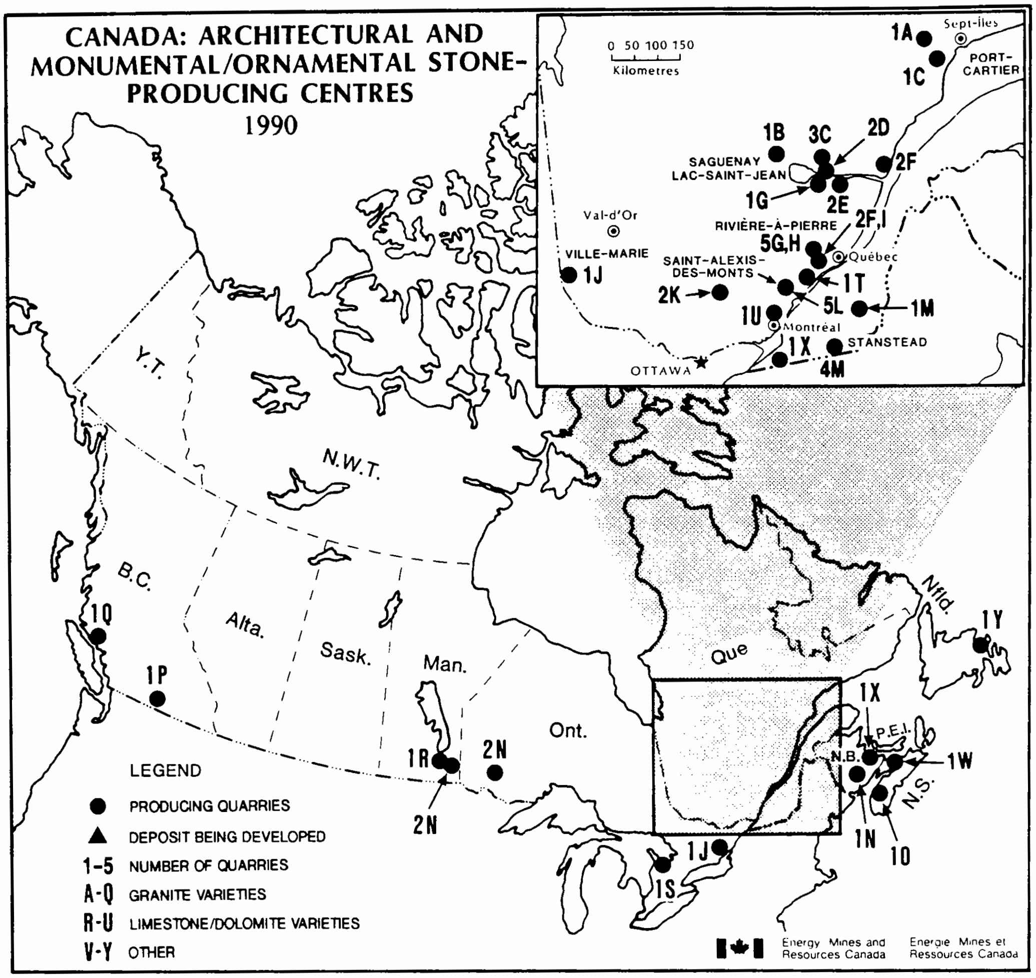
Sources: Energy, Mines and Resources Canada; Statistics Canada.
[e] Estimated; [r] Revised.
[a] Coded as building stone, rough (90% is considered to be granite).
[1] Includes rough stone for construction, monumental/ornamental and other uses. [2] Includes codes 2516.11 (roughly trimmed block) and 2516.12 (cut block by sawing or otherwise). Some re-exports to the United States may also be involved.

TABLE 10. CANADA, VALUE OF CONSTRUCTION BY PROVINCE,[1] 1989-91

	1989			1990			1991		
	Building Construction[2]	Engineering Construction[2]	Total	Building Construction[2]	Engineering Construction[2]	Total	Building Construction[2]	Engineering Construction[2]	Total
					($ millions)				
Newfoundland	1 050	608	1 659	1 065	609	1 674	1 169	1 172	2 341
Nova Scotia	1 821	737	2 558	1 880	907	2 787	1 705	1 076	2 780
New Brunswick	1 394	501	1 896	1 407	702	2 109	1 270	900	2 170
Prince Edward Island	269	92	361	268	92	360	265	111	376
Quebec	15 830	5 720	21 549	16 003	6 483	22 485	15 713	7 526	23 238
Ontario	32 434	7 828	40 263	29 705	7 809	37 514	28 380	9 538	37 917
Manitoba	1 967	1 115	3 082	1 854	1 348	3 202	1 802	1 384	3 186
Saskatchewan	1 797	1 633	3 431	1 809	1 908	3 717	1 846	2 082	3 928
Alberta	5 581	6 604	12 185	6 191	7 346	13 537	5 971	7 994	13 965
British Columbia, Yukon and Northwest Territories	9 096	4 332	13 428	9 993	4 480	14 473	9 070	4 827	13 897
Total Canada	71 238	29 174	100 412	70 174	31 684	101 858	67 189	36 609	103 798

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Actual expenditures 1989, preliminary 1990, intentions 1991. [2] Includes total value of new and repair work purchased.
Note: Numbers may not add to totals due to rounding.

Figure 1



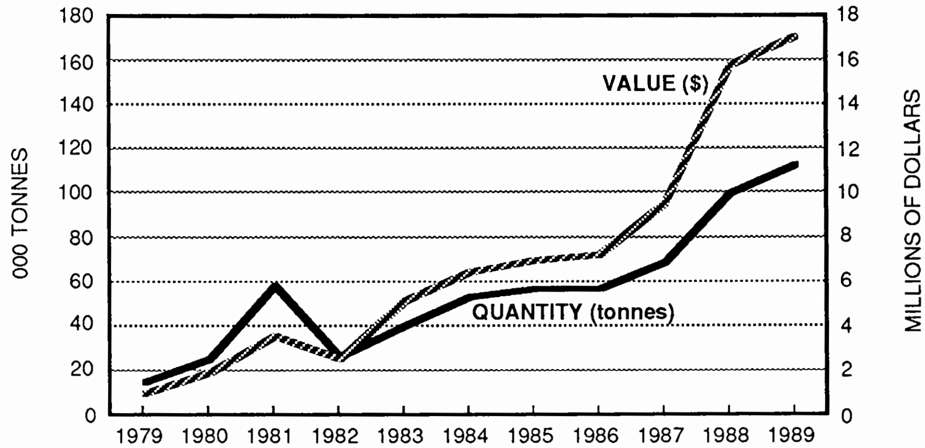
Source: Mainly Provincial Departments of Mines and Energy

A. Fine-grained pinkish-grey banded gneiss
B. Medium-grained mahogany granite
C. Coarse-grained black anorthosite
D. Medium-grained black gabbroic anorthosite
E. Medium-grained pinkish-grey quartz monzonite
F. Fine-grained pink granitic gneiss
G. Coarse-grained green charnockite
H. Coarse-grained pink-grey or brown-grey granite
I. Medium-grained grey dioritic gneiss
J. Medium-grained red granite
K. Fine-grained pink aplite
L. Coarse-grained brown or red quartz monzonite
M. Medium-grained grey granite
N. Medium-grained pink granite
O. Fine-grained blue-grey granite
P. Coarse coral pink granite
Q. Medium-grained blue-grey granite
R. Light-coloured mottled dolomitic limestone (Tyndall)
S. Fine-medium crystalline blue-grey to buff marble/dolostone (Arriscraft)
T. Medium-grained light brownish-grey limestone (Deschambault)
U. Medium-grained blue-grey limestone (Chazy)
V. Medium-grained olive sandstone
W. Fine-medium-grained olive-brown and blue-grey sandstone
X. Fine-medium-grained white to buff sandstone (Potsdam)
Y. Very fine-grained varicoloured slate

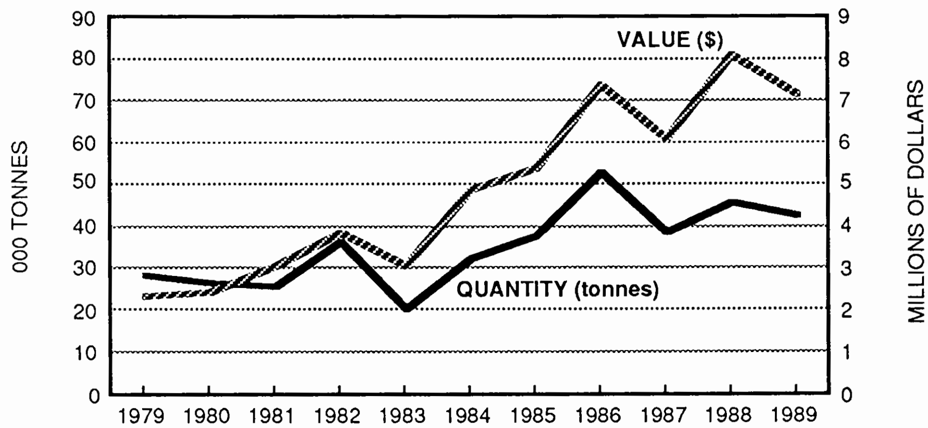
Figure 2

CANADA - PRODUCTION OF ROUGH GRANITE
(SOLD AND USED BY PRODUCERS)

CONSTRUCTION USES



MONUMENTAL/ORNAMENTAL



OTHERS (Flagstone, Curbstone, Paving Blocks and Other)

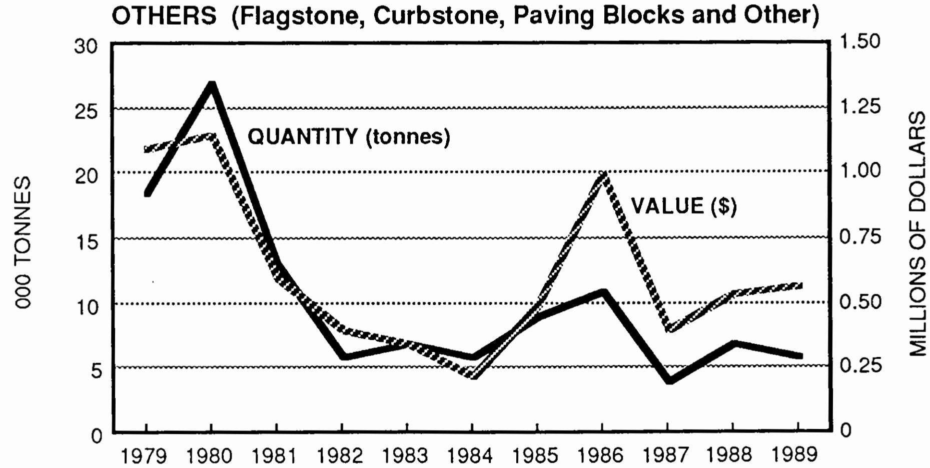
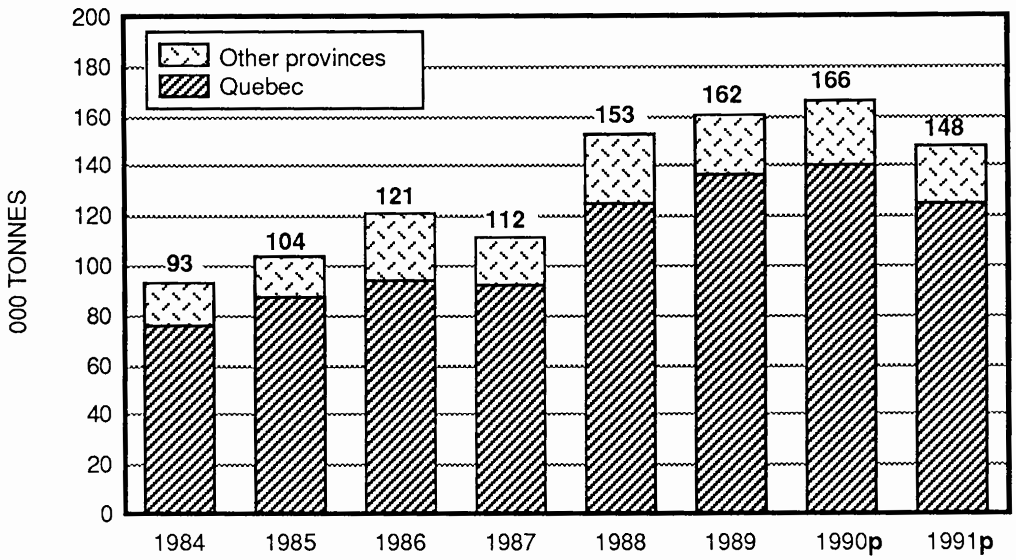
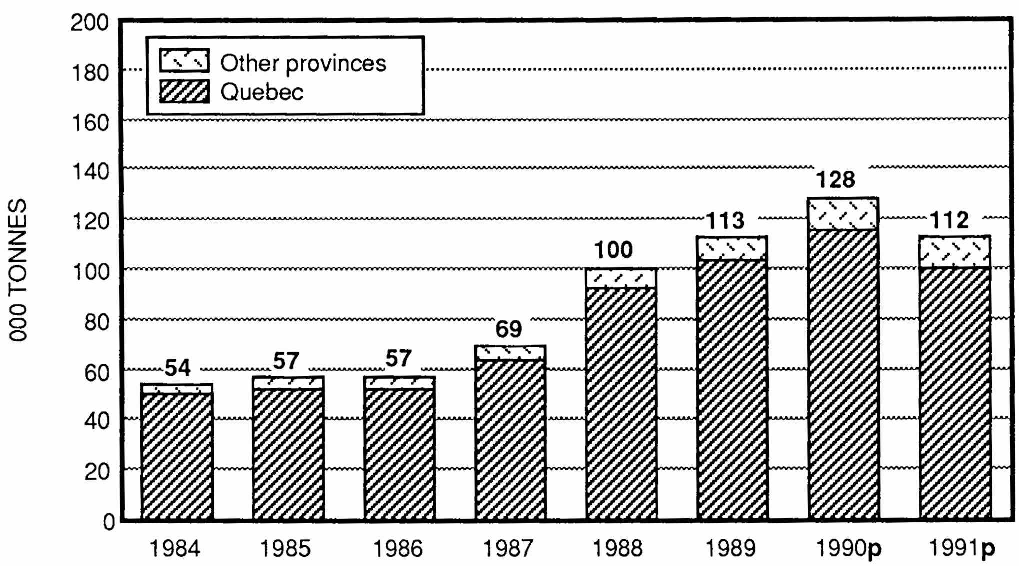


Figure 3

CANADA, ROUGH GRANITE - TREND IN PRODUCTION



CANADA - TREND IN PRODUCTION USED FOR CONSTRUCTION



p Preliminary.
Sources: Energy, Mines and Resources Canada; Quebec Ministry of Energy and Resources.

Sulphur

Michel Prud'homme

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-3733

SUMMARY

In 1991, the world sulphur market was generally balanced, in spite of the removal of sulphur tonnage formerly produced in Kuwait and Iraq. Much of the reduced supply was offset by increased production and exports by Saudi Arabia and Canada. World production of elemental sulphur declined 2.0 million tonnes (Mt) to 37.2 Mt; international trade was estimated at 16.0 Mt, down 10% over the previous year. Production rose in Canada, France, Iran, Japan, Saudi Arabia and the former U.S.S.R., while reduced output was reported in the United States, Germany, Iraq, Mexico and Poland. World demand for sulphur in fertilizers decreased marginally in 1991. Consumption of phosphate fertilizers dropped in Western Europe, Eastern Europe, North America, Oceania and the former U.S.S.R.; sales remained stable in Latin America. Growth in consumption was reported in Africa and Southeast Asia.

In international sulphur markets, little sales were realized in the first quarter of 1991 as major buyers, notably in North Africa, had refurnished their sulphur stocks late in December in anticipation of possible disruptions of supply from the Persian Gulf region. In reality, the Gulf war did not significantly affect the demand for, or the trade of, sulphur in 1991; it mostly impacted on international sulphur prices during the whole year. Late in 1990, the expectation of some tightness in sulphur supply resulted in upward pressures on sulphur prices, with quotations rising from US$90-$93/t (f.o.b. Vancouver) in the fall of 1990 to US$102-$105/t early in January. With a weak demand for sulphur prevailing in the first half and a sustained resistance from buyers on pricing, Canadian prices eroded to US$85-$88/t by June and to US$67-$72/t by August. By year-end, quotations for Canadian sulphur, f.o.b. Vancouver, were in the low US$60s.

Canadian elemental sulphur production increased 5.8% to 6.23 Mt and shipments remained stable at 6.9 Mt; higher exports to the United States offset the decline in offshore sales. In 1991, Canada ranked as the world's second largest producer of elemental sulphur with a 16% share and remained the leading exporter with a 38% share of world trade. By year-end, Canadian stocks amounted to 2.8 Mt.

CANADIAN DEVELOPMENTS

Elemental Sulphur

In 1991, the production of elemental sulphur in Canada increased 5.8% to 6.23 Mt. Production from natural gas processing accounted for 87.6%, while the remainder was from oil sands plants (8.7%) and oil refineries (3.7%). Gas-recovered sulphur in Alberta amounted to 5.02 Mt, compared to 4.77 Mt in 1990; this 5% increase resulted mostly from expanded output at Kaybob III and Kaybob I/II from tie-ins of new gas fields (Obed and Fir, respectively). Significant higher production also occurred at West Pembina and Petro-Canada's Brazeau plants, following the completion of expansion plans last year. Gas-related sulphur production from established reserves continued to decrease, except at Waterton and Ram River where higher operating rates prevailed during 1991. Reduced output was registered at Hanlan Robb, East Calgary, and Whitecourt, which together accounted for 60% of the total decline. Lower production in 1991 was also reported at Bigstone, Mazeppa-Okotoks, Strachan and Burnt Timber. Sulphur production from oil sands grew 9% to 544 000 t as both Syncrude and Suncor ran their operation at a sustained high level throughout 1991. In British Columbia, sulphur production from gas processing rose 7.2% to 450 000 t, accounting for 9% of total Canadian sulphur production; higher output was reported at Fort Nelson and Pine River. The recovery of sulphur from Canadian oil refineries increased 9.5% to 230 000 t, with two thirds of the increase reported from operations in eastern Canada. In 1990, sulphur shipments from refineries amounted to 201 902 t, of which 130 252 t were produced in eastern Canada. Domestic sales totalled 163 782 t while exports amounted to 38 120 t.

Shipments of elemental sulphur were estimated at close to 6.9 Mt, a level similar to that of last year. The significant rise in Canada's exports to the United States offset the 5% decrease in offshore shipments. Sulphur deliveries in Canada dropped to the 650 000 t/y level, while the domestic market for fertilizers remained soft during the whole year as phosphatic fertilizer plants operated at a reduced level.

Exports to the United States are estimated at 1.65 Mt in 1991, an 18% increase over 1990. For the third consecutive year, the United States remained the dominant export destination for Canadian sulphur, accounting for 27% of Canada's total exports.

In 1991, Canada's offshore exports of sulphur decreased 5.5% to 4.58 Mt, compared to 4.83 Mt in 1990. Canada sold sulphur to more than 30 countries. Morocco emerged as the principal offshore destination with a 24% share, followed by India (9%) and Tunisia (9%). Notable increases in sales were registered for Morocco (+20%), Tunisia (+40%), Senegal (+100%), and India (+100%). Losses in sales occurred in Oceania (-66%), the former U.S.S.R. (-60%), Brazil (-5%), Chile (-50%), Indonesia (-30%), Israel (-30%), and Western Europe (-45%). Sales to China rose from 29 769 t in 1990 to 75 654 t in 1991. An erosion of market share was reported in Eastern Europe (due to an increased U.S. share), and in Latin America (due to an increased Polish share). Higher market shares for Canada were reported in Asia and North Africa.

Canadian sulphur stocks in early January 1991 were estimated at around 3.5 Mt, distributed amongst 18 sites in Alberta. During the year, remelts were carried out to supplement production in order to meet requirements in domestic and export markets. While some additions to stocks occurred sporadically in the first half, net withdrawals in 1991 totalled close to 0.7 Mt, leaving about 2.8 Mt by year-end. Additions to stocks were reported in the first half at Kaybob I/II, Kaybob III, Hanlan Robb, Ram River, Waterton, East Crossfield and Strachan, while withdrawals occurred at more than 20 sites. Major remelts for 1991 were from Ram River, Kaybob I/II, East Calgary, Olds and East Crossfield, accounting together for two thirds of total withdrawals. The average remelt rate for the January-November period was estimated at 70 300 t/m, compared to 80 600 t/m for the same period last year; remelt rates above 124 000 t/m were registered in April, July, August and October. By the end of 1991, seven sites in Alberta accounted for 78% of remaining stocks, with major volumes (above 350 000 t) held at East Crossfield, Rainbow Lake, Ram River and Waterton.

On the domestic scene, the most important event of 1991 was the formation of a new sulphur marketing organization, Prism Sulphur Corporation. The new consortium will be responsible for offshore exports of close to 90% of Canadian sulphur. It was officially formed in December after close to 18 months of legal and financial negotiations amongst the group's initial 10 members. Prism, which now comprises 27 shareholders, was set to start marketing western-Canadian sulphur outside of North America effective January 1, 1992. The creation of the much-awaited consortium is expected to enhance the marketing efficiency of Canadian sulphur suppliers. An important effect of this move will be a more orderly approach to export markets by Canadian suppliers. This in turn will promote greater stability in Canadian offshore prices. The nine founding companies of the group consist of Amoco Canada Petroleum Company Ltd., Canadian Occidental Petroleum Ltd., Chevron Canada Resources, Gulf Canada Resources Limited, Husky Oil Operations Ltd., Mobil Oil Canada, Petro-Canada, Shell Canada Limited and Suncor Inc.

Alberta

On January 1, 1991, Amoco Canada Petroleum Company Ltd. assumed full responsibility for marketing all sulphur production formerly controlled by Dome Petroleum Limited. Amoco and Dow Chemical Canada Inc. announced plans to form a new oil and gas firm to become public in 1994. Amoco completed the addition of inlet facilities for connecting a new gas stream from the Fir-Spotter field to the Kaybob I/II processing plant; annual sulphur recovery is expected to increase by 152 000 t/y. The expansion program at the Brazeau plant near West Pembina was also completed; sulphur recovery rose from 350 t/d to 450 t/d.

Canadian Occidental Petroleum Ltd. closed the Okotoks gas-processing plant in August; all of the gas available in the area is to be processed by the company's newer facility at Mazeppa.

Chevron Canada Resources Limited added a new compression unit at Kaybob III in order to accommodate the new tie-ins, including Obed.

Gulf Canada Resources Limited started to haul sulphur material from the Nordegg River gas plant to its Strachan plant in western Alberta. Early in 1991, Gulf closed its Rimbey plant for several weeks after an explosion occurred causing a breakage of a gas line that resulted in a fatality. In October, Gulf also completed the tie-in of gas from the Ricinus field to Husky's Ram River plant.

Husky Oil Ltd. pursued its work in cleaning up groundwater contamination at Ram River. Contamination from sulphur blocks will be controlled; several options are under study to reduce dust from the 2500 t/d sulphur prilling tower. More than 1500 hectares of land are reported to be affected by sulphur dust; new sulphur-forming processes are being evaluated. The Husky's Lloydminster heavy oil upgrader project is ahead of schedule. Due for completion late in 1992, the $1.44 billion development involves two phases with the first to be commissioned in the summer of 1992. By year-end 1991, the engineering work was reported fully completed and 75% of the equipment was already on site. The sulphur recovery capacity of this facility is estimated at 90 000 t/y.

Mobil Oil Canada Ltd. installed an enhanced sulphur recovery system at its Lone Pine Creek gas plant near Carstairs, Alberta. A first in North America, the SuperClaus-99 unit will permit a reduction of sulphur dioxide emissions by up to 60%. This would result in an incremental sulphur recovery of up to 122 t/m. Mobil and Home Oil Company Limited will carry out a study to evaluate the feasibility of coordinating the operations of their respective gas-processing plants at Harmattan and Carstairs.

The $4.8 billion Other Six Leases Operations (OSLO) mega-project was put on hold during the fall of 1991 for an indefinite period. The project was to produce up to 85 000 barrels per day of synthetic oil from oil sands deposits in northeastern Alberta. The sulphur recovery capacity was designed at 260 000 t/y.

Shell Canada Limited started to operate its $65 million Bearberry sulphur recovery demonstration plant near Sundre. The 224 t/d liquid sulphur facility is expected to run for two to five years. Early in 1991, Shell Canada Limited and its partners (Canadian Hunter Exploration Ltd. and Conwest Exploration Co. Ltd.) announced a sour gas discovery close to the Caroline gas field; the discovery is reported to have a 46% H_2S content in its gas, which is more sour than that of the Caroline field estimated at near 35% H_2S.

In 1991, Shell announced capital expenditures of close to $1.1 billion, including $405 million for the Caroline natural gas development, which contains sulphur reserves estimated at 25 Mt. The total $950 million project includes a new gas-processing plant and an innovative 40-km underground liquid sulphur pipeline linking the plant to a new sulphur pellet-forming facility at Shantz. The Caroline plant incorporates two gas-processing trains, two sulphur recovery trains and a common utility unit for air, water and power requirements. The first train is expected to be commissioned late in 1992, while the second train is due for early 1993. The gas plants are to extract 99.8% of the sulphur in the sour gas, and have a total design capacity of 4100 t/d of elemental sulphur. By the end of 1991, the $50 million sulphur pipeline and the $50 million sulphur-forming plant at Shantz were completed. The forming facility includes 46 Rotoformer machines with a combined forming capacity of 4500 t/d of sulphur pellets. On site, 1540 workers were employed. The total cost of the sulphur-related work was estimated at $500 million. Early in 1991, Shell purchased Gulf Canada Resources Limited's working interests in the Caroline project for $100 million, thereby raising Shell's interests from 60% to about 70%.

Syncrude Canada Ltd. entered an agreement with Amoco Canada Petroleum Company Ltd. for custom processing off-lease bitumen, allowing the processing facilities to further utilize their surplus upgrading capacity by 10%; the three-year agreement is linked to the development of Amoco's $28 million oil sands project at Soars Lake, near Cold Lake in northern Alberta.

Several other activities were carried out in Alberta that were related to the sulphur industry. Expansions were announced by Amerada-Hess Canada Ltd. at Ricinus, Chauvco Oil and Gas Limited at Swalweel, Coho Resources Limited at McGregor Lake, Encor Energy Corporation Inc. at Teepee Creek, NW Resources Ltd. at Rainbow, Norcen Energy Resources

Limited at Carbondale, and Saratoga Processing Co. Ltd. at Coleman-Savannah Creek. Many gas-related acquisitions took place during 1991: Co-operative Energy Development Corporation (Co-Enerco) completed the property purchase of the Zama gas plant from Amoco Canada Petroleum Company Ltd., Amoco Canada Resources, Encor Inc., and Maligne Resources Limited; Petro-Canada and PetroCorp Inc. of Houston purchased Gulf Canada Resources' 36% operating interest in the Hanlan-Robb plant; and Suncor Inc. purchased Shell's 50% interest in the Rosevear gas field and processing plant. This latter sale should increase Suncor's sulphur nomination by close to 2400 t/m. Cansulex Limited signed three new members: Washington Energy Exploration Inc., Poco Petroleums Ltd. and Conwest Exploration Company Limited. These added up to 11 000 t/y of sulphur to Cansulex's total sales volumes. CanWorld Shipping Company Ltd., a wholly owned subsidiary of Cansulex Ltd., acquired Maple Shipping, a former division of Canadian Pacific Corporation.

British Columbia

Since 1990, several gas discoveries were made in northeastern British Columbia. Gas finds at Klua, Murray River, West Sukunka, West Bullmoose and Sukunka will likely result in incremental sulphur recovery, and gas-processing facilities will be expanded at Taylor and Pine River.

Westcoast Energy Inc. completed its $100 million expansion of its McMahon plant at Taylor, British Columbia; close to 180 000 t/y of sulphur recovery capacity has been added.

Procor Sulphur Services Inc. and Sulphur Pacific Services Ltd. announced their intention to construct a new sulphur-forming facility at Dawson Creek in northeastern British Columbia. The 60 000 t/y project will be commissioned late in 1992.

Sulphuric Acid

On a nine-month basis, sales of sulphuric acid in Canada were 11% lower compared to the same period last year, while a slight improvement was registered in exports to the United States. In 1991, the demand for sulphuric acid in Canada declined from the previous year's level due to depressed economic conditions that affected the pulp and paper sector. Acid consumption in industrial chemicals was reported steady, while strong sales were made to the oil-refining business. Consumption continued to decline in the aluminum and uranium sectors for the second consecutive year.

The production of sulphur products from smelters was estimated at 872 500 t, a 3% decrease from 1990. Sulphuric acid production fell 3.4%, while significant increases at Cominco and Horne were more than offset by the much-reduced output from Inco whose smelter in Copper Cliff operated at lower rates in 1991 in response to a weakness in international nickel prices. Production at Brunswick Mining and Smelting Corporation Limited in Belledune, New Brunswick, was steady; its operation ran for a similar six-month period in 1991. Also in 1991, the production of liquid sulphur dioxide from smelters rose 2%, mostly due to higher recovery achieved at Cominco; Canadian sales remained soft with stable prices throughout the year.

In 1990, the consumption of sulphuric acid in Canada was estimated at close to 2.5 Mt, of which 48% was acid produced from smelters; the remaining 52% was supplied by sulphur-burning operations. Sulphuric acid consumption in eastern Canada amounted to 1.11 Mt, accounting for 44% of total Canadian consumption. Agricultural chemicals accounted for 48% of sulphuric acid consumption, followed mainly by inorganic chemicals (18%), pulp and paper (9.2%), and uranium mining (8%).

Brunswick Mining and Smelting Corporation Limited resumed operations in mid-August after a 10-month strike at its Belledune smelter. Production at the nearby phosphatic fertilizer plant restarted in late September.

In May, Cominco Ltd. of Vancouver, British Columbia, completed the modernization of its $5.8 million phosphate granulation unit and the construction of a new $2.8 million phosphoric acid evaporator, both in Trail, British Columbia. The company commenced construction of two new ammonium sulphate crystallizers, at a cost of $8.4 million, for completion in March 1992. Cominco continued to evaluate different alternatives at its problem-plagued QSL lead smelter in Trail. The new $110 million plant, which was started in December 1989, was shut down in March 1990 due to inadequate performance and low recovery. On-site tests were performed during the summer, and further tests are being carried out with final results expected by mid-1992. Alternative smelting technologies are being appraised. The old smelter was reactivated in April 1990.

Falconbridge Limited announced production cutbacks for the summer of 1992 because of low nickel prices and weak world demand. Throughout 1991, the company continued to implement measures to reduce its SO_2 emissions at its smelter at Timmins, Ontario. Reductions were achieved in 1991 through lower metal production. Falconbridge has to comply with a cap of 100 000 t/y of sulphur dioxide emissions by 1994; however, the company has established its own maximum emissions cap at 75 000 t/y of SO_2 to be met by 1998. Falconbridge Limited and Marsulex Inc. announced plans for a new liquid sulphur dioxide unit at the Kidd Creek operation in Ontario. The plant is to use a portion of the SO_2 stream from the existing smelter in Timmins. The 30 000 t/y facility is slated for completion by mid-1992; its output is to be sold mainly to the pulp and paper and mining industries in eastern Canada and the northeastern United States.

Hudson Bay Mining and Smelting Co., Limited has started construction of a new zinc pressure leach plant and a copper smelter in Flin Flon, Manitoba. The $187 million project will involve the replacement of existing zinc concentrate roasting and calcine leaching operations with zinc pressure leaching technology, while the existing copper smelter concentrate roasting and calcine smelting processes will be replaced with Noranda continuous reactor technology. The upgrade project will allow the company to meet its sulphur dioxide emissions reduction target of 25% to 220 000 t/y by 1994. The plant is scheduled to be completed by the end of 1993; close to 35 000 t/y of sulphur will be recovered.

ICI Canada Inc. shut down its 70 000 t/y acid plant in Béloeil, Quebec, in September 1991. The operation will source its requirements for industrial-grade acid from merchant suppliers.

Inco Limited commissioned its first of two oxygen flash furnaces in October at its Copper Cliff smelter operations in Ontario. A new 2600 t/d acid plant was also put on stream and resulted in a 15% reduction in sulphur dioxide emissions by year-end. Inco also completed major technology changes at the Clarabelle mill that will permit improved rejection of high-sulphur pyrrhotite ore before smelting. Total capital cost of the modernization project rose to $600 million from the initial $500 million; the project is already 85% completed. The company's targeted SO_2 emissions for 1994 have been set at 265 000 t/y.

Last summer, Sherrit Gordon Limited shut down its phosphate fertilizers plant at Fort Saskatchewan, Alberta, for an indefinite period. The plant had a capacity of 60 000 t/y P_2O_5 and was consuming about 160 000 t/y of sulphuric acid. The operation is to continue to produce acid for both its own use and merchant sale.

Tioxide North America Inc. is to build a new $150 million chloride-route titanium dioxide plant at Bécancour, Quebec, by 1994, and will then close its sulphate-route plant at Tracy, Quebec, for environmental and economic reasons. The sulphate-processing plant was an important sulphuric acid consumer in Quebec, using close to 90 000 t/y of acid.

ENVIRONMENTAL ISSUES

Acid rain emissions are being reduced in Canada in a combined effort by governments and industry. Provincial utilities, such as Newfoundland and Labrador Hydro, are considering switching to low-sulphur fuel as a measure to reduce their sulphur dioxide (SO_2) emissions. All provincial coal-fired power generation projects now undergo government scrutiny with regard to federal-provincial acid rain reduction commitments.

In February, Canada, together with the United States and 23 European governments, signed the Convention on Transboundary Environmental Impact Assessment, which binds signatories to prevent, reduce and control transboundary pollution.

In March, Canada and the United States signed the bilateral Canada-U.S. Air Quality Accord that will allow both countries to monitor and control transboundary pollution. The United States is expected to reduce its SO_2 emissions by 50% by the year 2000, while Canada is committed to pursue its own acid rain abatement program. Under the latter, the seven provinces east of Saskatchewan would cut SO_2 emissions to 50% of the 1980 level by 1994. The accord also set up a dispute settlement mechanism to address any bilateral air quality problem that may arise between the two countries. A joint committee, formed of representatives from both governments, has been established to monitor the environmental impacts of polluting emissions.

In September, Environment Canada announced the establishment of a $30 million fund in the Green Plan's acid rain control program. The fund will be used to implement the federal-provincial agreements to cap SO_2 emissions in Canada.

Canada's Green Plan, released in 1990, aims to further reduce SO_2 emissions beyond 1994 by setting an emission cap in eastern Canada. Provision is made for an extended cap of no more than 3.2 Mt of sulphur dioxide on a national basis by the year 2000.

In the United States, the Environmental Protection Agency tabled its proposals for auctioning rights to emit SO_2, as suggested in the 1990 amendments to the *Clean Air Act*. This approach will allow performing utilities to market their surplus pollution credit allowances. The program will take effect in two phases involving 110 bigger plants by 1995 and close to 2000 smaller facilities by the year 2000. The trading system is expected to permit new utilities to operate while keeping the reduction program in line with targeted limits.

WORLD DEVELOPMENTS

Elemental Sulphur

In 1991, the world market was generally in balance with sufficient available tonnages to meet the world's sulphur requirements. The removal of sulphur tonnage formerly produced in Kuwait and Iraq was largely offset by incremental production from Saudi Arabia and Canada. The prospect of a potential shortage or tightness in international markets did not materialize despite early signals from spot quotations late in 1990. In 1991, world demand for sulphur in fertilizer dropped marginally as consumption of phosphate fertilizers declined in Western Europe, Eastern Europe, North America, Oceania and the former U.S.S.R. Sales were reported stable in Latin America, especially in Brazil, which imported similar sulphur tonnages compared to last year. A higher consumption of sulphur was reported in Africa and Southeast Asia.

The Gulf war and the drastic changes in Eastern Europe led to some adjustments in trading patterns. More tonnages moved from Saudi Arabia within the Middle East. The economic and political changes that occurred in Eastern Europe and the Soviet Union during 1991 resulted in much-reduced sulphur imports and in shifts in export destinations of established suppliers. Lower sulphur shipments were exported to the former U.S.S.R. from Canada and Poland; subsequently, both countries moved available tonnages to other markets such as India and Morocco for Canada, and Brazil and North Africa for Poland. As a general pattern during 1991, the major exporters sought business in a reduced marketplace, leading to the implementation of market-share policies which has resulted in price erosions.

In 1991, world sulphur production was estimated at 37.2 Mt, a 5.5% decrease over the previous year. Sulphur output rose in Iran (38%), France (10%), Japan (6%), Saudi Arabia (7%), Canada (5.5%) and the former U.S.S.R (2%), but declined in Poland (13%), Mexico (7%), the United States (8%), and Germany (1.5%). Output in Iraq dropped 80% while no production was reported in Kuwait.

At the beginning of 1991, producers' stockpiles were estimated at 8.4 Mt, with Canada holding a 42% share. During the year, stock withdrawals were made by Canada, the United States and Mexico, while additions occurred in Poland, Saudi Arabia, Iraq and France. Remelts in Canada accounted for 75% of total withdrawals during 1991.

United States

The United States remained the world's largest sulphur producer as well as a major Frasch-producing country, accounting for 28% of world production in 1991. Production of elemental sulphur decreased 9% to 9.5 Mt; sulphur recovered from oil- and gas-processing plants accounted for 70% and amounted to 6.6 Mt, a similar level compared to the previous year. The decline in total sulphur production was due to much-reduced output from Frasch mines as a consequence of the closure of two operations in 1991; Frasch output was estimated at 2.9 Mt, down from 3.73 Mt in 1990. Production of other forms of sulphur (e.g., acid) decreased marginally to 1.2 Mt and accounted for approximately 11% of overall production of sulphur-in-all-forms. In 1991, sulphur was produced at 171 plants operating in 32 states. Apparent U.S. consumption declined 5% to 12.4 Mt for use mostly in fertilizers (66%), chemicals (14%) and petroleum refining (5%). Higher consumption of sulphur was reported in central Florida for the production of phosphate-based fertilizers, for which close to 5.0 Mt are consumed annually. Exports rose 328 000 t to 1.26 Mt, with new sales registered to the former U.S.S.R. and Romania. Other exports were stable, especially to Brazil, Senegal and Western Europe. Imports recorded a significant 21% increase to 3.0 Mt, with higher volumes from Canada. As a result of reduced output, increased imports and higher exports, producers' stocks of elemental sulphur declined slightly, down to about 1.2 Mt at year-end.

Freeport-McMoRan Resource Partners, Ltd. continued its construction work at the Main Pass Block 299 project, 30 km offshore the mouth of the Mississippi River in the Gulf of Mexico. Discovered in 1988, Main Pass Block 299 contains massive sulphur reserves estimated at 68 Mt. The project will comprise two sulphur production platforms with a total design capacity of 2.5-3.0 Mt/y. Oil and gas production started in July 1991; heating of the sulphur dome was scheduled to start in April 1992 for production by mid-year. Sulphur production from Main Pass is expected to reach 2.0 Mt/y by 1994. As anticipated, Freeport Sulphur Co. shut down two Frasch mines in offshore Louisiana (Garden Island Bay and Grand Isle) due to depletion of economic reserves. In 1991, Freeport continued to run its third mine, Caminada, which produced 0.95 Mt in 1991. Pennzoil Sulphur Co. produced close to 1.6 Mt at the Culberson Frasch mine in West Texas, while Texasgulf Inc. produced about 0.15 Mt at its Boling Dome mine in New Gulf, Texas.

Commonwealth of Independent States

In 1991, the former U.S.S.R. was the world's third largest producer of brimstone, with a 16% share in world production. Its elemental sulphur production was stable, estimated at 5.89 Mt. Gas-recovered sulphur was the major source of sulphur production accounting for 48%. Late in 1991, 11 of the former republics of the U.S.S.R. created the new Commonwealth of Independent States (C.I.S.), consisting of Russia, Ukraine, Byelorussia and non-Baltic states. Frasch and mined sulphur production are centred in Ukraine at Rozdol (1.8 Mt/y) and in Turkmenistan at Gaurdak (0.5 Mt/y). Recovered sulphur is produced in Russia at Astrakhan (1.5 Mt/y) and at Orenburg (1.1 Mt/y), in Uzbekistan at Mubarek (0.5 Mt/y), and in Kazakhstan at Tengiz (up to 1.2 Mt/y by 1995). Sulphur-producing states of the C.I.S. are evaluating the benefits of conducting their own distribution and sales. Control of the fertilizer industries is now under state jurisdiction. Most sulphur consumption in the former U.S.S.R. is for phosphate fertilizer manufacture, which is located mostly in Russia and the Ukraine. In 1991, the Astrakhan gas project continued to face some technical and environmental problems. Astrakhan I was reported to run at 40% of capacity with an output in the vicinity of 1.0 Mt for 1991. The start-up of Astrakhan II is not expected before 1994. In the spring of 1991, the first 450 000 t/y plant at the Tengiz oil and gas project started, with production in 1991 estimated at 0.2 Mt. The commissioning of Tengiz II and III is projected for 1992/93. Frasch sulphur operations continued to face environmental and economic pressures. Frasch production is expected to decline gradually from 2.6 Mt/y in 1990 to 2.0 Mt/y by 1995. Recovered sulphur output is expected to grow as a consequence of successful developments at Astrakhan and Tengiz from 3.2 Mt/y in 1990 to 7.7 Mt/y in 1995. Overall elemental sulphur production is forecast at 9.5 Mt/y by 1995, a 66% increase over 1990. With domestic sulphur consumption estimated at 8.1 Mt in 1995, higher production will likely result in a potential surplus of 1.5 Mt of sulphur available for export. In 1991, Freeport-McMoRan Resource Partners, Ltd. signed an agreement with some republics' agencies for the creation of a new forming and offshore marketing organization, with handling facilities to be constructed at Yuzhnyy on the Black Sea. The agreement primarily covers recovered sulphur produced at Astrakhan, Orenburg and Mubarek. Occidental Petroleum Corporation of the United States, which would have been involved in sulphur recovery, cancelled its participation in the Tengiz project.

Poland

Poland was the fourth largest world producer of elemental sulphur accounting for 11% of world production, and remained the second largest exporter of elemental sulphur after Canada. Production in 1991 decreased 13% to 4.04 Mt. Poland extracted Frasch sulphur at three mines and one industrial pilot project at Baznia (30 000 t). The major mines are located at Jeziorko, Machow and Grzybow. The Jeziorko operation faced environmental pressures and difficulties in tapping its reserves, which together may result in reduced output in the next few years. The Machow mine is expected to shut down before 1994; late in 1991, the operation was placed on stand-by. Economic reserves at Grzybow continued to decline and could be depleted by 1994; however, a voluntary reduction in sulphur extraction to below 0.5 Mt/y may extend the life of this mine beyond 1994. A new replacement Frasch mine at Osiek is expected to be commissioned in 1995 with production in the 0.5 Mt/y range; reserves at Osiek are reported sufficient to warrant an annual output at the 1.0 Mt level. Sulphur production is forecast to decline to 4.0 Mt/y by 1995 from 5.0 Mt/y in 1990. Other more pessimistic projections have anticipated production to be cut down to 2.5-3.0 Mt/y. In 1991, Poland's sulphur exports were estimated at 2.9 Mt, down from 3.8 Mt in 1990. Major declines in sales occurred in its traditional markets (the former U.S.S.R., Eastern Europe and India) due to a reduced level of consumption and a switch to hard currencies. As a result, Poland exported more tonnages to Brazil and Tunisia. Early in 1991, Poland signed a five-year contract with Morocco for exports of 700 000 t/y of sulphur. Stocks at year-end rose 0.5-0.7 Mt to above 1.0 Mt.

Mexico

Mexico was the world's fifth largest producer of brimstone, accounting for 5% of world production. Mexico produced 1.6 Mt of sulphur in 1991, 400 000 t less than last year. Frasch production declined 13% to 1.26 Mt and accounted for two thirds of total Mexican sulphur output. Sulphur production from oil refining rose to 615 000 t. Technical problems continued to be experienced at Jaltipan, which may affect the anticipated commissioning of the nearby new Porterillos Frasch mine in 1992. Azufrera Panamericana (APSA), the state-owned sulphur company, reiterated that operation at its co-integrated Coachapa and Otapan Frasch mines will continue despite reports that both mines may shut down in the short term due to economic and technical constraints. Production at the Texistepec Frasch mine was reported stable. A new 220 000 t/y Frasch mine is expected to start in 1993 at Sehuacala-Minati near Coachapa. Sulphur recovered from petroleum and gas refining is projected to increase marginally due to the completion of several projects by Petroleos Mexicanos in Salina Cruz and Tula; two other 40 t/d sulphur recovery units are under construction near Salina Cruz. Exports in 1991 declined 6% to 1.3 Mt; the United States was the major importing country accounting for 90% of total Mexican sulphur exports. Stocks declined by 50 000 t to 90 000 t by year-end.

Saudi Arabia

Saudi Arabia was the sixth largest sulphur producer in the world with a 5% share. In 1991, Saudi sulphur production rose 30 000 t to 1.8 Mt. Close to 75% came from natural gas processing at Uthmaniyah, Shedgum and Berri, while the remainder was recovered from oil refineries at Jubayl, Yanbu and Rabigh. The Saudi sulphur plants ran at 90% of capacity, estimated at 1.66 Mt/y. Higher levels of gas production during the Gulf war resulted in increased sulphur recovery that ranged between 125 000 t/m and 180 000 t/m during 1991. No damage was reported to sulphur-related refineries due to the Gulf war. Saudi Arabia exported virtually all of its production, with major shipments to Egypt, Morocco and India. Exports were maintained at a high level during the first quarter of 1991, while lower sales in the second and third quarters resulted in pouring sulphur into inventories. In 1991, exports totalled 1.6 Mt, with increased sales to India, Egypt and Turkey. By year-end, stockpiles at Berri had increased 200 000 t to reach an estimated 2.1 Mt. In August, Saudi Arabia Marketing & Refining Co. announced its intention to carry out a massive multi-year $4 billion refining upgrade program which would affect all of its oil refineries; the impact on sulphur recovery is still uncertain.

Iraq

Iraq ranked as the seventh largest world producer of brimstone in 1989. During 1991, sulphur production was estimated at 130 000 t, compared to 1.25 Mt in 1990. Sulphur was extracted at the Mishraq Frasch mine and recovered at two natural gas plants at B'aiji and Kirkuk. The Kirkuk gas refinery suffered minor damages, with output close to 25 000 t in 1991 compared to 250 000 t in 1990. No damage was reported at Mishraq located in northern Iraq near Mossul; however, gas supplies were restrained. The planned 1.0 Mt/y expansion at Mishraq is near completion and could be activated within the next two years. In 1991, output from Mishraq totalled 105 000 t, accounting for 80% of total sulphur production. Some exports were made to Jordan during the year.

Japan

Japan was the world's eighth largest sulphur producer with a 4% share. In 1991, its sulphur production amounted to 1.24 Mt. Sulphur was recovered from oil refining, which has been increasing steadily since the mid-1980s. Japan exported 360 000 t, mostly to South Korea, which accounted for 80% of Japan's total exports. Sulphur recovery is expected to grow to 1.5 Mt/y within the next two years as new diesel desulphurization units are brought on stream. The incremental sulphur output is slated for the export markets.

France

France ranked amongst the top ten world producers with a 2.6% share of world production. Sulphur was recovered from the Lacq gas field and from oil refining. Sulphur production continued to rise for the second consecutive year to reach 950 000 t in 1991, compared to 867 000 t in 1990. Sulphur recovered from oil refining rose 5% to 250 000 t, accounting for 26% of total sulphur production. Sulphur recovery at the Société Nationale Elf Aquitaine's (SNEA) Lacq operations is expected to remain at the 700 000 t/y level for the next five years, a slight increase from the 0.65 Mt/y registered in 1989, but short of the previous 1.8 Mt/y level in the 1970s and 1980s. Sulphur stocks were estimated at 1.87 Mt, a 5% increase from 1990. In 1991, SNEA awarded contracts to Procor Sulphur Services for the construction of a new 600 t/d sulphur recovery unit for Lacq and a new 1000 t/d granulating unit due for completion in 1992. Exports in 1991 declined 13% to 433 000 t with major shipments within Western Europe and to Tunisia. With higher consumption than production, France is a net importer of sulphur; imports in 1991 were mostly from Poland (50%), Canada (20%) and Germany (20%).

Other Middle East Countries

Sulphur production in Iran rose 28% to 755 000 t in 1991. Exports were stable at 375 000 t with major deliveries to Tunisia and India. Sulphur was recovered from sour gas plants accounting for 93% of total output, with the remainder coming from oil refining. In July, a new sulphur-processing unit was brought on stream at the Hasheminejad gas refinery, doubling Iran's sulphur recovery capacity. In Abu Dhabi, the Abu Dhabi National Oil Corporation continued its upgrading work at the oil and gas project on Das Island. Rehabilitation contracts were awarded for revamping two sulphur recovery units with capacity being expanded from 460 t/d to 550 t/d; incremental production in the 250 000 t/y range is expected in 1992/93. Sulphur output from these units will be shipped to forming facilities at Ruwais where a new 750 t/d granulating unit with the Procor GX technology will be installed. In Kuwait, no sulphur production was recorded in 1991. The Mina al-Ahmadi refinery restarted in July while the Mina Abdullah refinery is expected to be reactivated in 1992. The Shuaiba refinery was severely damaged and will remain shut.

PRICES

The whole year has been a major disappointment for sulphur suppliers; international prices dropped steadily, declining by 45% over the 12-month period. Entering 1991, the anticipation of some constraints in supply at the onset of the Gulf war resulted in upward pressures on international prices. Quotations for Canadian sulphur, f.o.b. Vancouver, rose from US$90-$93/t to US$102-$105/t. Contract negotiations with Canadian suppliers lagged during all of the first quarter, leading to some pricing accommodations during the second quarter. In June, prices were down to US$83-$86/t. During the summer, two major reductions of the Tampa liquid sulphur prices affected the Vancouver prices, in combination with a global weakness in world sulphur demand. By August, Canadian prices, f.o.b. Vancouver, declined a further US$18/t to the US$66-$72/t range. Sales in the second quarter picked up in accordance with the availability of sulphur at unexpectedly low prices. Most contracts for the second half were settled at this level. At year-end, the emergence of a new marketing consortium did not affect the marketplace as spot indications entering 1992 demonstrated another possible decrease in prices in the low US$60s, and even below the US$60/t mark.

The favourable netbacks achieved in the North American market led Canadian suppliers to increase their level of sulphur shipments into the lucrative Tampa market. At the beginning of 1991, price quotations for liquid sulphur (f.o.r. Alberta) paralleled international trends and tended to increase from US$62-$64/t to US$68-$100/t. During the first half, prices remained in the US$62-$65/t range. In July and August, U.S. Frasch suppliers initiated two consecutive decreases in the Tampa prices in the magnitude of US$15/long ton in order to remain competitive against Canadian volumes. Consequently, Canadian prices, f.o.r. Alberta, dropped down to US$30-$35/t in September. In early November, another US$12/long ton cut in the Tampa prices resulted in a further reduction in the Alberta prices, which finished the year at US$20-$25/t.

USES

About 60% of all sulphur consumed in the world is used in the production of fertilizers such as superphosphate, ammonium phosphate, and ammonium sulphate. The second largest consuming sector is the chemical industry where sulphur is used in products ranging from pharmaceuticals to synthetic fibres in plastics and petroleum catalysts. Other consumers of sulphur include the manufacturers of titanium dioxide used in paint, enamels, paper and ink, iron and steel, and nonferrous metals. These consuming industries use sulphur in the form of sulphuric acid, which accounts for almost 90% of total sulphur consumption (60% of sulphuric acid consumption is in fertilizers). Products requiring sulphur in non-acid form include insecticides and fungicides, pulp and paper, photography, leather processing, rayon and rubber.

OUTLOOK

Following the destabilized pricing conditions that prevailed throughout 1991, the world sulphur market is set for another eventful year. The emergence of the new Canadian export consortium is expected to provide the much needed export marketing stability sought by Canadian suppliers. Moreover, the commissioning of the new Main Pass Frasch mine in offshore Louisiana should compensate for the indefinite closure of a few mines in Poland, Mexico and the United States.

The demand for sulphur in phosphate fertilizers will be affected by the uncertainties in the social and economic conditions that continue to occur in the former Soviet Republics and Eastern Europe. Entering 1992, several major fertilizer producers have refurnished their stocks of sulphur, giving signals for tough negotiations in the first half of 1992.

In 1992, Canadian sulphur production is projected to decrease to below 5.9 Mt, mostly as a result of technical problems that have plagued the Obed field since late 1991. No major expansions in sulphur output are foreseen in 1992, except the commissioning of Husky's heavy oil upgrader with a 90 000 t/y capacity. In British Columbia, gas-related developments, triggered by major gas discoveries over the last two years, could be postponed due to continuing weak prices for natural gas; sulphur recovery in that province is forecast to remain static in 1992. Sulphur production from smelters will likely decline marginally as reduced operating rates in 1992 have been called for by nickel producers in Ontario.

In the short-to-medium term, world sulphur demand is forecast to increase from 1990 at a growth rate of 1.0%-1.2%/y to reach 61.8 Mt by 1995. Sulphur consumption in non-fertilizer applications is projected to reach 25.5 Mt in 1995, a 0.4 Mt increase over 1990. Sulphur consumption in fertilizers is forecast to grow at a rate of 1.0%-2.0%/y. Growth rates above 3.0% are predicted in developing countries. Demand in Western and Eastern Europe is expected to decline, and to remain flat in the mature North American market.

On the supply side, sulphur productive capability is expected to increase between 1990 and 1995 by a net 5.0 Mt/y. New world-scale projects will more than offset the anticipated closures of several sulphur-producing operations in a few countries.

New developments in the production of sulphur from tar sands and oil refining are projected to add close to 1.8 Mt/y to world capacity by 1995. Major increases are to occur in Kuwait through the rehabilitation of its oil refining industry damaged during the Persian Gulf war.

During the 1990-95 period, close to 4.0 Mt/y of Frasch sulphur capability will have been removed from the marketplace due to technical and economic difficulties. Important decreases are to occur in Mexico and Poland. Despite the commissioning of new mines in the United States, Poland and Iraq, the expected mine shutdowns will likely result in a net loss of about 0.8 Mt/y of sulphur capability from Frasch mining.

More importantly, new sour gas developments around the world will play a dominant role in the expansion of sulphur production between 1990 and 1995. Major new projects include developments in the former U.S.S.R. (Tengiz II and III, and Astrakhan II) and in Canada (the Caroline project). These projects would result in the addition of about 4.0 Mt/y to total sulphur capability.

In 1995, world sulphur production is forecast at 66.2 Mt, of which 45.3 Mt is elemental sulphur. The supply-demand balance for sulphur will likely remain in a deficit situation up to 1993, leading into a potential surplus at the 1.3-1.5 Mt/y level by 1995. This potential would, however, represent only 3.0% of total world supply. The increasing surplus anticipated by 1993 would likely hinder any significant increase in prices. Sustained low prices will have a negative economic impact on high-cost Frasch sulphur producers in Poland and Mexico.

Note: Information in this review was current as of January 31, 1992.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2503.00	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur				
2503.10.00	Crude or unrefined sulphur	Free	Free	Free	Free
2503.90.00	Other	Free	Free	Free	Free
2802.00.00	Sulphur, sublimed or precipitated; colloidal sulphur	Free	Free	Free	Free
2807.00.00	Sulphuric acid; oleum	Free	Free	Free	Free
2811.23.00	Sulphur dioxide	Free	Free	Free	1.6%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991.

TABLE 1. CANADA, SULPHUR SHIPMENTS AND TRADE, 1990 AND 1991

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
SHIPMENTS[1]					
	Sulphur in smelter gases[2]	789 815	81 229	726 352	76 592
	Elemental sulphur[3]	6 873 495	436 174	6 904 489	276 799
	Total sulphur content	7 663 310	517 403	7 630 841	353 391
IMPORTS				(Jan.-Sept.)	
2503.10	Sulphur, crude or refined				
	United States	2 341	536	1 298	184
	Other countries	29	7	60	16
	Total	2 370	544	1 358	200
2503.90	Sulphur, n.e.s.				
	United States	10 846	2 475	4 711	1 225
	Total	10 846	2 475	4 711	1 225
2802.00	Sulphur sublimed or precipitated; colloidal sulphur				
	United States	1 592	511	1 043	315
	Other countries	39	29	10	8
	Total	1 631	540	1 053	323
2807.00	Sulphuric acid; oleum				
	United States	71 289	5 451	58 524	4 838
	Other countries	30	4	113	15
	Total	71 319	5 455	58 637	4 853
2811.23	Sulphur dioxide				
	United States	840	274	119	59
	Total	840	274	119	59
EXPORTS					
2503.10	Sulphur, crude or unrefined[4]				
	United States	1 411 855	138 333	1 228 934	128 975
	Morocco	820 616	87 795	569 322	62 010
	Brazil	316 084	34 180	264 252	31 037
	Tunisia	301 836	33 219	251 247	29 788
	Indonesia	303 672	31 530	216 542	23 639
	Mexico	256 834	28 830	129 574	15 303
	South Korea	186 612	19 240	144 768	14 059
	Israel	253 578	27 298	112 149	13 029
	Taiwan	170 858	17 797	85 430	9 497
	South Africa	225 200	22 260	91 585	9 443
	France	155 076	17 182	83 893	9 113
	Australia	272 895	29 232	25 991	2 918
	Other countries	1 369 807	143 537	826 391	97 079
	Total	6 044 923	630 433	4 030 078	445 890
2503.90	Sulphur, n.e.s.				
	United States	11 100	1 414	12 623	1 194
	Other countries	1 500	135	–	–
	Total	12 600	1 549	12 623	1 194
2802.00	Sulphur, sublimed or precipitated; colloidal sulphur				
	United States	291	101	282	36
	Total	291	101	282	36
2807.00	Sulphuric acid; oleum				
	United States	1 280 446	46 399	951 049	36 477
	Other countries	56	32	37	9
	Total	1 280 502	46 431	951 086	36 486
2811.23	Sulphur dioxide				
	United States	61 867	11 241	57 083	8 339
	Total	61 867	11 241	57 083	8 339

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; n.e.s. Not elsewhere specified; p Preliminary.
[1] Data compiled regardless of origin (i.e., domestic and foreign source materials). [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 synthetic crude oil. [4] Countries are ranked in descending order of value based on nine-month 1991 data.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, SOUR GAS AND OIL SANDS SULPHUR EXTRACTION PLANTS, 1989-91

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Sulphur Capacity[1] 1989	1990	1991
	(Alberta, except where noted)	(percent)		(tonnes)	
SOUR GAS					
Alberta Energy Company Ltd.	Sinclair-Hythe	3	256	256	256
Amerada Hess Corporation	Olds-Garrington	15	389	389	389
Amoco Canada Petroleum Company Ltd.	Bigstone Creek	16	385	385	385
Amoco Canada Petroleum Company Ltd.	Brazeau-Peco	0.8	110	110	110
Amoco Canada Petroleum Company Ltd.	Caroline-Garrington	n.r.	–	10.4	10.4
Amoco Canada Petroleum Company Ltd.	Caroline-Harmattan	0.8	8	8	8
Amoco Canada Petroleum Company Ltd.	East Crossfield-Elkton	34	1 797	1 797	1 797
Amoco Canada Petroleum Company Ltd.	Edson-Pine Creek	1.4	289	289	292
Amoco Canada Petroleum Company Ltd.	Kaybob South I/II-Fir	11	1 086	1 086	1 090
Amoco Canada Petroleum Company Ltd.	Lone Pine Creek	10	283	283	283
Amoco Canada Petroleum Company Ltd.	W. Pembina-Brazeau	n.r.	340	340	520
Amoco Canada Petroleum Company Ltd.	Zama	8	74	74	74
Canadian Occidental Petroleum Ltd.	East Calgary-Crossfield	17	1 696	1 696	1 696
Canadian Occidental Petroleum Ltd.	Mazeppa-Okotoks	36	577	577	577
Canadian Occidental Petroleum Ltd.	Paddle River	0.1	19	19	19
Chevron Canada Resources Limited	Kaybob South III	16	3 557	3 557	3 557
Chevron Canada Resources Limited	Medicine Lodge	–	–	–	45
Encor Energy Corp. Inc.	Teepee Creek	8	30	30	30
Esso Resources Canada Limited	Bonnie Glen	0.4	12.5	12.5	34.5
Esso Resources Canada Limited	Joffre	3.4	17	23.5	23.5
Esso Resources Canada Limited	Quirk Creek	9	299	299	301
Esso Resources Canada Limited	Redwater	2.6	11	11	11
Gulf Canada Limited	Brazeau River-Nordegg	1.3	42	42	46.5
Gulf Canada Limited	Homeglen-Rimbey	1	128	128	128
Gulf Canada Limited	Nevis	4	197	197	197
Gulf Canada Limited	Strachan	9	953	953	953
Home Oil Company Limited	Carstairs	0.5	65	65	65
Husky Oil Ltd.	Rainbow Lake	2	139	139	142
Husky Oil Ltd.	Ram River (Ricinus)	19	4 572	4 572	4 572
Husky Oil Ltd.	Windfall-Whitecourt	21	1 330	1 330	1 333
Mobil Oil Canada, Ltd.	Harmattan-Elkton-Leduc	46	490	490	66
Mobil Oil Canada, Ltd.	Lone Pine Creek	10	157	157	162
Mobil Oil Canada, Ltd.	Wimborne	13	182	182	182
Norcen Energy Resources Limited	Minnehik-Buck Lake	0.1	45	45	45
NW Resources Ltd.	Rainbow-Fire	n.r.	n.r.	n.r.	20
Pembina Corporation	Turner Valley	2.5	11	16	16
Petro-Canada Inc.	Brazeau-Peco	7	444	444	447.3
Petro-Canada Inc.	Gold Creek	3	43	43	43
Petro-Canada Inc.	Hanlan Robb	9	1 092	1 092	1 092
Petro-Canada Inc.	Wildcat Hills	4	177	280	280
Poco Petroleum Ltd.	Sturgeon Lake	9	98	98	98
Saratoga Processing Company Limited	Savannah Creek (Coleman)	24	389	389	389
Shell Canada Limited	Caroline-Bearberry	90	–	–	224
Shell Canada Limited	Burnt Timber Creek	13	489	489	489
Shell Canada Limited	Jumping Pound	6	597	597	597
Shell Canada Limited	Progress	0.7	15	15	16
Shell Canada Limited	Rosevear South	8	171	171	171
Shell Canada Limited	Simonette River	16	95	95	95
Shell Canada Limited	Waterton	19	3 107	3 107	3 107
Suncor Inc.	Rosevear	8	110	110	111
Westcoast Energy Inc.	Fort Nelson, B.C.	n.r.	1 100	1 100	1 100
Westcoast Energy Inc.	Taylor Flats, B.C.	3	460	460	460
Westcoast Energy Inc.	Pine River, B.C.	n.r.	1 055	1 055	1 055
OIL SANDS					
Suncor Inc.	Mildred Lake	n.a.	441	441	441
Syncrude Canada Ltd.	Fort McMurray	n.a.	1 255	1 255	1 255

Source: Energy Resources Conservation Board publication ERCB ST 91-50, October 1991.
– Nil; n.a. Not applicable; n.r. Not reported.
[1] Maximum design capacity.

TABLE 3. CANADA, PETROLEUM REFINERY SULPHUR CAPACITIES OPERATING IN 1989-91

Operating Company	Location	Daily Capacity 1989	1990	1991
			(tonnes)	
Canadian Ultramar Limited	St. Romuald, Quebec[1]	40	50	50
Chevron Canada Limited	Burnaby, British Columbia	10	10	10
Consumers' Co-operative Refineries Limited	Regina, Saskatchewan	220	220	220
Esso Petroleum Canada	Dartmouth, Nova Scotia	76	76	76
	Edmonton, Alberta	40	40	40
	Nanticoke, Ontario	35	35	35
	Port Moody, British Columbia	20	20	20
	Sarnia, Ontario	140	140	140
Irving Oil Limited	Saint John, New Brunswick	100	100	100
Petro-Canada Products Inc.	Lake Ontario-Mississauga, Ontario	44	44	44
	Edmonton, Alberta[2]	56	56	56
	Lake Ontario-Oakville, Ontario	40	40	40
	Port Moody, British Columbia[3]	0	25	25
Shell Canada Limited	Burnaby, British Columbia	15	15	15
	Sarnia, Ontario	35	35	35
	Scotford, Alberta	14	14	14
Sulconam Inc.	Montreal, Quebec	300	300	300
Suncor Inc.	Sarnia, Ontario	50	50	50
Total effective capacity[4]		1 235	1 270	1 270

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada; Company interviews, 1991.
[1] 30 t/d capacity on stand-by at St. Romuald, Quebec. [2] Petro-Canada Products Inc. has a 60 t/d back-up desulphurization unit at Edmonton; however, both units cannot run simultaneously. [3] Petro-Canada Products Inc.'s sulphur-processing unit in Port Moody, British Columbia, shut down in 1989. [4] Effective capacity comprises operating productive capacity.

TABLE 4. CANADA, PRINCIPAL SULPHUR DIOXIDE AND SULPHURIC ACID PRODUCTION CAPACITIES, 1991

Operating Company	Plant Location	Raw Material	Annual Capacity: Liquefied SO_2	Annual Capacity: Sulphuric Acid[1]	Annual Capacity: Sulphur Equivalent[2]
			(000 tonnes)		
EASTERN CANADA					
Brunswick Mining and Smelting Corporation Limited	Belledune, N.B.	SO_2 lead & zinc conc.		176	58
Canadian Electrolytic Zinc Limited (CEZ)	Valleyfield, Que.	SO_2 zinc conc.		430	140
Falconbridge Limited	Kidd Creek, Ont.	SO_2 zinc conc.		220	72
	Kidd Creek, Ont.	SO_2 copper conc.		470	153
	Sudbury, Ont.	SO_2 nickel conc.		355	116
Gaspé Copper Mines, Limited	Murdochville, Que.	SO_2 copper conc.		165	54
Inco Limited	Copper Cliff, Ont.	SO_2 pyrrhotite and nickel conc.		950	310
	Copper Cliff, Ont.	SO_2 copper conc.	100	n.a.	50
Noranda Minerals Inc.	Rouyn-Noranda, Que.	SO_2 copper conc.		425	139
Sulco Chemicals Ltd.	Elmira, Ont.	Elem. sulphur		33	11
Subtotal			100	3 224	1 103
WESTERN CANADA					
Border Chemical Company Limited	Transcona, Man.	Elem. sulphur		150	49
Cameco Corporation-Rabbit Lake Operation	Rabbit Lake, Sask.	Elem. sulphur		72	23
Cameco Corporation-Key Lake Operation	Key Lake, Sask.	Elem. sulphur		72	23
Cominco Ltd.	Trail, B.C.[3]	SO_2 lead & zinc conc.	80	430	210
Esso Chemical Canada	Redwater, Alta.	Elem. sulphur		910	297
Marsulex Inc.	Fort Saskatchewan, Alta.	Elem. sulphur		160	52
Sherritt Gordon Limited	Fort Saskatchewan, Alta.	Elem. sulphur		233	75
Westcoast Energy Inc.	Prince George, B.C.	Elem. sulphur	30	75	40
Subtotal			110	2 102	769
Total Canada			210	5 326	1 872

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada; Canadian company interviews 1991.
n.a. Not applicable.
[1] 100% H_2SO_4. [2] Elemental sulphur equivalent of sulphuric acid is 32.7% and sulphur equivalent of liquefied SO_2 is 50%. [3] Cominco operation at Trail also has a 30 000 t/y production capacity for elemental sulphur, which has been added to the total sulphur equivalent production capacity of Cominco.

TABLE 5. CANADA, SULPHUR SHIPMENTS AND TRADE, 1980-91

	Shipments[1]				Imports[2]	Exports[2]
	Pyrites	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Elemental Sulphur
	(tonnes)					
1980	14 328	894 732	7 655 723	8 564 783	1 767	6 850 143
1981	5 000	783 000	8 018 000	8 806 000	4 633	7 309 216
1982	9 000	627 000	6 945 000	7 581 000	2 159	6 111 444
1983	–	678 286	6 631 123	7 309 409	2 365	5 670 275
1984	–	844 276	8 352 978	9 197 254	3 019	7 326 847
1985	–	822 359	8 102 163	8 924 522	3 167	7 848 380
1986	–	758 231	6 965 775	7 724 006	10 763	6 257 054
1987	–	783 115	7 322 791	8 105 906	24 711	6 571 800
1988	–	856 496	8 106 641r	8 963 137r	21 825	7 384 160
1989	–	808 789	6 868 930	7 677 719	18 311	5 514 059
1990	–	789 815	6 873 495	7 663 310	12 477	6 057 523
1991p		726 352	7 084 486	7 810 838	10 294	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; p Preliminary; r Revised.
1 Shipment data compiled regardless of origin (i.e., domestic and foreign source materials). 2 Includes only elemental sulphur in a crude or refined form.

TABLE 6. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1980-90

	Production	Imports	Exports	Apparent Consumption
	(tonnes - 100% acid)			
1980	4 295 366	18 048	323 775	3 989 639
1981	4 116 860	82 495	337 518	3 861 837
1982	3 130 854	192 514	259 740	3 063 628
1983	3 686 427	126 573	273 204	3 539 796
1984	4 043 389	28 330	553 780	3 517 939
1985	3 890 092	17 306	744 732	3 162 666
1986	3 536 062	29 127	755 606	2 809 583
1987	3 436 977	44 623	803 178	2 673 422
1988	3 804 856	40 078	851 622	2 993 312
1989	3 718 578r	28 433	978 190r	2 768 821
1990	3 816 163	71 319	1 280 502	2 606 980

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

TABLE 7. WORLD PRODUCTION OF SULPHUR, 1987-90

	1987		1988		1989		1990p	
	All-Forms[1]	Elemental	All-Forms	Elemental	All-Forms	Elemental	All-Forms	Elemental
				(000 tonnes)				
WORLD TOTAL	**58 167**	**37 536**	**60 377**	**39 448**	**61 221**	**40 412**	**60 319**	**39 019**
WESTERN WORLD	**35 765**	**25 799**	**36 755**	**26 691**	**38 646**	**28 057**	**38 789**	**27 808**
WESTERN EUROPE	**7 682**	**3 441**	**7 853**	**3 461**	**8 192**	**3 595**	**7 812**	**3 544**
Finland	507	50	569	45	679	45	643	46
France	1 243	1 063	1 154	974	1 067	874	1 079	898
Germany	1 983	1 293	2 046	1 294	2 566	1 451	2 213	1 386
Italy	691	241	721	280	734	285	780	297
Norway	242	12	201	8	232	15	283	13
Spain	1 223	25	1 375	51	1 219	65	1 065	75
Others	1 793	701	1 787	809	1 695	860	1 749	829
AFRICA	**1 075**	**185**	**1 027**	**195**	**1 048**	**225**	**1 043**	**190**
South Africa	855	175	803	185	815	215	774	180
Others	220	10	224	10	233	10	269	10
ASIA, MIDDLE EAST	**6 332**	**4 248**	**6 872**	**4 848**	**7 601**	**5 534**	**7 445**	**5 307**
Japan	2 476	1 020	2 530	1 090	2 656	1 176	2 842	1 268
Saudi Arabia	1 450	1 450	1 450	1 400	1 500	1 500	1 610	1 610
Others	3 406	2 768	2 892	2 358	3 445	2 858	2 993	2 429
OCEANIA	**254**	**44**	**280**	**60**	**285**	**65**	**264**	**70**
NORTH AMERICA	**17 267**	**15 238**	**17 665**	**15 635**	**18 400**	**16 256**	**19 273**	**16 213**
Canada	6 729	5 876	6 919	6 017	6 809	5 859	6 891	5 951
United States	10 538	9 362	10 746	9 618	11 591	10 397	12 382	10 262
LATIN AMERICA	**3 156**	**2 643**	**3 057**	**2 492**	**3 120**	**2 382**	**2 952**	**2 484**
Mexico	2 391	2 306	2 244	2 144	2 192	2 012	2 142	2 142
Others	765	337	813	348	928	370	810	342
EASTERN EUROPE	**6 766**	**5 165**	**6 914**	**5 239**	**6 355**	**4 985**	**5 642**	**4 522**
Poland	5 098	4 930	5 169	5 004	5 030	4 865	4 636	4 426
Others	1 668	235	1 745	233	1 325	120	1 006	96
U.S.S.R.	10 857	6 242	11 513	7 178	10 855	6 640	10 260	6 360
China	4 575	330	4 990	340	5 160	330	5 423	329
Other countries[2]	200	–	205	–	205	–	235	–

Source: The British Sulphur Corporation Limited, 1991.
– Nil; p Preliminary.
[1] All-forms includes elemental sulphur, sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases, mostly in the form of sulphuric acid. [2] Includes North Korea, Vietnam and Cuba.

TABLE 8. CANADA, SULPHURIC ACID, REPORTED CONSUMPTION BY END USE, 1988-90

	1988	1989[r]	1990[p]
		(tonnes)	
Agricultural chemicals and fertilizers	1 415 404	1 330 022	1 180 773
Industrial inorganic chemicals	528 750	520 108	496 600
Pulp and paper	247 506	286 085	279 873
Uranium mines	331 580	300 095	218 362
Nonferrous smelting and refining	141 918	122 648	100 654
Crude petroleum and natural gas	40 881	50 100	37 293
Leather and textile	21 480	27 951	27 390
Other mines, metal and nonmetal	38 353	32 784	19 355
Soap and cleaning compounds	17 901	17 242	19 260
Iron and steel mills	14 227	8 960	7 315
Electrical products	10 249	9 748	6 830
Food, brewery and distillery	6 251	654	821
Plastics and synthetic resins	9 322	7 358	600
Other end uses	167 449	129 585	132 513

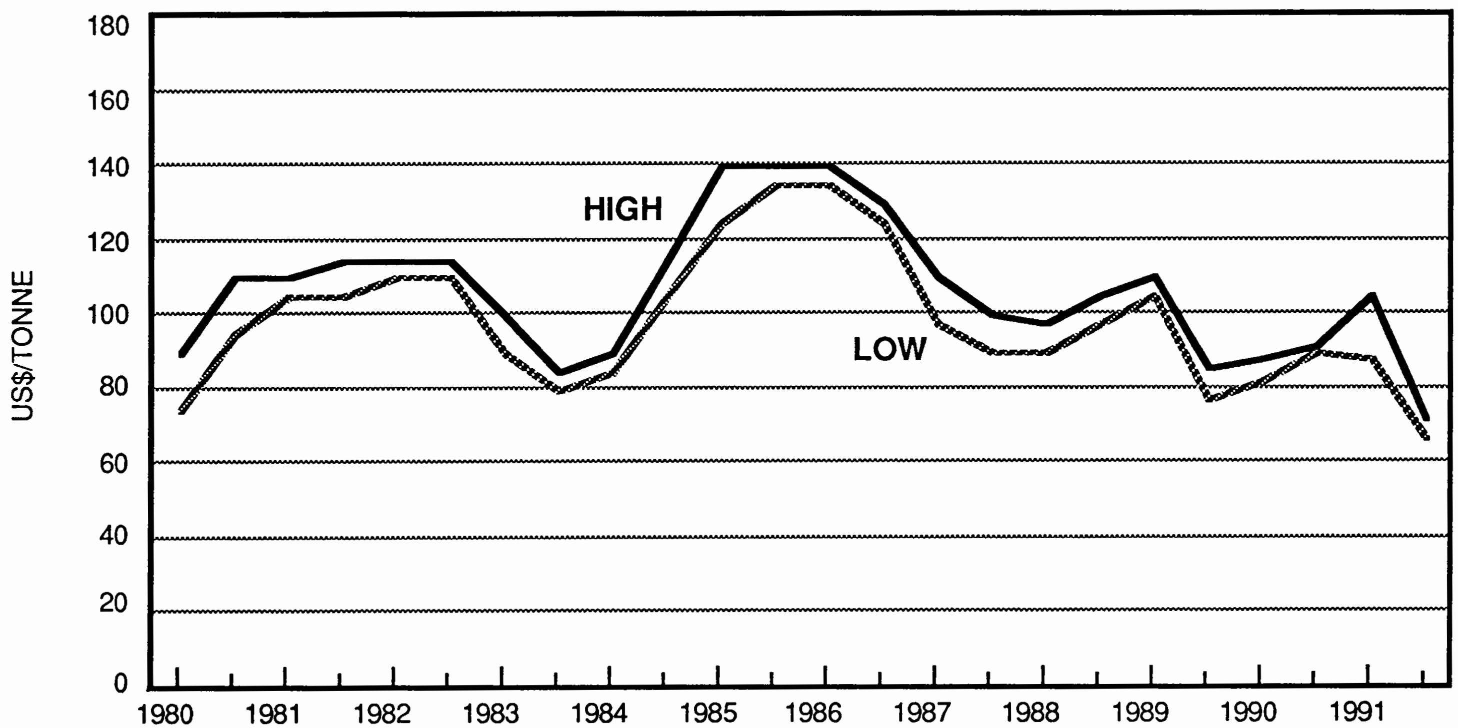
Source: Reports from producing companies, compiled by Mineral Policy Sector, Energy, Mines and Resources Canada.
[p] Preliminary; [r] Revised.

Figure 1

SULPHUR PRICES

F.O.B. VANCOUVER, CONTRACT

(CURRENT DOLLARS)



Source: Energy, Mines and Resources Canada.

Tin

Philip Wright

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4403

The price of tin averaged US$2.54/lb on the London Metal Exchange (LME) in 1991, compared to $2.82 in 1990. The decline was due to high tin metal stocks combined with little growth in demand. An estimated drop in Western World mine production of about 20 000 tonnes (t) from the 1990 level of 158 100 t was the result of the closure of high-cost mine capacity. Concentrate shortages forced smelters to operate at well below capacity, and 1991 Western World metal production was about 158 000 t compared to 177 600 t in 1990. Western World consumption of tin is expected to be similar to the 1990 level of 183 000 t despite the recession in major markets.

The Association of Tin Producing Countries (ATPC) decreased its export quotas by member countries by 9.1%, and China agreed to hold exports to 15 000 t. A possible increase in sales by the U.S. Defense Logistics Agency from its stockpile could slow the steady stock reductions seen over the past few years.

CANADIAN DEVELOPMENTS

Canadian tin mine production in 1991 came from the 9000-t/d open-pit mine of Rio Algom Limited, near East Kemptville, Nova Scotia. In September, Rio Algom announced that it would close the mine and mill effective January 3, 1992. The company cited the low price of tin and the high Canadian dollar as reasons for the closure.

In the last few years, Rio Algom has made provisions of $24 million, including $12 million in 1991, to cover the anticipated costs of the closure. After the announcement, management at East Kemptville presented a plan to the Nova Scotia government and the labour union to continue operating the mine. The plan was not accepted when several issues, including responsibility for mine reclamation costs, could not be resolved.

NovaGold Resources Inc. acquired the Mount Pleasant tin-tungsten mine in New Brunswick. The mine was run as a tungsten operation from 1983 to 1985 by former owner, Billiton Metals Canada Inc. Geological reserves of tin at the metallurgically complex Mount Pleasant mine are 5.1 million tonnes (Mt) grading 0.79% tin. NovaGold holds the New Brunswick licence for the ferric chloride leach process developed by the Canada Centre for Mineral and Energy Technology (CANMET). NovaGold is examining the possibility of using the process to recover tin at Mount Pleasant.

WORLD DEVELOPMENTS

Brazil

Brazil has been the world's largest producer of tin in concentrates in recent years. Estimated production was about 31 000 t in 1991 compared to 39 100 t in 1990. This represents a decrease for the second consecutive year.

Decreased tin production was mainly the result of a drop in output from the Bom Futuro mine. The mine, which produced 17 000 t of tin in concentrates in 1990, was ordered closed in August for environmental reasons. The deposit was being mined by an estimated 2000-3000 independent "garimpeiros" miners. The mine was still closed by year-end with total production for 1991 estimated at about 11 500 t. The closure is part of an ongoing legal battle for control of the Bom Futuro mine between Cogari, the garimpeiros' cooperative, and Ebesa, the consortium of mining companies led by state-owned Paranapenema SA.

Federal court rulings in September and October recognized Ebesa's right to mine Bom Futuro. However, in December, an injunction on behalf of Cogari was issued to delay mining by Ebesa. Ebesa plans to spend several months installing environmental controls at Bom Futuro before producing 15 000 t/y of tin in concentrates for a period of 15 years. The expected takeover of Bom Futuro would likely cause a significant decrease in the smuggling of tin concentrates to neighbouring Bolivia.

Paranapenema opened a sales office and warehouse in Providence, Rhode Island, in May to sell high-grade tin directly to U.S. tin consumers. The company hopes to attract customers in the tinplate, alloying and chemical industries where high-purity, low-lead tin is required.

In December, another garimpeiros' cooperative, Coopegro, acquired the Mineracao Aripuana mine in Mato Grosso state from Paranapenema for US$1 million. Paranapenema sold the operation when it became unprofitable to mine using large-scale mining equipment.

Cia Estanifera do Brasil (Estanbras) closed its 6000-t/y tin smelter in Minas Gerais State due to a shortage of tin concentrates. The shortage developed when the Brazilian government, in an attempt to curb smuggling, introduced new rules prohibiting direct cassiterite sales from garimpeiros.

China

China was the world's second largest producer of tin in concentrates in 1990, producing 35 800 t. The country exported about 15 800 t in 1990, close to the 15 000-t limit it promised to the ATPC. China has been under pressure in recent years to increase exports of tin as a source of much-needed foreign currency. At its 1991 annual meeting in October, the ATPC accepted, in principle, China's admission into the association.

China was fourth in the world in tin metal production in 1990, producing 28 000 t. Tin deposits in the country are an extension of those in Southeast Asia and are concentrated in the provinces of Yunnan, Guangxi, Guangdong, Jiangxi and Hunan, and on the island of Hainan.

Indonesia

In a restructuring of operations which began in 1990, state-owned PT Tambang Timah indicated that, in order to cut costs, it would reduce its 24 000 workforce to 11 000 by 1995, contract out higher-cost onshore mines, and concentrate on offshore dredging operations. The Indonesian government agreed to provide US$76 million toward the company's restructuring and to loan it a further $146 million to replace ageing mining equipment.

Indonesian production of tin in concentrates in 1991 is expected to be lower than the 1990 total of 31 700 t. The country ranked third in the world in 1990 in tin metal production with 30 400 t.

Malaysia

The number of operating tin mines continued to fall in 1991, as tin prices fell below the cost of production for many operations despite cost-cutting measures. Particularly hard hit was the dredging sector, where state-controlled Malaysia Mining Corp. cut its fleet of dredges from nine to four by July. Production of tin in concentrates in 1991 was about 21 000 t compared to 28 500 t in 1990.

Malaysian smelters suffered a shortage of concentrates during the year. Both Datuk Keramat Holdings Bhd's (DKH) 60 000-t/y Georgetown smelter and Malaysia Smelting Corp.'s (MSC) 60 000-t/y Butterworth smelter operated well below capacity. In addition to Malaysian concentrates, the two smelters obtained feed in 1991 from a number of countries, including Canada. Malaysia produced 49 000 t of refined tin in 1990, but in 1991 is expected to produce well below this level.

Both DKH and MSC announced that they would each begin producing about 120 t/y of high-purity (99.99%) tin at their smelters when electrolytic equipment was installed late in the year. The announcements followed the closure of the Capper Pass smelter, which produced high-purity tin, in the United Kingdom.

Bolivia

A month-long strike by 1200 workers at the Huanuni mine of Corporacion Minera de Bolivia (Comibol) was settled in early July. The dispute over pay increases resulted in a loss of 300 t of tin production.

Plans to privatize six mines, including the Bolivar and Catavi tin mines, reached an advanced stage as the Bolivian government, which operates the mines, announced that it planned to lay off 2000 workers at Comibol. The workers would be available for rehire by the new owners.

Bolivia produced 17 300 t of tin in concentrates and 13 100 t of tin metal in 1990. Tin concentrates and metal output is expected to increase in 1991 for the fourth straight year.

Thailand

Thai Pioneer Enterprise Co. announced plans for the re-opening of its 5000-t/y Pathum Thani tin smelter which closed in 1981. The company plans to smelt concentrates from both domestic and foreign sources.

Thailand's only currently operating tin smelter, Billiton B.V.'s Thaisarco smelter at Phuket, is reported to have operated at well below its capacity of 38 000 t/y during 1991 due to a shortage of tin concentrates. Thaisarco purchased concentrates from Laos during the year to help ease the shortage.

In 1990, Thailand produced 14 600 t of tin in concentrates and 15 500 t of tin metal.

United Kingdom

Carnon Holdings Ltd. closed its Wheal Jane mine in Cornwall in February. The mine had ceased production of tin in 1990 but continued producing zinc concentrates until closure. Carnon Holdings continues to operate the nearby South Crofty mine at a rate of 2300 t/y of tin in concentrates. In 1990, the United Kingdom produced 3400 t of tin in concentrates.

RTZ Corporation PLC closed its Capper Pass tin smelter. The company cited appreciation of the pound and a shortage of tin concentrates brought about by low tin prices as reasons for the closure. The 23 000-t/y custom smelter, specializing in the treatment of low-grade concentrates and residues, employed 489 people.

In 1990, ATPC countries represented only 48% of total world tin mine production. For 1992, this percentage will increase significantly with China's membership. Brazil, the world's largest producer of tin in concentrates, is still not a member of the ATPC.

The ATPC began a supply rationalization scheme in March 1987. Its objective was to accelerate the absorption of the huge tin inventories caused by the cessation of the International Tin Council's buffer stock operations and to prevent further price declines. The program involved the establishment of yearly export quotas among its members. Brazil, although not a member of the ATPC, has cooperated in recent years in limiting its exports of tin.

Since the formation of the ATPC supply rationalization scheme, stock levels have dropped from 73 000 t to an estimated 37 000 t at the end of 1991. At its annual meeting, the ATPC agreed to curtail 1992 exports by member countries to 87 100 t from the 1991 total of 95 800 t. China agreed to limit exports to 15 000 t and Brazil, while not setting an export quota, agreed to limit its tin-in-concentrates production to 34 000 t.

The Sixth International Tin Agreement

The Sixth International Tin Agreement (ITA) was an international producer/ consumer arrangement aimed at stabilizing the price of tin, mainly through the operation of a buffer stock and by the selective use of export controls. The Sixth ITA entered provisionally into force on July 1, 1982, under the direction of the International Tin Council (ITC). On October 24, 1985, the ITC ceased buffer stock operations and defaulted on loans and contracts. ITC creditors took various legal actions against the ITC and its members. After protracted negotiations (led by Canada) between ITC members and its creditors, a settlement was reached on March 30, 1990. ITC creditors were paid £182.5 million. The ITC held its last meeting in London on July 31, 1990, at which time the organization was declared dissolved.

Research Organizations

The International Tin Research Institute (ITRI) is entrusted with the task of maintaining and extending the use and effectiveness of tin in modern technology. It is financed by the governments of five of the major tin-producing countries: Indonesia, Malaysia, Nigeria, Thailand and Zaire. Its headquarters and laboratories are in Uxbridge, England. In early January 1992, the ITRI announced that it would be closing five of its seven information centres to reduce costs.

The South-East Asia Tin Research and Development (SEATRAD) Centre is a regional organization established by the governments of Indonesia, Malaysia and Thailand, with assistance from the Economic and Social Commission for Asia and the Pacific, and other United Nations agencies. The purpose of the centre is to promote, conduct and coordinate research and training in relation to the technical and economic aspects of exploration, mining, mineral processing and the smelting of tin. The centre's headquarters and laboratory are located in Ipoh, Malaysia. In addition to the work being conducted in the laboratory, field projects are maintained in various member countries in Southeast Asia. The centre is financed by equal contributions from member countries.

USES

Solder recently surpassed tinplate as the largest market for the metal. In Canada, it accounted for over 53% of tin consumption in 1990. Strong growth in the electronics industry, which accounts for over 50% of tin used in solders, has provided a new impetus for tin use. Growth in tin solder is, however, limited by the trend towards the use of less solder per assembly. This trend is more evident in the increasing use of surface-mounted components which permits greater solder savings. A growing trend in North America is to replace standard lead-tin solder in water pipes with silver-tin solder. The latter has a tin content of 95% versus 50% in the former.

Tinplate is the second most important use of tin. Tinplate use in the canning industry has been under severe competitive pressures from aluminum, except for large containers where, due to rigidity problems with aluminum, tinplated steel is still preferred. Thinner tin coatings on food and beverage cans have also reduced tin consumption. Tinplate competition also comes from non-tin-coated steels, tin-free steel and electrolytic chromium-coated steel.

In Canada, prior to 1987, most beverage cans were made of tinplated steel. At that time, a major shift began to take place to use aluminum cans due to aluminum's higher recyclability. However, because of lower costs for steel cans in Ontario, major manufacturers in that province switched back to tinplated steel in 1991.

The fastest growing new use for tin has been in chemical applications. Tin is used in an array of inorganic and organic chemicals, for application as plastic (polyvinyl chloride) stabilizers, agricultural pesticides, anti-fouling paints for ships, and biocidal compounds for the protection of materials such as paints, textiles and building materials. Recent research has shown the effectiveness of tin-based compounds as flame- and smoke-inhibitors. As fire retardants, these compounds are non-toxic, safe and easy to handle, and have a wide range of applications.

Tin is also used for tinning (which includes electronic uses, hot dipping and electroplating in the electronics industry), in the manufacture of pewterware, and in bronze, brass and other tin-containing alloys. Tin-containing alloys are used in construction, machinery and equipment, and consumer durables.

The use of tin capsules for sealing wines represents a promising new market for tin. A recent ban on tin-lead capsules for wine in countries of the European Community has led to the successful introduction of tin capsules in wine bottling. Tin is ideal for this purpose because it is non-toxic, is easily adapted to existing capping technology, forms an attractive, high-quality product, and can be easily and safely opened. The International Tin Research Institute estimates that the potential market for this application could be 10 000 t/y of tin.

Western World tin consumption is estimated at 180 000 t in 1991 compared to 183 000 t in 1990.

PRICES AND STOCKS

Despite the closure of high-cost mine capacity during 1991, prices weakened as a result of high stock levels, stagnant demand in a prolonged recession, and increased sales from the U.S. DLA.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
2609.00	Tin ores and concentrates	Free	Free	Free	Free	Free	Free
7204.30	Waste and scrap of tinned iron or steel	Free	Free	Free	Free	Free	Free
8001.10	Tin, not alloyed	Free	Free	Free	Free	Free	Free
8001.20	Tin alloys						
8001.20.10	Tin-antimony alloys	Free	Free	Free	Free	Free	3.2%
8001.20.20	Tin-lead antimony alloys	6.8%	Free	Free	Free	Free	3.2%
8001.20.90	Other	10.2%	6.5%	Free	Free	Free	3.2%
8002.00	Tin waste and scrap	Free	Free	Free	Free	Free	Free
8003.00	Tin bars, rods, profiles and wire						
8003.00.10	Bars and rods, not alloyed or of tin-antimony alloys	Free	Free	Free	1.6%	3.2%	3.7%
8003.00.10.10	Not alloyed	Free	Free	Free	1.6%	3.2%	3.7%
8003.00.30	Bars and rods, of phosphor-tin alloys	5.5%	3.5%	1.1%	1.6%	3.2%	3.7%
8003.00.50	Bars and rods, of other alloys; profiles; other wire	10.2%	6.5%	2%	1.6%	3.2%	3.7%
8004.00	Tin plates, sheets and strip, of a thickness exceeding 0.2 mm						
8004.00.10	Of tin-lead-antimony alloys	6.8%	Free	1.3%	0.9%	2.5%	3.7%
8004.00.20	Of phosphor-tin alloys	5.5%	3.5%	1.1%	0.9%	2.5%	3.7%
8004.00.90	Other	10.2%	6.5%	2%	0.9%	2.5%	3.7%
8004.00.90.10	Not alloyed	10.2%	6.5%	2%	0.9%	2.5%	3.7%
8004.00.90.20	Of tin-antimony alloys	10.2%	6.5%	2%	0.9%	2.5%	3.7%
8004.00.90.90	Other	10.2%	6.5%	2%	0.9%	2.5%	3.7%
8005.20	Powders and flakes						
8005.20.10	Powders, not alloyed	4%	Free	0.8%	1.6%	2.9%	4.9%
8005.20.20	Alloyed powders, flakes	10.2%	6.5%	2%	1.6%	2.9%	4.9%
8006.00	Tin tubes, pipes and tube or pipe fittings (i.e., couplings, elbows, sleeves)	10.2%	6.5%	2%	0.9%	4.5%	4.9%
8007.00	Other articles of tin	10.2%	6.5%	6.1%	2.1%-2.9%	5.3%	5.8%
8007.00.00.10	Anodes for electroplating	10.2%	6.5%	6.1%	2.1%-2.9%	5.3%	5.8%

Sources: Customs Tariffs, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Custom Tariff Schedules of Japan, 1991.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

Note: Where there is a tariff "range," a complete match of the HS code was not available; therefore, the high and low for the product in question is shown.

TABLE 1. CANADA, TIN PRODUCTION AND TRADE, 1990-91, AND CONSUMPTION 1989-90

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION					
	Tin content of tin concentrates and lead-tin alloys	x	x	x	x
EXPORTS				(Jan.-Sept)	
2609.00	Tin ores and concentrates				
	Malaysia	2 278	12 746	2 470	15 318
	Mexico	469	2 486	199	1 155
	United Kingdom	–	–	9	57
	Singapore	72	320	–	–
	Germany[1]	9	61	–	–
	Total	2 828	15 614	2 678	16 532
7204.30	Waste and scrap of tinned iron or steel				
	United States	1 114	853	1 217	711
	Other countries	484	142	209	71
	Total	1 598	995	1 426	782
8001.10	Tin, not alloyed, unwrought				
	United States	43	317	11	84
	Other countries	...	10	–	–
	Total	43	327	11	84
8001.20	Tin alloys, unwrought				
	United States	301	2 010	301	1 860
	Total	301	2 010	301	1 860
8002.00	Tin waste and scrap				
	United States	427	403	222	272
	Other countries	102	47	128	63
	Total	529	450	350	335
8003.00	Tin bars, rods, profiles and wire				
	United States	159	974	146	827
	Total	159	974	146	827
8004.00	Tin plates, sheets and strip, of a thickness exceeding 0.2 mm				
	United States	21	35	60	80
	Singapore	88	16	–	–
	Other countries	–	–	...	5
	Total	109	52	60	85
8005.20	Tin powders and flakes				
	South Korea	2	58	3	76
	Other countries	1	32	–	–
	Total	3	90	3	76
8007.00	Tin articles n.e.s.				
	United States	..	3 244	..	1 813
	Other countries	..	1 781	..	669
	Total	..	5 025	..	2 482

TABLE 1 (cont'd)

Item No.		1990		Jan.-Sept. 1991p	
		(tonnes)	($000)	(tonnes)	($000)
IMPORTS					
2609.00	Tin ores and concentrates	...	3	...	2
7204.30	Waste and scrap of tinned iron or steel	25 950	2 307	2	252
8001.10	Tin, not alloyed, unwrought	3 624	28 372	2 443	16 233
8001.20.10	Tin-antimony alloys	83	646	74	530
8001.20.20	Tin-lead antimony alloys	22	179	11	87
8001.20.90	Other tin alloys	30	257	33	265
8003.00.10.10	Bars and rods, not alloyed	28	230	3	28
8003.00.50	Bars and rods, of other alloys; profiles; other wire	22	238	23	207
8004.00	Tin plates, sheets and strip, of a thickness exceeding 0.2 mm	32	227	41	280
8005.20.10	Powders, not alloyed	15	141	6	61
8005.20.20	Alloyed powders, flakes	1	21	2	30
8006.00	Tin tubes, pipes and tube or pipe fittings	20	179	12	131
8007.00.00.10	Other articles of tin - anodes for electro-plating	3	20	5	37

		1989	1990
		(tonnes)	
CONSUMPTION[2]			
	Tinplate and tinning	1 704	1 384
	Solder	1 235r	1 918
	Babbit	274r	96
	Bronze	207	106
	Other uses (including collapsible containers, foil, etc.)	147	96
	Total	3 567	3 600

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary; r Revised; x Confidential.
[1] Where applicable, data for East and West Germany have been combined. [2] Available data as reported by consumers.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, TIN PRODUCTION, TRADE[1] AND CONSUMPTION, 1975, 1980 AND 1985-91

	Production[2]	Exports[3]	Imports [4]	Consumption[5]
		(tonnes)		
1975	319	1 052	4 487	4 315
1980	243	883	4 527	4 517
1985	119	358	3 696	3 511
1986	x	3 727	3 925	3 270
1987	x	2 778	3 792	3 780
1988	x	3 591	4 008[r]	3 489
1989	x	2 790	3 862[r]	3 567
1990	x	2 828	3 624	3 600
1991[p]	x	2 678[a]	2 443[a]	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
. . Not available; [p] Preliminary; [r] Revised; x Confidential.
[a] Exports and imports are January-September figures.
[1] Beginning in 1988 exports and imports are based on the new Harmonized System and may not be in complete accordance with previous method of reporting. [2] Tin content of tin concentrates shipped plus tin content in lead-tin alloys produced. [3] Tin in ores and concentrates (H.S. class 2609.00). [4] Tin metal (H.S. class 8001.10).
[5] Available data as reported by consumers; current coverage exceeds 90% whereas until 1972, coverage was in the order of 80%-85%.

TABLE 3. WORLD TIN PRODUCTION, CONSUMPTION AND PRICES, 1984-91

	Production			Prices[2]	
	Tin in Concentrates	Metal[1]	Consumption	LME[3]	N.Y. Dealer
		(000 t)			(US$/lb)
1984	206	215	209	5.56	5.67
1985	199	205	209	5.57	5.25
1986	184	203	223	2.87	2.94
1987	186	202	229	3.10	3.15
1988	202	223	234	3.25	3.31
1989	224	230	234	3.93	3.97
1990	211	223	230	2.82	2.88
1991	. .	. .	. .	2.54	2.59

Sources: International Tin Statistics (1984-85); World Bureau of Metal Statistics (1986-90).
. . Not available.
[1] From primary and secondary material. [2] "Metals Week." [3] London Metal Exchange. For 1987, 1988 and part of 1989, the "Europe Free Market" in-warehouse Rotterdam prices were used to calculate averages.

TABLE 4. WORLD CONSUMPTION[1] OF TIN METAL, 1987-90

	1987	1988	1989	1990p
		(tonnes)		
WESTERN WORLD				
United States	37 000	38 100	37 200	36 800
Japan	32 600	32 200	33 800	34 800
Federal Republic of Germany	17 300	19 400	18 600	18 700
United Kingdom	9 800	10 200	10 200	10 400
France	7 400	7 800	8 100	8 300
South Korea	5 800	7 300	6 900	7 800
Netherlands	4 900	4 900	6 100	6 900
Italy	6 000	6 000	5 900	6 100
Brazil	7 900	6 700	6 900	6 100
Hong Kong	2 500	3 000	2 500	5 000
Taiwan	4 000	4 600	3 900	4 800
Other	37 300	39 100	40 200	37 300
Total Western World	172 500	179 300	180 300	183 000
EASTERN BLOC				
U.S.S.R.	29 000	28 000	24 000	20 000
China	12 500	14 000	18 000	18 000
Other	15 100	12 500	11 900	8 700
Total Eastern Bloc	56 600	54 500	53 900	46 700
Total World	229 100	233 800	234 200	229 700

Source: World Bureau of Metal Statistics.
[1] Tin refined from primary and secondary sources.

TABLE 5. WORLD PRODUCTION[1] OF TIN IN CONCENTRATES, 1987-90

	1987	1988	1989	1990p
		(tonnes)		
WESTERN WORLD				
Brazil	29 000	42 800	50 200	39 100
Indonesia	26 300	29 600	31 300	31 700
Malaysia	30 400	28 900	32 000	28 500
Bolivia	8 100	10 500	15 800	17 300
Thailand	14 800	14 000	14 700	14 600
Australia	7 700	7 000	7 700	7 400
Peru	5 300	4 400	5 100	5 100
United Kingdom	4 100	3 500	4 000	3 400
Canada[2]	3 400	3 600	2 800	3 800
Zaire	2 200	1 900	1 600	1 600
Portugal	100	100	100	1 300
Other	6 500	6 100	6 400	5 300
Total Western World	137 800	152 400	171 700	159 100
EASTERN BLOC				
China	28 000	30 000	33 000	35 800
U.S.S.R.	15 000	15 000	14 000	13 000
Other	4 700	5 000	5 000	4 100
Total Eastern Bloc	47 700	50 000	52 000	52 900
Total World	185 500	202 400	223 700	212 000

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
[1] Recoverable tin content of ores and concentrates produced. [2] Figures for Canada represent exports.

TABLE 6. WORLD PRODUCTION[1] OF TIN METAL, 1987-90

	1987	1988	1989	1990p
	(tonnes)			
WESTERN WORLD				
Malaysia	44 400	49 900	50 900	49 000
Brazil	28 400	42 700	44 200	35 100
Indonesia	24 200	28 200	29 900	30 400
Thailand	15 400	14 700	14 700	15 500
Bolivia	2 600	5 400	9 700	13 100
United Kingdom	17 000	16 800	10 800	12 000
Netherlands	4 000	3 700	4 700	6 300
Mexico	2 400	3 100	4 400	5 000
South Korea	1 800	2 500	2 400	2 500
Other	15 300	10 700	11 500	8 700
Total Western World	155 500	177 700	183 200	177 600
EASTERN BLOC				
China	25 000	24 000	28 300	28 000
U.S.S.R.	18 000	18 000	15 000	14 000
Other	3 400	3 100	3 200	3 600
Total Eastern Bloc	46 400	45 100	46 500	45 600
Total World	201 900	222 800	229 700	223 200

Source: World Bureau of Metal Statistics.
[1] Tin refined from primary and secondary sources.

TABLE 7. MONTHLY AVERAGE TIN PRICES, 1990 AND 1991

	N.Y. Dealer		London Metal Exchange	
	1990	1991	1990	1991
	(US$/lb)			
January	3.07	2.59	3.02	2.55
February	2.87	2.57	2.84	2.53
March	2.97	2.55	2.91	2.50
April	3.04	2.59	2.96	2.52
May	2.99	2.64	2.92	2.59
June	2.88	2.65	2.80	2.59
July	2.81	2.62	2.73	2.57
August	2.80	2.61	2.72	2.56
September	2.75	2.57	2.65	2.53
October	2.88	2.56	2.82	2.52
November	2.83	2.54	2.78	2.50
December	2.64	2.55	2.59	2.50
Yearly average	2.88	2.59	2.82	2.54

Source: "Metals Week."

Uranium

Robert T. Whillans

The author is with the Energy Sector, EMR Canada.
Telephone: (613) 996-2599

OVERVIEW

Canada's uranium industry faced renewed uncertainty in 1991 as market opportunities faded due to falling prices and oversupply. Denison Mines Limited announced that its Elliot Lake, Ontario, operation would close in 1992 upon completion of deliveries to Ontario Hydro, and Rio Algom Limited announced that its Hydro contract would cease in 1996. In October, the Nuexco Exchange Value (EV)[1] spot-price indicator fell to US$7.25/lb U_3O_8, an all-time low in constant dollar terms. Despite mine closures and output cuts globally, excess supply prevailed in 1991 as inventory surpluses persisted and new sources of uranium emerged, most notably from the former Soviet Republics.

Despite the weak uranium market in 1991, Cameco Corporation resumed milling at Rabbit Lake, Saskatchewan, after a two-year shut-down, and Canada's uranium marketers signed new export contracts for the delivery of about 8300 tonnes of uranium (tU). Most of these contracts contained quantity-flexibility provisions that have become more prevalent in uranium contracts in recent years. The average price of all export deliveries in 1991 was well below that of 1990. Less than 2% of deliveries in 1991 were spot sales.

Given the depressed state of the uranium market, new production capacity could be deferred to the late 1990s if prices do not recover in the near term. Government reaction to societal concerns that the environment must be protected means that all new uranium mining projects will undergo intensive public scrutiny. In Saskatchewan, the referral of six new uranium projects for environmental review by independent panels will likely increase the lead time needed to bring them on stream.

PRODUCTION AND DEVELOPMENTS

In 1991, the deteriorating oversupply and price situation had a significant impact on Canada's uranium industry. Primary uranium output for the year is estimated at 8100 tU, down almost 10% from the 1990 level; production could remain well below output capability in 1992. The decline stems from the 1990 closure of two mines in Ontario and to the related contract renegotiations with Ontario Hydro; the increased production in Saskatchewan, as Rabbit Lake operations resumed, could not offset the decreased output in Ontario. Table 1 shows that with the Rio Algom mine closures and Denison workforce reductions, direct employment at Canada's uranium production centres fell to some 2500 workers in 1990, a 40% drop in one year, and to about 2200 workers in 1991. Figure 1 locates Canada's existing producers and major uranium deposits, while Figure 2 illustrates the output and ownership share of Canada's uranium production centres in 1990.

In 1991, uranium was ranked sixth in terms of production value among Canada's metal commodities. As shown in Table 2, estimated 1991 shipments under all active domestic and export contracts were 7813 tU, valued at C$472 million, well down from 1990 levels.

The difference between the annual production and shipment figures reflects inventory adjustments by the producers. As domestic requirements represent only about 15% of current Canadian output, most of Canada's uranium production is available for export.

To illustrate the differences between the uranium industries in Ontario and Saskatchewan, Table 3 lists the operational characteristics of Canada's existing uranium production centres in 1990.

Elliot Lake, Ontario

In April 1991, Denison Mines announced that Ontario Hydro had given Notice of Termination of its uranium supply contract, effective January 1, 1993, and that Denison would close its operation permanently upon completion of contract deliveries, affecting some 1000 workers. Subsequently, Denison reached an agreement with Ontario Hydro whereby 1991 and 1992 deliveries would be accelerated, permitting current production and workforce levels to be maintained until closure, expected in the second quarter of 1992.

Ontario Hydro announced in June 1991 that it had agreed to continue Rio Algom's current (Stanleigh mine) contract beyond 1993, but only until 1996 as opposed to the original 2020 date. Deliveries will be increased between 1992 and 1995, requiring the addition of up to 75 employees by early 1992. Workers at Stanleigh are also involved in asset disposal and environmental decommissioning activities related to the Quirke and Panel mine closures.

To lessen the impact of the Elliot Lake employment loss, the Ontario government has undertaken several initiatives. In late 1990, $15 million was provided to assist with economic diversification and revitalization in the area. In mid-1991, a multi-million-dollar package was offered to help the community make the transition from a dependence on uranium mining to a more diversified economy. Ontario Hydro will provide $65 million to help area communities adjust in the short term and diversify in the long term, and $25 million for a number of energy initiatives, such as local energy efficiency programs and developing co-generation potential. In addition, the utility estimates that its commitment to purchase uranium from the Stanleigh mine until 1996 represents a $160 million premium above current uranium market prices.

Athabasca Basin, Saskatchewan

Cameco resumed ore processing at Rabbit Lake in August 1991, after a two-year shut-down due to poor markets. Stockpiled ore from the Collins Bay B deposit, mined out in February 1991, provides the feed. Licensed by the Atomic Energy Control Board (AECB) to produce up to 5400 tU annually, Rabbit Lake output was expected to exceed 700 tU in 1991, and to reach nominal capacity of 4600 tU by 1996. At the adjoining Eagle Point property, site preparations are well under way; construction of the underground decline began in mid-year, and it should reach the orebody by mid-1992. At the Key Lake site, Cameco has accelerated mining at the Deilmann pit to mine it out before 1995 for use as a tailings impoundment facility. The Key Lake mill may be used to process ore from McArthur River once the Key Lake ore is exhausted.

In its first step towards privatization, Cameco signed an underwriting agreement in June 1991 for an initial share offering, at a unit price of $12.50. Fully subscribed within a few days in July, the offering saw more than 10 million shares sold, with gross proceeds of $130 million. In September 1991, the Province of Saskatchewan offered 5.3 million special warrants at $14.75 each. If these are fully exercised by late 1994, and if employees exercise all their bond conversion rights by 1996, public ownership in Cameco will be increased from the current level of 20% to about 38%.

In late 1990, Cluff Mining submitted an Environmental Impact Statement (EIS) to the AECB for approval to extend its Dominique-Janine (DJ) pit southward, thereby prolonging surface mining by seven years and allowing underground production to be supplemented. As mining operations would extend 100 m into Cluff Lake and require construction of a dam, the DJ proposal was referred for environmental review (note the DJ and other projects below). The DJ North pit was mined out in December 1991.

Additional Production Possibilities

On April 18, 1991, the Minister of Energy, Mines and Resources (EMR) referred six proposals for new uranium mining facilities in Saskatchewan for public review by an independent panel, pursuant to the federal government's Environmental Assessment and Review Process (EARP) Guidelines Order. Five will be reviewed by a joint federal-provincial panel, namely: the extension of the Cluff Mining operation by developing the South and West Dominique-Janine deposits, the Denison/Midwest Joint Venture South McMahon Lake project, Minatco's McClean Lake project, the Cigar Lake Mining project at Cigar Lake, and Cameco's McArthur River project. The sixth proposal, the expansion of Cameco's Rabbit Lake operation by developing the Eagle Point/Collins Bay A & D deposits, will be reviewed by a federal-only panel, because conditional approval has already been granted by Saskatchewan authorities.

Appointment of the five-member joint panel was announced on August 22, 1991, and a total of $350 000 was made available in September to assist participants in reviewing EISs and preparing for and participating in the public hearings associated with the five new projects.

The four-member federal-only panel was established effective November 8, 1991. Specific Terms of Reference were released for both panels, which had begun their respective reviews by year-end. The joint panel will consider the differing stages of development at each project it reviews and will endeavour to report within 18 months of the receipt of satisfactory EISs; the federal-only panel will make all reasonable effort to report by the summer of 1992.

On December 19, 1991, the joint panel released its operational procedures and the first of the five EISs that it will review. The release of these procedures will assist those wishing to participate in the review process by providing information about how the panel will conduct its review and outlining the intended approach to be followed. The Midwest project EIS was selected as the first to be studied, and it will undergo a 90-day public review during which time the panel will accept written comments on its completeness. Based upon its own review and the submitted comments, the panel will decide if sufficient data have been provided to proceed with public hearings, or if additional information is required. On January 13, 1992, the 90-day review of Minatco's EIS for its McClean Lake project was announced; the receipt of Cluff Mining's EIS for its Dominique-Janine extension was expected shortly.

Uranium

On January 7, 1992, the Chairman of the joint panel announced that scoping meetings for the Cigar Lake and McArthur River projects would begin on February 7, 1992. The main purpose of these meetings is to provide review participants with an opportunity to identify for the panel those issues or concerns that should be included in the EIS guidelines that will be issued by the panel to the project proponents.

At Cigar Lake, the successful completion of initial test mining of high-grade ore was announced in October 1991. Entering the orebody from below and extracting about 50 t of ore, the specially-designed remote-controlled boring machine performed very well. Mined-out areas were filled with concrete without difficulty, and the radiation levels were below expectations. Ore grading 14% U was hoisted to the surface in shielded containers and placed in a concrete storage facility. Under development since late 1987, the project will continue test mining based on these satisfactory results in order to improve the efficiency of this experimental mining method. The project, jointly owned by Cameco (48.75%), Cogema Canada Ltd. (36.375%), Idemitsu Uranium Exploration Canada Ltd. (12.875%), and Korea Electric Power Corporation (2%), is expected to be in commercial production before the turn of the century.

Cameco's McArthur River strike, 70 km northeast of Key Lake, has been the only significant new uranium discovery announced in the past two years. In December 1991, it was revealed that further drilling had boosted probable *in-situ* reserve estimates 30% to 100 000 tU, at an average grade of about 4% U, and that the mineralization is consistent throughout the deposit. The orebody, drilled along its length of 1700 m, is situated at a depth of 500-550 m. Follow-up evaluations continue, with the feasibility study and EIS to be completed in 1992. Depending on the markets, development timing should permit first production to coincide with the depletion of ore stockpiled at Key Lake, where Cameco indicates McArthur River ore will be processed. The joint venture partners are Cameco (43.99%), Uranerz Exploration and Mining Limited (UEM) (29.78%), AGIP Resources Ltd. (10.00%), Interuranium Canada Limited (9.06%), and Cogema (7.17%).

Test mining results at the Midwest project near South McMahon Lake have been evaluated and an EIS was submitted to provincial authorities and the AECB in late 1990. Hopeful that the environmental review will not delay the project, the partners expect to complete mine development by 1994. The proposed mine would operate six months per year, with stockpiled ore feeding the 125 t/d mill for the full year. Annual processing capacity is expected to be 37 200 t of ore grading 3.8% U, to produce 1385 tU/y; the mill could handle ore grades down to 2.5% U. Current mineable reserves are estimated at 361 000 t of ore, indicating a 10-year mine life. Denison Mines (45%) operates the joint venture with UEM (20%), Bow Valley Industries Ltd. (20%), and OURD (Canada) Co., Ltd. (15%), a subsidiary of Overseas Uranium Resources Development Corporation (OURD) of Japan, whose equity interest in the project was transferred from PNC Exploration (Canada) Co. Ltd. during 1991.

Minatco's McClean Lake (Wolly) project, adjacent to the Rabbit Lake property, hosts sizeable uranium resources estimated to contain in excess of 17 300 tU, judged by Minatco as being profitably mineable at an average grade of 2.7% U. Three quarters of the known reserves are mineable by open-pit methods at the Jeb and Sue deposits; the remaining reserves, at the McClean orebody proper, are exploitable from underground. Exploration and development work continues, and Minatco has completed an EIS in preparation for a production decision. Given favourable markets and timely environmental approvals, construction of the mill and mining of the Jeb deposit would start in 1993, two years before first concentrate production. To enhance its project schedule, Minatco has already executed a surface lease agreement and its attendant human resource agreement with the provincial government. The mill could operate until 2006 at an annual production rate of 1540 tU/y. Minatco acquired 100% of the project in 1990 from its joint venture partners, Canadian Occidental Petroleum Ltd. and Canadian Nickel Company Limited.

In July 1990, Urangesellschaft Canada Limited (UCL) requested that the EARP review of its Kiggavik project in the Northwest Territories be delayed indefinitely. UCL needed more time "to respond thoroughly to the request for considerable additional information." Continuation of the project, held by UCL (79%), CEGB Exploration (Canada) Ltd. (20%), and Daewoo Corporation (1%), may also be affected by recommendations of the Nunavut Planning Commission, an independent body established to develop a Land Use Plan for the Inuit land claims settlement area. Late in the year, the Commission recommended completing the Kiggavik EARP review, but deferring uranium development until the Nunavut land claim resource management bodies are established and the relevant issues not addressed by the EARP are reviewed. The discovery potential for uranium deposits in this area has meant that the Commission's work is followed with keen interest by the uranium industry. In mid-December, an agreement was reached with the federal government, subject to Inuit ratification in April 1992, for the creation of the new territory of Nunavut, comprising essentially the eastern half of the Northwest Territories.

The start-up date for any of these projects is contingent on the receipt of the necessary regulatory/environmental approvals and on developments in the international uranium market.

EXPLORATION

In 1991, the Uranium Resource Appraisal Group (URAG) of EMR completed its seventeenth annual assessment of Canada's uranium supply capabilities and an associated survey of exploration activity. The results were reported[2] late in the year.

As in previous years, uranium exploration activity in 1990/91 was again concentrated in areas favourable for the occurrence of deposits associated with Proterozoic unconformities, most notably in the Athabasca Basin of northern Saskatchewan. Exploration expenditures declined to $45 million in 1990 as market opportunities waned, and could be lower again in 1991. Recent levels of expenditure mainly reflect the test mining program under way at Cigar Lake, Saskatchewan, where initial tests were conducted successfully during 1991. Overall, combined exploration and surface development drilling in 1989 and 1990 reached 158 000 m and 66 000 m, respectively, 90% of which occurred in Saskatchewan.

In the 1990/91 field season, 27 companies participated in 33 active projects, managed by just 12 operators.[3] The most active of these, spending virtually the total $45 million, were, in alphabetical order, Amok Ltd., Cameco Corporation, Cigar Lake Mining Corporation, Cogema Canada Limited, Interuranium Canada Limited, Minatco Ltd., PNC Exploration (Canada) Co. Ltd., Rio Algom Exploration Inc., Uranerz Exploration and Mining, and Urangesellschaft Canada Limited. Table 4 summarizes uranium exploration activity in Canada from 1976 to 1990, and shows that until the 1990/91 exploration season, the number of million-dollar projects has remained relatively constant since 1982.

In May 1991, Cameco announced the discovery of a high-grade uranium deposit in northern Saskatchewan (see Figure 1) at a depth of 500-550 m. The P2 North deposit at the McArthur River project, 70 km northeast of Key Lake, has been drilled along strike for 2 km. The best intersection returned 47% U across 9 m, but grades up to 65% U have been reported. Initial resource estimates suggested over 77 000 tU but, as noted earlier, subsequent drilling has increased *in-situ* reserves by 30% to 100 000 tU.

RESOURCES

Uranium supply from Canada in the next decade will come from "known" resources, estimates of which are divided into three major categories–measured, indicated and inferred–which reflect different levels of confidence in the reported quantities. Most of these resources are associated with deposits identified in Figure 1.

In its latest annual assessment of domestic uranium supply capabilities, EMR reported[2] that estimates of known uranium resources, as of January 1, 1991, had increased by 2% from January 1990 to 594 000 tU, as shown in Table 5. Resource additions in 1990 more than offset losses resulting from production and from adjustments at Elliot Lake, Ontario, including consideration for the closure of Rio Algom's Quirke and Panel mines.

SUPPLY CAPABILITY

Production capability from Canada's existing operations fell more than 15% in 1990 when Rio Algom's Quirke and Panel mines closed at Elliot Lake, Ontario. Although the expansion of processing capacity at Cameco's Rabbit Lake, Saskatchewan, operation has more than offset the Elliot Lake loss, Canadian output in 1991 remained well below capability as producers continued to avoid the spot market and gear output to their existing contract commitments. At most operations, significantly higher uranium prices will be required to bring production up to full capacity.

To illustrate Canadian uranium availability in the short term, Figure 3 provides a projection of production capability to 2005, based only on existing production centres. The projection assumes a level of production that could be realistically achieved, under current circumstances, supported by known resources in the so-called low-cost category; these known resources are recoverable at a price of $100/kgU or less. No firm commitments have been made for the start-up of any production centres beyond those now in operation. Table 6 places Canada in the world context with respect to actual uranium production from 1984 to 1990 inclusive.

Developments in the international uranium market and uncertainty regarding the costs associated with certain of the planned projects noted above make it difficult to project production capability levels in the future.

GOVERNMENT INITIATIVES

Late in the year, the Minister of EMR informed the uranium industry that the further-processing component of Canada's uranium export policy would be phased out, thereby bringing it into closer conformity with the government's commitment to freer trade. All new export contracts reviewed by the federal government after December 15, 1991, will not be subject to the further-processing requirement. However, for existing contracts, the further-processing requirement and associated exemption criteria will remain in place until December 31, 1995, after which time the requirement will be totally eliminated.

In June 1991, Australia's Labour Party ruled out expanding the country's uranium industry, voting to maintain the policy of limiting production to existing operations. With 30% of the world's known uranium resources, Australia accounts for only 10% of the world's uranium output. The Party ignored recommendations that new mines and uranium enrichment should be allowed in Australia, prompting the opposition Conservatives, who were ahead of the Labour Party 45% to 38% in a 1991 public opinion poll, to pledge to expand uranium mining if elected in 1993. The proponents of a policy change advocated a gradual expansion of the industry, but the opponents view the uranium and nuclear industries as tarnished, unpopular and dangerous. The Labour Party decision was seen as benefitting Canada, since Australia is one of Canada's major competitors.

INTERNATIONAL DEVELOPMENTS

In early 1991, the U.S.S.R. stepped up the marketing of both enriched uranium product and uranium concentrates in the West, thus exacerbating an already difficult situation. In response, uranium producers in the United States filed an anti-dumping petition against the U.S.S.R. in an effort to bring about a more orderly marketing arrangement. With spot prices no longer bearing any relation to production costs, the viability of even Canada's lowest-cost producers was being threatened. When the U.S.S.R. collapsed late in 1991, it was feared that the individual Republics might begin marketing uranium independently from the central authority, Techsnabexport (TENEX); early in 1992, TENEX was apparently being pressured by the Republics to triple the level of uranium exports to the West during the year.

The volume of Soviet uranium entering the West has been excessive, reportedly exceeding 9000 tU in 1991 for the United States and the European Community alone, thus challenging Canada as the world's principal uranium exporter. (Canadian production was 8100 tU in 1991, and 12 440 tU in the peak year of 1987.) At least a portion of the Soviet uranium is believed to be coming from inventories. With such surpluses overhanging Western markets, and with prices already at historic lows, the price of uranium has been depressed even further in order to generate discretionary demand.

Uranium producers may face more stringent regulations with respect to radiation protection and safety in the near future. The International Commission on Radiological Protection (ICRP) has recommended lowering the current 50 milliSievert/year (mSv/y) dose limit for atomic radiation workers to 20 mSv/y averaged over five years. Early studies show that the lower limits could have a significant impact in terms of higher costs and possible mine closures, particularly with respect to high-grade underground mines. National regulators are currently studying the new recommendations to determine how best to implement them, and uranium producers are assessing the potential impact of the lower limits on their specific operations.

MARKET OVERVIEW

The international uranium market deteriorated throughout the 1980s, and large inventories of uranium were built up as mine output surged in anticipation of burgeoning civilian nuclear power programs. Although reactor consumption first exceeded new mine output in 1985, it was not until 1989, following a new round of mine closures, that the draw-down of inventories finally began to reach significant proportions. However, by then the unravelling Communist system revealed both a huge annual surplus of uranium production in the East Bloc and a massive civilian inventory of uranium at least equal to the peak level of Western inventories. By 1990, East-West relations were such that this East Bloc uranium had begun to appear in the West in significant quantities. Beyond this new trade flow lies the spectre of the liquidation of the large military inventories of the former U.S.S.R.

Canada's uranium producers have been affected significantly by these international developments. In recent years, production from the Elliot Lake mining district has been displaced by the newer, low-cost, high-grade operations of Saskatchewan's Athabasca Basin. These are among the most competitive operations in the world and many new deposits have been identified for future development. However, this will require a mix of contracts with better prices than those available on the current spot market. The long-term outlook may be favourable, but it suggests replacement of deposits as they are exhausted as opposed to expansion of output. While the Canada-U.S. Free Trade Agreement gives Canada access to the world's largest market with the lowest inventory levels, there is a limit to the market share available to Canadian producers. In fact, it seems inevitable that the former Soviet Republics will attain a significant degree of market penetration.

MARKETS AND PRICES

Although reactor requirements still exceed output, the uranium market continues to suffer from oversupply as the draw-down of inventories has been slower than expected and, as noted, new sources of supply keep emerging. Prospects for a dramatic recovery in prices are considered slim, and any improvement will depend very much on two factors: namely, how quickly these inventory surpluses can be absorbed, and the extent to which non-traditional supplies penetrate the market on a continuing basis.

Uranium price volatility persisted in 1991 as brokers and traders remained quite active. The Nuexco EV fluctuated between US$9.50 and US$7.25/lb U_3O_8, and rallied to US$8.75 at year-end. The price increase may reflect reaction to the U.S.-led anti-dumping suit against the Soviet Republics, in turn diminishing the aggressive sales effort and helping to bolster prices. If the U.S. action leads to a more restrained marketing arrangement by the Republics, some analysts predict that spot prices could rise significantly by year-end 1992.

In Canada, the average price of all export deliveries made during 1991 was C$61/kgU, or US$21/lb U_3O_8, well below the 1990 average. Less than 2% of Canada's export deliveries in 1991 were spot sales, double that of 1990 and 1989, compared with a high of 35% in 1987, and the previous level of 1% in 1981. The average price of Canadian export deliveries for the period 1974 to 1991 is shown in Table 7.

Table 8 shows, by country of buyer, the nominal amount of uranium under Canadian export contracts reviewed and accepted since 1974, and illustrates Canada's diverse export base. As of January 1, 1992, forward commitments under all export contracts and domestic contracts were in the order of 45 000 tU and 7000 tU, respectively. (The renegotiation of Ontario Hydro's contracts in 1991 reduced outstanding domestic commitments by a factor of ten.) Table 9 shows actual exports of Canadian-origin natural uranium from 1984 to 1990 for Canada's principal export customers; actual exports in 1991 are expected to match those of 1990. Figure 4 illustrates the future importance of Canada's export markets in terms of forward scheduled deliveries of uranium in concentrates.

REFINING

Cameco operates Canada's only uranium refining and conversion facilities, located at Blind River and Port Hope, Ontario, respectively. At Blind River, uranium concentrates are refined to uranium trioxide (UO_3), an intermediate product, and then transported by truck to Port Hope. There, the UO_3 is converted into either uranium hexafluoride (UF_6), for use in foreign light-water reactors following enrichment outside of Canada, or uranium dioxide (UO_2), for use in CANDU reactors.

Due to the soft uranium markets, Cameco has reduced output at both facilities in recent years. At Port Hope, a cyclical production schedule was implemented in 1991, whereby production of UF_6 and UO_2 will be alternated twice each year until further notice. The cutbacks have allowed Cameco to reduce conversion product inventories and to lower operating costs.

The Blind River refinery, with an annual design capacity of 18 000 tU as UO_3, processes uranium concentrates from several countries. Due to the depressed conversion market, and Cameco's decision to reduce production, output in 1990 was about 8154 tU as UO_3, some 5% below the 1989 level. Employment was also reduced, as the site workforce decreased from 127 in 1989 to 98 in 1990. At Port Hope, combined production at the two conversion facilities, which have a capacity of 10 500 tU as UF_6 and 2500 tU as UO_2, respectively, was about 8398 tU in 1990, some 9% below the 1989 level. Employment remained stable, with a site workforce of about 280.

For the period 1991 through 1995, Cameco has UF_6 conversion service contracts totalling some 23 000 tU under 44 long-term agreements, the 5 largest of which account for approximately 35% of the total. From 1996 through 2000, Cameco will convert some 8000 tU to UF_6 under 20 long-term contracts, with the 5 largest customers accounting for about 65% of the total.

NUCLEAR POWER DEVELOPMENTS

Domestic developments had an important impact on the Canadian nuclear program during 1991. At the end of the year, the combined generating capacity of Canada's 19 in-service CANDU reactors was about 13 000 megawatts electric (MWe) (see Table 10). In 1991, over 17% of Canada's electric power was nuclear generated; in Ontario, nuclear-generated electricity exceeded 50%, and in New Brunswick it was over 35%.

At Ontario Hydro's Darlington Nuclear Generating Station (NGS) east of Toronto, major progress was made in identifying the cause of fuel end-plate cracks in Unit 2, which resulted in its shut-down in January 1991. Although no fuel damage occurred in Unit 1, it was shut down during commissioning in early 1991 pending identification of the cause of the problem at Unit 2. In August, further commissioning of Unit 1 began and, at year-end, 100% power was reached; Unit 3 is expected to start up in mid-1992, and Unit 4 in the spring of 1993.

Work continues at Ontario Hydro's Pickering A and Bruce A NGSs to improve performance, replace pressure tubes, and make system modifications to meet the new licensing requirements. At Bruce A, Units 1 and 2 are undergoing boiler tube repairs; Unit 1 was expected back in service in early 1992. These repairs are being completed in conjunction with an $825 million rehabilitation of the entire station, which will entail upgrading many components to increase performance levels to previous standards. Pressure tubes in Units 1 and 2 will be replaced as part of a $1.2 billion project beginning in early 1994.

Although this work will lower the average Canadian reactor performance for a few years, overall system lifetime capacity factors are still expected to meet the 80% planning target. Units 3 and 4 of Bruce A operated well in 1991, and the four-unit Pickering B and Bruce B stations had average capacity factors of about 91% and 88%, respectively, for the 10-month period ending October 31, 1991. New Brunswick's Point Lepreau NGS continues to perform very well, with a 10-month gross capacity factor (to November 1991) in excess of 97% compared with a 94% capacity factor since its in-service date in 1983.

On the international front, the Canadian government approved a C$315 million loan to Romania in September to enable the completion of construction on the Cernavoda 1 CANDU 6 reactor. In December 1991, Atomic Energy of Canada Limited (AECL) received an invitation to bid on two additional CANDU 6 reactors for South Korea, namely Wolsong 3 and 4, which are scheduled to come into service in 1998 and 1999, respectively. AECL signed the contract for Wolsong 2 in December 1990, and the reactor is scheduled to go into service in 1997.

In Ontario, the New Democratic Party (NDP) government continues to promote demand-side management initiatives, including intensified energy conservation efforts by Ontario Hydro, energy efficiency and supply alternatives, and a moratorium on new nuclear power facilities. Ontario Hydro will be permitted to complete the Darlington units under construction and to continue the research and development required for existing reactor programs. Public hearings by the Ontario Environmental Assessment Board into Ontario Hydro's 25-year Demand/ Supply

Plan commenced in April 1991 and could last two years. In mid-December, Ontario Hydro released a dramatically revised version of its 25-year plan, reflecting NDP policies, wherein construction of any new generating plants will be delayed for the foreseeable future, and reduced forecast load growth will be met by non-utility generation and demand-side management.

On September 20, 1991, AECL and Saskatchewan Power Corporation (SaskPower) signed a Memorandum of Understanding (MOU) relating to the establishment of a nuclear industry in Saskatchewan, including the design and siting of a prototype CANDU 3. Activities under the MOU were put on hold following the election of an NDP government in the fall of 1991, although AECL has established an office in the province. Over a six-month period in 1991, an independent panel conducted consultations on the province's energy options; the main recommendations in its preliminary report, released in November 1991, are to study current levels of energy efficiency, analyze the economic potential of demand-side management, and conduct a public review of nuclear generation for the province. In New Brunswick, negotiations continued with the provincial utility for the supply of a CANDU 3 reactor.

OUTLOOK

In the 1970s, anticipation of flourishing civilian nuclear power programs led to enormous uranium inventories; through the 1980s, the global uranium market continued to deteriorate. Although reactor consumption has exceeded mine output for several years and inventory draw-down has begun to reach meaningful proportions, the break-up of the Communist system has undoubtedly played a key role in delaying the restabilization of the international uranium market.

Canada's uranium producers have struggled with these developments, and a sizeable portion of domestic production capability has been displaced. Many new deposits have been identified in Canada for future development, but this will require a mix of contracts with better prices than those available on the current spot market. The Canada-U.S. Free Trade Agreement may give Canada access to the world's largest market with the lowest inventory levels, but there is a limit to the market share available to Canadian producers that depends on the degree of market penetration achieved by the former Soviet Republics.

As noted above, Canada has several new uranium projects being developed for production. Because of the potential environmental implications of their development, they will be subjected to intensive reviews before they receive regulatory approval. Such reviews will inevitably lead to higher development costs and longer lead times, and it would be imprudent to be complacent about the timing, availability and cost of uranium from these potential new production projects.

Future developments will require prices that are higher than those prevailing in the current marketplace. A recent Canadian study by Mackenzie,[4] which examined the impact of taxation on uranium mining projects in Australia and Canada, supports this view with respect to the development of new uranium projects. The study, carried out for EMR by the Centre for Resource Studies at Queen's University, concluded that "only the very best uranium mining projects have a chance of being developed under current market conditions, and that even these can be rendered uneconomic by excessive taxation regimes. It follows that exceptionally good-quality targets will have to be identified to provide the economic justification for uranium exploration."

It is clear that nuclear power will continue its important role in the electricity supply mix of many countries, including Canada. Most analysts still project a need for new production centres in the latter half of the 1990s, and Canada's uranium industry is well placed to maintain its role as the world's principal uranium supplier. The potential for additional uranium discoveries in Canada is excellent and policies have been put in place that are designed to encourage investment and maintain Canada's role as a reliable and competitive supplier for its trading partners. Given its many strengths, the prospects for the future of Canada's uranium industry must be viewed with cautious optimism.

REFERENCES

1 The price at which transactions for significant quantities of natural concentrates could be concluded as of the last day of the month according to the Nuclear Exchange Corporation (Nuexco), a Colorado-based uranium brokerage firm.

2 "Canada Remains World's Leading Uranium Supplier"–News Release 91/87, EMR Canada, September 23, 1991.

3 In certain cases, the identified operator has reported the total expenditures of a joint-venture effort. Therefore, contributions by other parties not responding to the URAG survey are accounted for in the $45 million total.

4 Mackenzie, Brian W. et al, "Uranium Mining in Canada and Australia: The Impact of Taxation," Centre for Resource Studies, Queen's University, Kingston, Ontario, 1991.

Note: Information in this review was current as of January 31, 1992.

TABLE 1. URANIUM PRODUCTION IN CANADA AND WORK FORCE SUMMARY, 1989 AND 1990

Province and Producer	Total Work Force[1] (Dec. 31) 1989	1990	Annual Output[2] (tU) 1989	1990
ATHABASCA BASIN, SASKATCHEWAN				
Cluff Mining	120	145	727	771
Cameco Corporation				
Key Lake	350	370	4 893	4 976
Rabbit Lake[3]	220	230	1 796	–
Subtotal	690	745	7 416	5 747
ELLIOT LAKE, ONTARIO				
Denison Mines Limited	1 580	1 300	1 697	1 319
Rio Algom Limited				
Quirke[3]	990	–	1 074	774
Panel[3]	590	–	665	440
Stanleigh	430	450	471	449
Subtotal	3 590	1 750	3 907	2 982
Total	4 280	2 495	11 323	8 729

Sources: Company annual reports; Atomic Energy Control Board open files.
– Nil.
[1] Figures rounded. [2] Primary output. In 1990, an additional 50 tU was recovered by the Elliot Lake producers from Cameco's refinery/conversion facility by-products, compared with about 31 tU in 1989 and 73 tU in 1988. These amounts are NOT included in the Canadian totals of primary uranium production. [3] The Rabbit Lake mill, closed throughout 1990, was restarted in August 1991; the Quirke and Panel operations were permanently closed in August 1990.

TABLE 2. VALUE OF URANIUM SHIPMENTS[1] BY PROVINCE, 1986-91

	Unit	1986	1987	1988	1989	1990	1991p
Ontario producer shipments	tU	4 752	4 901	3 872	4 099	4 597	1 293
Value of shipments	$ million	566	581	446	501	627	165
Saskatchewan producer shipments	tU	6 750	8 711	8 194	6 896	5 123	6 520
Value of shipments	$ million	476	601	572	412	261	307
Total producer shipments	tU	11 502	13 612	12 066	10 995	9 720	7 813
Total value of shipments	$ million	1 042	1 182	1 018	913	888	472

p Preliminary.
[1] Shipments in tonnes of uranium (tU), contained in concentrate, from ore-processing plants.

TABLE 3. OPERATIONAL CHARACTERISTICS OF EXISTING CANADIAN URANIUM PRODUCTION CENTRES, 1990

Company/ Facility Name	Ore-Processing Plant[1] Capacity Nameplate/ Actual	Recovery Overall	Annual Throughput Ore Total	Ore Grade
	(t/d)	(%)	(t)	(%)
Cluff Mining/ Cluff Lake	+ 900/ 850	96	127 000	0.64
Denison Mines Limited/ Elliot Lake	7 700/ 6 670	94	1 942 000	0.07
Cameco Corporation/ Rabbit Lake	2 000/ n.a.	n.a.	n.a.	n.a.
Cameco Corporation/ Key Lake	+ 800/ + 820	99	264 000	2.0
Rio Algom Limited/ Elliot Lake				
Quirke[2]	5 000/4 580	93	1 176 400	0.07
Panel[2]	3 000/2 800	92	679 700	0.07
Stanleigh	+ 4 500/2 750	95	605 100	0.08

Sources: Corporate annual reports; Atomic Energy Control Board open files.
n.a. Not applicable (mill on standby).
[1] Figures rounded. [2] Closed August 1990.

TABLE 4. URANIUM EXPLORATION ACTIVITY IN CANADA, 1976-90

Year	Expenditures[1]	Drilling[2]	Million-Dollar Projects[3]
	($ million)	(km)	(number)
1976	44	155	4
1978	90	334	7
1980	128	503	24
1982	71	247	13
1984	35	197	12
1986	33	162	11
1987	37	164	12
1988	59	201	11
1989	58	158	11
1990	45	66	6

[1] Direct exploration and drilling expenditures in current dollars. [2] Exploration and surface development drilling; excludes development drilling on producing properties. [3] Number of projects where direct exploration and drilling expenditures exceeded $1 million in current dollars.

TABLE 5. ESTIMATES OF CANADA'S URANIUM RESOURCES RECOVERABLE FROM MINEABLE ORE,[1] JANUARY 1, 1990, AND JANUARY 1, 1991

Price Ranges Within Which Mineable Ore is Assessed[2]	Measured		Indicated		Inferred	
	1/1/90	1/1/91	1/1/90	1/1/91	1/1/90	1/1/91
			(000 tU)			
Up to $100/kg U	45	29	87	117	177	149
$100 to $150/kg U	2	3	93	65	93	80
Subtotal	47	32	180	182	210	229
$150 to $300/kg U	22	17	33	40	91	94
Total	69	49	213	222	301	323

[1] Actual or expected losses in mining recovery and ore processing have been accounted for; these factors were individually applied to resources tributary to existing or prospective production centres. In underground operations, mineable ore is generally 75% to 85% of the ore-in-place; higher mining recoveries are achievable in open-pit operations. Ore-processing recoveries in Canada normally range from 90% to 97%; Canada's weighted average mill recovery for existing conventional uranium operations was 96% in 1990. [2] The Canadian dollar figures reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used and the processing losses expected. The price of $100/kgU was used by URAG to illustrate those resources that were of economic interest to Canada in 1989 and 1990.
Note: $1/lb U_3O_8 = $2.6/kgU.

TABLE 6. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1984-90

	1984	1985	1986	1987	1988	1989	1990
				(tonnes U)			
Canada[1]	11 170	10 880	11 720	12 440	12 470	11 350	8 780
United States	5 720	4 350	5 200	5 000	5 190	5 320	3 420
South Africa	5 740	4 880	4 610	3 960	3 850	2 950	2 530
Namibia	3 690	3 600	3 300	3 540	3 600	3 100	3 210
Australia	4 390	3 250	4 150	3 780	3 530	3 660	3 530
Niger	3 400	3 180	3 110	3 000	2 970	2 990	2 830
France	3 170	3 200	3 250	3 380	3 390	3 240	2 830
Gabon	1 000	940	900	800	930	850	710
Other[2]	950	900	870	890	910	940	3 800
Total[3]	39 230	35 180	37 110	36 790	36 840	34 400	31 640

Sources: *Uranium: Resources, Production and Demand*, a report jointly produced by the Nuclear Energy Agency of the OECD and the International Atomic Energy Agency, and miscellaneous national and international reports.
[1] Canadian figures from 1988 onward include uranium recovered from refinery/conversion facility by-products, and differ from primary production figures shown elsewhere. [2] Includes Argentina, Belgium, Brazil, Germany (West), India, Israel, Japan, Portugal, Spain and Yugoslavia; for 1990, Pakistan, Hungary and Germany (East) are included. [3] Totals are of the listed figures only.
Note: Country figures are rounded to the nearest 10 tU.

TABLE 7. CANADIAN URANIUM EXPORT PRICE,[1] 1974-91

Year	Average Export Prices: Current Dollars	Average Export Prices: Constant 1991 Dollars	Spot Sale Portion of Deliveries
	($kg/U[2])		(%)
1974	39	107	n.r.
1975	52	129	n.r.
1976	104	238	n.r.
1977	110	237	n.r.
1978	125	254	n.r.
1979	130	240	n.r.
1980	135	225	n.r.
1981	110	166	1
1982	113	157	1.5
1983	98	129	10
1984	90	115	26
1985	91	114	20
1986	89	108	21
1987	79	92	35
1988	79	88	13
1989	74	78	<1
1990	71	73	<1
1991	61	61	<2

n.r. Not reported.
[1] EMR's Uranium Resource Appraisal Group (URAG) derives the Export Price figure annually. It is based on the average price under all export contracts made by Canadian producers for deliveries in the given year; prices are rounded.
[2] \$/kgU x 0.38465 = \$/lb U_3O_8.
Note: The constant dollar values are derived using the Implicit Price Index for Gross Domestic Product.

TABLE 8. CANADIAN URANIUM UNDER EXPORT CONTRACTS[1]

Country of Buyer[2]	Tonnes U
Argentina[3]	10
Belgium	3 110
Finland	2 858
France	10 095
Germany	14 580
Italy	1 115
Japan	21 178
South Korea	6 888
Spain	3 559
Sweden	8 995
Switzerland	154
United Kingdom	7 039
United States	75 181
Total	154 762

[1] The nominal quantity of uranium in all contracts reviewed and accepted under Canadian uranium export policy since September 5, 1974. Country totals are adjusted to reflect new and amended contracts, and the exercising of quantity-flexibility options, as of December 31, 1991. [2] In most cases, indicates country of end-user. [3] As manufactured fuel bundles for Argentina's CANDU reactor.

TABLE 9. EXPORTS OF URANIUM OF CANADIAN ORIGIN, 1984-90

Country of Final Destination	1984	1985	1986	1987	1988	1989	1990
			(tonnes of contained uranium[1])				
Belgium	121	157	63	–	153	190	–
Finland	137	81	116	142	151	71	83
France	525	612	1 013	1 438	964	696	799
Indonesia	–	–	–	–	–	1	–
Italy	50	53	301	293	–	46	–
Japan	2 436	1 799	816	1 317	717	1 729	2 005
Netherlands	–	–	85	40	–	–	–
South Korea	30	194	402	828	874	635	339
Spain	–	–	150	150	100	97	–
Sweden	254	514	449	377	783	497	285
Turkey	–	–	2	–	–	–	–
United Kingdom	692	685	700	824	1 204	871	882
United States	2 397	3 524	3 692	6 063	4 682	3 950	4 035
West Germany	295	269	654	1 317	806	615	220
Total	6 937	7 888	8 443	12 789	10 434	9 398	8 648

Source: Atomic Energy Control Board.
– Nil.
[1] Some of this uranium was first exported to an intermediate country for conversion and/or enrichment, prior to transfer to the country of final destination.

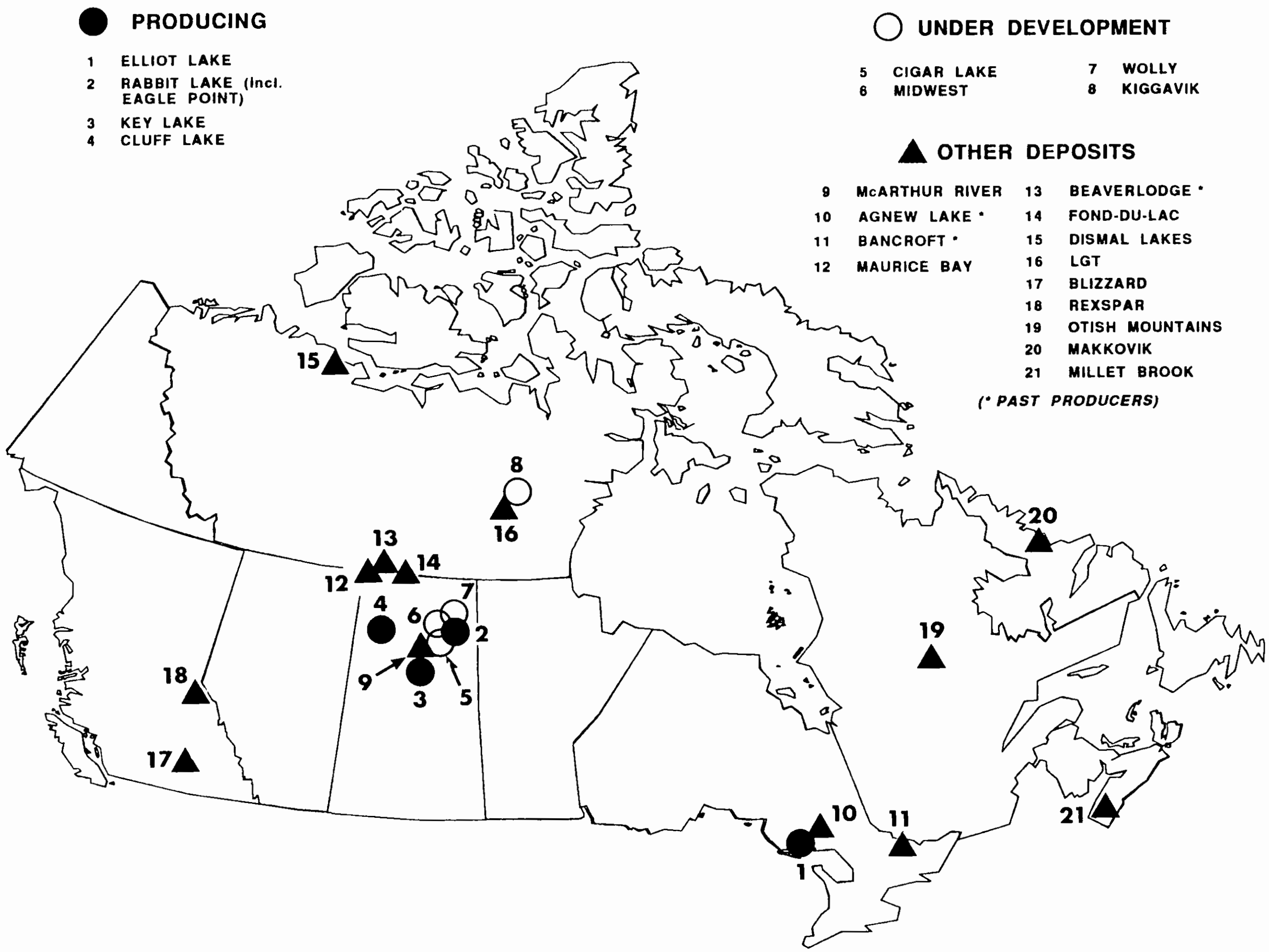
TABLE 10. NUCLEAR POWER PLANTS IN CANADA[1]

Reactors	Owners	Net Capacity	In-Service Dates
		(MWe)	
Pickering 1 to 4	Ontario Hydro	2 060	1971-73
Bruce 1 to 4	Ontario Hydro	3 076	1977-79
Point Lepreau	NBEPC[2]	635	1983
Gentilly 2	Hydro-Québec	638	1983
Pickering 5 to 8	Ontario Hydro	2 064	1983-86
Bruce 5 to 8	Ontario Hydro	3 394	1984-87
Darlington 1 to 4	Ontario Hydro	3 524	1990-93[f]
Total net capacity (MWe) expected by 1993		15 391	

[f] Forecast.
[1] As of January 1991. [2] The New Brunswick Electric Power Commission.

Figure 1

URANIUM DEPOSITS IN CANADA

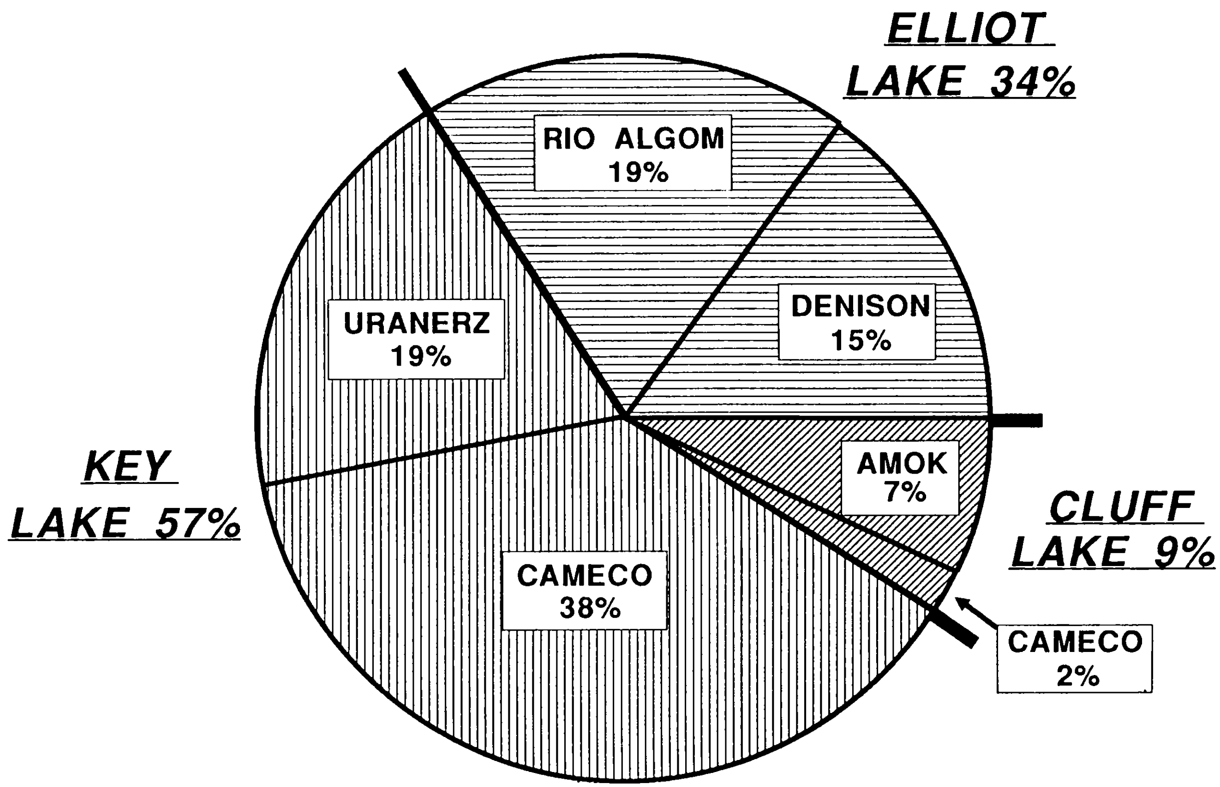


Source: Uranium Division, Electricity Branch, Energy, Mines and Resources Canada.

Figure 2

CANADIAN URANIUM PRODUCTION AND OWNERSHIP IN 1990

(1990 PRIMARY PRODUCTION = 8 730 TONNES OF URANIUM)



Note: Cameco's Rabbit Lake Mill was closed throughout 1990.
Source: Uranium Division, Electricity Branch, Energy, Mines and Resources Canada.

Zinc

Philip Wright

The author is with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-4403

The zinc market performed poorly in 1991 with increased mine and metal production and rising stock levels in the face of continued weak demand. The average price for Special High Grade (SHG) zinc on the London Metal Exchange (LME) was US51¢/lb, down from US69¢/lb in 1990 and US78¢/lb in 1989.

Western World zinc consumption reached a record 5 352 000 tonnes (t) in 1991, up from 5 250 000 t in 1990 as increases in demand in Europe and Asia more than offset weaker demand in the United States and the United Kingdom. Mine production reached a record level of about 5 504 000 t in 1991 with increases in Australia, the United States and Peru offset partially by a decrease in Canada. Zinc metal production also set a record at about 5 374 000 t, with increases in Canada, Peru and Japan.

Zinc stocks at the end of 1991 represented about six weeks of consumption with record stocks on the LME. Substantial metal and concentrate surpluses are forecast for 1992 unless further production cutbacks or closures are announced. Combined with the forecasted continued weak demand for much of the year and a large stock level, prices are expected to weaken further in 1992. The price of zinc is expected to average about US45¢/lb in 1992.

CANADIAN DEVELOPMENTS

Canadian mine production in 1991 fell to 1 148 000 t, a decrease of 55 000 t from 1990. The decrease was the result of production cutbacks, transportation problems, several mine closures and the protracted labour dispute at the operation of Brunswick Mining and Smelting Corporation Limited. These problems were partially offset by the return to production of Cominco Ltd.'s Sullivan mine. Despite the decline for the fourth consecutive year, Canada remained the world's largest producer of zinc concentrates with about 21% of Western World supply.

In 1991, three mines opened while six mines closed. Three mines are scheduled for renewed labour contracts in 1992 and production cutbacks, initiated in 1991, will have a further impact in 1992 along with any further reductions in production which may be initiated due to continued low zinc prices.

Canadian metal production rose in 1991 to 660 500 t, an increase of 11.6% over 1990 and a return to near the level of 1989. The increase reflected completion of design modifications at Cominco Ltd.'s Trail operation in order to treat Red Dog concentrate, and the return to consistent feed with the re-opening of the Sullivan mine.

British Columbia

Cominco continued modifying its zinc smelter at Trail to accommodate concentrates from the Red Dog mine in Alaska. In June, as part of its efforts to increase efficiency and reduce costs, the company announced the layoff of 10% of its workforce. Due to continuing low zinc prices, Cominco announced in November that it would operate the 300 000-t/y Trail zinc refinery at 90% capacity.

Bethlehem Resources Corporation and Goldnev Resources Inc. re-opened the 1000-t/d Goldstream mine near Revelstoke in July. The partners acquired the former producer from Noranda Inc. in 1989. The mine has a capacity of 3000 t/y of zinc in concentrates.

At the Myra Falls mine of Westmin Resources Limited, underground diamond drilling intersected two new copper-zinc discoveries known as the Battle and Gap zones. Westmin began underground development from the H-W mine workings late in 1991 to reach the new zones late in 1992. In an attempt to cut operating costs at the mine, Westmin laid off 18% of its workforce in September and switched to lower-cost longhole open-stoping techniques.

Minnova Inc. and Rea Gold Corporation began the underground phase of mining at their Samatosum mine near Barrière in September. The mine is currently operating at 450 t/d. Open-pit reserves will be exhausted in April 1992, while underground reserves are currently sufficient to sustain underground mining until September 1992.

The British Columbia government has agreed, in principle, to contribute $37 million to transportation facilities for the $140 million development of the Stronsay lead-zinc project 240 km northwest of Fort St. John. This mine is owned 70% by Curragh Resources Inc. and 30% by Asturiana de Zinc SA. The deposit, formerly known as Cirque, has a geological reserve of 52 million tonnes (Mt) averaging 8% zinc, 2% lead and 42 grams per tonne (g/t) silver.

A plan between Placer Dome Inc. and International Corona Corporation to develop the Eskay Creek deposit north of Stewart fell through when the two companies could not agree on certain technical details. International Corona and Placer Dome are the principal owners of Prime Resources Group Inc. and Stikine Resources Ltd., each of whom owns 50% of the Eskay Creek gold deposit, which is also rich in base metals.

Yukon

Curragh Resources Inc. began production from its Vangorda open pit at Faro. Mining of the Vangorda and nearby Grum deposits is designed to maintain production of 200 000 t/y of zinc in concentrates as operations at the original Faro mine gradually come to a close. The Grum deposit is scheduled for production in 1992. Shipments from Faro were hindered by heavy summer rains which caused transport problems, and production was reduced by a 10-week labour dispute which began in early April.

In September, Curragh opened its Sa Dena Hes underground lead-zinc-silver mine, formerly known as the Mt. Hundere project, near Watson Lake. The mine, which has a capacity of 52 000 t/y of zinc in concentrates, was developed for a capital cost of $70 million. Lead and zinc concentrates from the mine are trucked to Skagway, Alaska, for shipment to world markets.

Manitoba

Hudson Bay Mining and Smelting Co., Limited (HBMS) closed its Rod mine at Snow Lake in August due to exhaustion of ore. At the Trout Lake mine, which is a joint venture between HBMS, Granges Inc. and Manitoba Mineral Resources Ltd., deep drilling from the mine workings continues to delineate several new massive sulphide lenses.

In December, HBMS announced that the $187 million modernization of its Flin Flon smelter complex would proceed. The project will result in a reduction of sulphur dioxide emissions by at least 25%, a reduction of airborne particulates by over 50%, and an improvement of the plant-site work environment. It will also ensure that Flin Flon operations conform to new environmental regulations to come into force in 1994.

Ontario

In May, Mattabi Mines Limited, a subsidiary of Noranda Minerals Inc., closed its Lyon Lake mine and Mattabi concentrator near Ignace. The Lyon Lake mine had a capacity of 30 000 t/y of zinc in concentrates.

At its Kidd Creek mine, Falconbridge Limited cut its zinc production by 20 000 t/y as a result of low zinc prices.

Minnova Inc. completed exploration drilling of the Pick Lake massive sulphide deposit near its Winston Lake mine at Schreiber. The deposit contains a reserve of over 1.6 Mt, grading 17.7% zinc and 1.1% copper, in two zones.

Pigment and Chemical Inc., one of North America's largest zinc oxide producers, closed its 18 000-t/y Milton, Ontario plant. The demand for zinc oxide had fallen in response to the recession.

Quebec

Breakwater Resources Ltd. suspended operations in June at its 500-t/d Estrades mine near Joutel due to low metal prices. Breakwater will consider re-opening the mine when base-metal prices improve. The mine had a capacity of 18 000 t/y of zinc in concentrates.

Production from the Normetal mine near La Sarre ceased in December as the orebody was exhausted. Ore from the mine was processed at Noranda's Mattagami mill. The mine, owned by Exploration Minière Normétal Inc. and Exploration Minière La Sarre Inc., had a capacity of 3000 t/y of zinc in concentrates.

Noranda opened its Norita East mine at Matagami in October. Ore from the mine is processed at the company's Mattagami mill. When in full production in 1992, the mine will have a capacity of 25 000 t/y of zinc in concentrates.

Noranda encountered start-up problems in the new cellhouse at its Canadian Electrolytic Zinc Limited zinc refinery at Valleyfield. Production was also hindered by a shortage of concentrates as a result of the prolonged strike at the Brunswick mine. In October, Noranda announced that it would hold 1991 zinc production to below 200 000 t/y at the 230 000-t/y refinery due to a reduced demand for zinc.

Aur Resources Inc. and Louvem Mines Inc. completed a feasibility study on their Louvicourt massive sulphide project near Val-d'Or. The capital cost of bringing a 5000-t/d mine at Louvicourt into production is expected to be $326 million, with production commencing in 1994. According to the study, diluted mineable reserves at Louvicourt are currently 22.8 Mt grading 4.0% copper, 2.0% zinc, 1.2 g/t gold and 30.8 g/t silver. In January, Aur announced that it had entered into an agreement in principle with Teck Corporation and Cominco Ltd. to develop the Louvicourt deposit.

Audrey Resources Inc. and partner Minnova Inc. concluded an agreement for the two-stage development of the 1100, B and C lenses beneath the current workings of the Mobrun mine near Rouyn-Noranda. In the first stage, the partners plan to drive an 885-metre (m) ramp to the 4845-m level to gain access to the upper portion of the 1100 lens and facilitate deep drilling on the B and C lenses. In the second stage, the current shaft would be deepened by 200 m to gain access to deeper portions of the 1100 lens. Reserves at Mobrun were exhausted in early 1992 and the mine is closed pending the new underground development.

On the Grevet property near Lebel-sur-Quévillon, VSM Exploration Inc. and Serem Québec Inc. continued exploration drilling. Preliminary geological reserves on the property now stand at 18.4 Mt grading 7.2% zinc, 0.4% copper, 0.2% lead and 31.3 g/t silver. The partners also began drilling on nearby optioned properties.

New Brunswick

The 10-month strike at Brunswick Mining and Smelting Corporation Limited's Brunswick mine at Bathurst was settled on May 8, 1991. The mine regained its full production rate of 10 500 t/d by the end of July. The company cut its workforce by over 10% after resuming production in an attempt to reduce operating costs. Brunswick is also switching from mechanized cut and fill to lower-cost blasthole open-stoping in the lower levels of the mine as increased rock stresses at depth require bulk mining methods.

Heath Steele re-started development of its C zone in September for production in early 1992. The zone was partially developed in the 1970s. Mining of the C zone will add two years to the life of the Heath Steele mill, which is currently processing 2600 t/d of ore from the B and Stratmet mines. In August, the mine also processed a 14 600-t shipment of ore from the nearby CNE open pit of Stratabound Minerals Corp. A second shipment of ore from the CNE mine is expected in early 1992.

Nova Scotia

Westminer Canada Limited suspended operations at its Gays River lead-zinc mine in May after experiencing continued groundwater and ground stability problems. The underground mine had a capacity of 16 000 t/y of zinc in concentrates. In November, the company put the mine and 800-t/d mill up for sale and stated that production could be resumed, by a new owner if further drainage wells and a better pumping system were installed.

WORLD DEVELOPMENTS

Western World mine production rose for the third consecutive year. The 1991 total of about 5 504 000 t was an increase of 2.5% over 1990. Increases occurred in Australia and Peru, but were partially offset by a decrease in Canada.

Europe

European output of zinc concentrates was down for the fourth consecutive year. In 1991, Europe accounted for 16% of the Western World total. Ten European mines closed in 1991, including four in Sweden and two in Spain. The largest were EXMINESA's (Exploracion Minera Internacional Espana S.A.) Rubiales mine in Spain with a capacity of 44 000 t/y of zinc in concentrates, and Outokumpu Oy's Vihanti mine in Finland with a capacity of 35 000 t/y of zinc in concentrates. By contrast, the only new mine capacity to come on stream in Europe in 1991 was at Pirites Alentejanas, SARL's Aljustrel pyrites mine in Portugal where a concentrator to produce 27 000 t/y of zinc in concentrates was opened.

Australia

Australian mine output rose for the fifth consecutive year in 1991 and accounted for 19% of Western World production. In Queensland, Pancontinental Mining Ltd. switched from open-pit to underground mining at its Thalanga mine. This resulted in a zinc capacity increase of 7500 t/y to 42 000 t/y of zinc in concentrates.

Also in Queensland, M.I.M. Holdings Limited experienced transportation problems early in the year at its Mt. Isa mine as heavy rains in northern Queensland disrupted the rail link to port facilities at Townsville. In an attempt to reduce operating costs by 20% over two years, M.I.M. Holdings announced a reduction of 200 staff positions at Mt. Isa. The company also recently announced the allocation of A$49.5 million to establish a fine-grinding project at Mt. Isa to increase recoveries of zinc, lead and silver.

At Denehurst Ltd.'s Woodlawn mine in New South Wales, the decline to the satellite Currawong orebody was completed. A tailings retreatment plant was opened at Woodlawn. A total capacity increase of 20 000 t/y of zinc in concentrates has resulted from the completion of these two projects.

Pasminco Ltd. lost about 4800 t of concentrate production at its Broken Hill mine in New South Wales due to damage to a haulage shaft caused by a malfunction in the hoisting system. The company also reduced production at its Elura mine by two thirds, or 57 000 t/y of zinc in concentrates, and reduced the workforce from 400 to 60.

In Tasmania, Pasminco reduced the workforce at its Rosebury mine in an attempt to lower operating costs. The company intends to maintain current production at the mine. At Aberfoyle Limited's Hellyer mine, higher-than-expected throughput and grades resulted in increased zinc concentrate production.

Murchison Zinc Co. Pty. Ltd. completed improvements to the ore-hoisting and loading system at its Scuddles mine in Western Australia, resulting in increased ore production. The nearby Golden Grove concentrator typically processes 2200 t/d of copper-zinc ore from the Scuddles mine.

In 1991, advanced exploration continued on several large lead-zinc deposits, including Century and Dugold River in northern Queensland and MacArthur River in the Northern Territory.

United States

Production of zinc concentrates from the United States represented 10% of the Western World total in 1991. The large increase since 1989 has been mainly from production at Cominco Ltd.'s Red Dog mine in Alaska.

Cominco shipped a total of 232 000 t of zinc in concentrates from its Red Dog mine during the 1991 shipping season from July 10 to October 8. Cominco expects the mine to be operating at its capacity of 325 000 t/y of zinc in concentrates within the next year.

Equinox Resources Ltd. opened its 1000-t/d Van Stone mine in Washington in April but temporarily suspended operations in October until lead and zinc prices improve. Concentrates from the Van Stone mine were trucked to Cominco's Trail metallurgical complex in British Columbia.

The mine produced 3000 t of zinc in concentrates in 1991.

Other mines which closed in 1991 were Bunker Hill Mining Company (U.S.) Inc.'s Bunker Hill mine, Alta Gold's Ward mine, Cyprus Minerals Company's Pinos Altos mine, New Butte Mining's Butte Hill mine, Star-Phoenix Mining Company's Star mine, and Washington Mining Company's Sunnyside mine. The total capacity closed was 62 000 t/y of zinc in concentrates.

Peru

Peru's mine output in 1991 increased, reaching 623 000 t, up 8% over 1990; this represented 11% of the Western World total. The increased production was due to fewer labour and production disruptions than occurred in 1990.

Expansions at Cia Minera Atacocha S.A.'s Atacocha mine and Soc. Minera El Brocal S.A.'s Colquijirca mine, and the closure of Cia Minera Colquirrumi S.A.'s San Agustin mine, led to a net increase in capacity of 9500 t/y of zinc in concentrates.

A three-week strike by 2000 unionized workers at Centromin Peru S.A.'s Cerro de Pasco mine affected the production of zinc late in the year.

SMELTING

Western World production of refined zinc reached a record level of about 5 374 000 t in 1991 despite production cutbacks late in the year. Smelter expansions in Europe, Mexico and the United States, along with new capacity in India, more than offset the closure of several smaller smelters in Europe.

Europe

European refined zinc production rose marginally from 1990. Asturiana de Zinc S.A. (ADZ) completed a US$100 million expansion of its smelter in Spain. The 100 000-t expansion makes Asturiana de Zinc the world's largest zinc smelter with a capacity of 320 000 t/y of refined zinc. Also in Spain, the 40 000-t/y Cartagena zinc smelter of Espanola del Zinc S.A. experienced several production losses throughout the year. The smelter was closed in December 1990 and January 1991 for not complying with environmental emission standards. The smelter was also closed from July 15 to August 31 due to roaster damage resulting from a month-long strike which began on June 8.

In December, Acec-Union Minière SA announced that it would close its 120 000-t/y Overpelt zinc smelter in Belgium in early 1992 and postpone the planned expansion of its Balen zinc smelter, also in Belgium, until 1995. The decision is part of a major reorganization of the company.

In Germany, expansion commenced on the 140 000-t/y Datteln electrolytic zinc plant. The 40 000-t/y expansion will include a new tank house, a new purification method, and a pressure leach circuit. In November, the plant was closed for four weeks for roaster repairs and it lost 7400 t of zinc production. Also in Germany, Berzelius Metalluetten GmbH closed its Duisburg zinc smelter for six weeks for repairs and to complete a 15 000-t/y expansion which will bring capacity to 100 000 t/y of refined zinc.

Three small European zinc refineries with a capacity of 57 000 t/y of refined zinc closed in 1991. These were Bleiberger Bergwerks Union AG's Gailitz smelter in Austria, V.E.B. Bergbau und Hutten's Freiberg smelter in Germany, and Metalquimica del Nervion S.A.'s Erandio smelter in Spain.

In Italy, Pertusola Sud SpA announced that it will close its 100 000-t/y Crotone zinc refinery in 1992 for two years while it is modernized.

Peru

Minero Peru Comercial SA continued to experience production disruptions in 1991 at its 102 000-t/y Cajamarquilla zinc refinery due to power restrictions following terrorist activities and a two-day strike that took place in February. A three-week strike also affected production at Centromin Peru S.A.'s 70 000-t/y La Oroya zinc refinery.

United States

Laclede Steel Corp. opened its 7000 t/y secondary zinc plant in September. The US$25 million treatment plant will process 40 000 t/y of electric arc furnace dusts at the company's Illinois steel works to produce Prime Western-grade zinc.

Mexico

A four-week strike at Met-Mex Penoles SA de CV's Torreon smelter forced the company to declare force majeure on zinc shipments. The dispute, which began February 14, was over wages and other benefits. Penoles completed a 25 000-t/y expansion at the Torreon plant during the year to bring capacity to 130 000 t/y of refined zinc.

India

Hindustan Zinc Ltd. commissioned its new 70 000-t/y zinc smelter in the State of Rajasthan in October. The smelter, employing the Imperial Smelting Process, will secure feed from Hindustan Zinc's own mines, including the nearby Rampura-Agucha mine which started up in March and which will reach its full capacity of 70 000 t/y of zinc in concentrates in 1992.

Japan

Mitsui Mining & Smelting Co. Ltd. began construction of a new 72 000-t/y zinc refinery, expected to cost US$46 million. The new refinery will replace the existing plant, located at the same site, thereby increasing cost efficiency.

Atika Zinc Co. Ltd. announced that the expansion planned for its 156 000-t/y Iijima zinc smelter would be scaled down from 78 000 t/y to 44 000 t/y. The decision was taken because of low zinc prices and weak demand for refined zinc.

SECONDARY ZINC

With the increasing use of zinc-galvanized steel in the automobile and construction industries, secondary zinc from electric arc furnace dusts has become an increasingly important source of zinc. Electric arc furnace dusts contain certain toxic metals, such as cadmium, and currently must be disposed of in hazardous landfill sites. The decreasing space available at such sites and the associated increases in disposal costs have provided a further incentive for recycling. In recent years, technologies for recycling these materials, which contain zinc, have been developed.

The Waelz kiln is the most common method of processing electric arc furnace dusts. Several other pyrometallurgical processes exist in the pilot plant stage.

The requirement of such plants to be near their feed source, ie., steel mill complexes, would suggest that treatment of electric arc furnace dusts will be most important in the United States, Japan and Western Europe. Recently, an electrochemical process has been developed for removing zinc from steel.

CONSUMPTION AND USES

Western World consumption of zinc reached a record 5 352 000 t in 1991, up 1.9% from the previous record set in 1988. The weaker demand in the United States and the United Kingdom was more than offset by increased demand in Asia and the rest of Europe.

Zinc is used extensively in the automobile and construction industries for corrosion protection and remains the most cost-effective means of protecting steel against corrosion. The use of zinc for galvanizing has grown steadily in recent years and this trend is expected to continue in the future.

Zinc is widely used because of its special qualities, which include: its low melting point, which facilitates shaping by casting; its high electrochemical activity, which provides cathodic corrosion and contact protection (galvanizing) for iron and steel products; and its ability to alloy readily with copper to make brass. About 46% of zinc consumption is in galvanizing. The automotive industry is the largest consumer of galvanized steel. Consumer demand for increased corrosion protection has resulted in car manufacturers using more zinc-coated steel in bodywork. Zinc coatings are applied by electrogalvanizing for exposed painted parts requiring high surface quality, and by hot-dip galvanizing for unpainted parts.

Galvanized steel is used in construction for structural components, roofing, siding and reinforcing bars. Zinc and zinc-aluminum thermally sprayed coatings are utilized for long-term corrosion protection of large steel structures such as bridges and hydro-electric transmission towers. The manufacture of brass and bronze is the second most important use of zinc, accounting for 20% of consumption. These alloys are used in plumbing fittings, heating and air conditioning components, and other products. The third most important use of zinc is in the die-casting industry for products such as builders' hardware and automobile fittings. The development of new alloys and manufacturing techniques, such as thin-walled die-casting, has taken place in recent years to make zinc alloy castings more competitive relative to plastics and other substitute materials. The balance of zinc consumption is for items such as zinc semi-manufactures, oxides, chemicals and zinc dust. Zinc oxide is an important component in the manufacture of tires and rubber products.

Rolled zinc has been a popular roofing material in parts of Europe for many years. Eight Canadian zinc producers have joined together to sponsor the zinc façade for the Canadian pavilion at Expo '92 in Seville, Spain. The 2000-m^2 façade will be covered with one-metre by one-metre sheets (about 50 t) of pre-weathered zinc.

Galfan, a zinc alloy developed by the International Lead-Zinc Research Organization, Inc. (ILZRO), continues to outperform normal galvanized steel and other coatings, such as Galvalume, in corrosion protection. It has high formability and paintability. Galfan, which contains 90% zinc, 5% aluminum and a small but significant amount of rare earth elements, was first used commercially in Japan in 1983. In 1991, producers of Galfan-coated products formed the North American Galfan Development Association to increase the awareness and consumption of Galfan-coated steel.

INTERNATIONAL LEAD AND ZINC STUDY GROUP

The International Lead and Zinc Study Group was formed in 1959 to improve market information and to provide opportunities for regular inter-governmental consultations on lead and zinc markets. Particular attention is given to providing regular and frequent information on supply and demand and its probable development.

The Study Group is headquartered in London, England. Its membership includes most major lead- and zinc-producing and consuming countries. While it has an extensive information-gathering and dissemination role, the Group has no market intervention powers. It holds a general session each year in the fall. Member countries' delegations include industry representatives as advisors. Canada has been an active member since its inception, and chaired the Group in 1988 and 1989.

The 36th Session of the Study Group was held in Vienna, Austria, in October 1991, and was attended by representatives of 28 member countries as well as observers from several nations and organizations. In addition to statistical trends, a review of current mine and smelter projects, and the economic outlook for lead and zinc, the 1991 session focused on trade and environmental issues, and recycling.

PRICES AND STOCKS

Zinc prices continued to decline in 1991 due to a weakening demand combined with rising metal stocks and increased metal production due to fewer production problems than in 1990. The average price on the London Metal Exchange (LME) for 1991 was US50.6¢/lb.

Zinc prices began the year at US56.7¢/lb, falling to 51.7¢ in January with the start of the Gulf war. After trading in the 52¢-56¢ range through February and March, a market squeeze, compounded by rising LME stocks and production problems in Australia, raised the price of zinc to its high for the year of 65.1¢ on April 16. The squeeze, which saw the cash/three-month backwardation reach $240/t, was not based on supply/demand fundamentals and the price soon fell to 52.6¢ by month-end.

After the announcement in early May of a settlement at the Brunswick mine, the zinc price dropped and traded throughout the summer in a narrow range. It reached its low for the year of 44.1¢ on October 15 amid weakening demand, record LME stock levels and a growing metal surplus. Zinc prices rose in November and December to 56¢. Although some production cuts and closures were announced by the industry, the rise was due more to technical reasons than to market fundamentals. Zinc closed the year at 53.4¢/lb.

Total reported stocks of refined zinc stood at 550 000 t at the end of 1990, which represented 5.5 weeks of metal consumption. Although producer, consumer and merchant stocks all fell slightly in 1991, stocks of zinc on the LME reached their highest total since the introduction of SHG zinc in September 1988. Total stocks at the end of 1991 stood at 624 000 t, a substantial rise from the beginning of the year.

HEALTH AND THE ENVIRONMENT

Canada's four zinc smelters all use roast-leach-electrolysis technology. Three of these smelters recover a high percentage of the sulphur contained in the original feed as sulphuric acid or elemental sulphur. The modernization of Hudson Bay Mining and Smelting Co., Limited's smelter in Flin Flon to install zinc pressure leach (ZPL) technology commenced in the summer of 1991. The ZPL circuit captures sulphur in its elemental form instead of sulphur dioxide. The creation of elemental sulphur in the zinc plant will result in a 25% reduction in sulphur dioxide emissions for the Flin Flon complex, allowing it to meet Manitoba's 1994 sulphur dioxide emission regulations.

Environmental issues, such as metals toxicity, mine-site reclamation, recycling and hazardous waste disposal, are having an increasing influence on the metals industry. In 1991, 14 mining companies from around the world formed the International Council on Metals and the Environment (ICME) to help industry become more active in helping develop and implement sound environmental and health policies and practices. The ICME is headquartered in Ottawa and joins a growing number of industry associations, such as the Washington-based American Zinc Association, in an attempt to address environmental issues affecting the zinc industry.

OUTLOOK

The main uses of zinc are in the automobile and construction industries; therefore, the demand for zinc is greatly affected by general economic performance. The current recession is expected to continue well into 1992. Western World zinc consumption in 1992 should be equal to that for 1991 as the world economy falls deeper into a recession before improving later in 1992.

Western World mine production is also expected to remain static. Increases in Australia, India and North America will be offset by reductions in Europe and Peru. Additional mine closures due to continued low metal prices are also expected. A large surplus of zinc concentrates will likely occur in 1992.

Zinc smelting capacity increased by 238 000 t in 1991. Further expansions in 1992 will be offset by announced closures in Europe resulting in a 264 000-t reduction of capacity. Despite these closures and announced production cutbacks by Canadian smelters, a surplus in zinc metal production of 200 000-250 000 t is expected for 1992.

Prices, which fell considerably in 1991, are expected to weaken further in 1992 as the anticipated increase in demand late in the year is not expected to be enough to eliminate the surplus of zinc metal created by high smelter production, high stock levels and increased imports from the Eastern Bloc. The average price of zinc in 1992 is forecast to be about US45¢/lb.

In the longer term, zinc consumption in the Western World is projected to grow at an annual average rate of 1.5% to the end of the century. Although zinc use in galvanizing will see steady growth, particularly in the continuous galvanizing line, demand is not expected to increase in die-casting where thin-walled die-cast technology is implemented to keep zinc cost-competitive with substitute materials.

In 1992, Canadian mine production should increase marginally over 1991 with the settlement of labour disputes in New Brunswick and the Yukon. Mine production may be reduced, however, if further production cutbacks or closures are implemented due to continuing low metal prices or if labour negotiations are unsuccessful for three contracts coming due. Several new deposits discovered during a high level of base-metal exploration in the late 1980s and in 1990 will likely start production in the mid-1990s, given favourable prices. Canadian metal production is expected to be lower than in 1991 due to announced cutbacks, and it will be lowered even further if labour disputes occur at Trail or Valleyfield in 1992.

Note: Information in this review was current as of January 31, 1992. Tables have been subsequently updated to accurately reflect more recent world production and consumption figures for 1991.

7904.00	Zinc bars, rods, profiles and wires						
7904.00.10	Bars, rods or profiles, containing by weight 90% or more of zinc	Free	Free	Free	2.9%	8%	4.8%
7904.00.21	Bars, rods or profiles; wire, coated or covered	10.2%	6.5%	6.1%	2.9%	8%	4.8%
7904.00.22	Wire, not coated or covered	8%	5%	4.8%	2.9%	8%	4.8%
7905.00	Zinc plates, sheets, strip and foil containing by weight 90% or more of zinc						
7905.00.11	Of a thickness exceeding 0.15 mm but less than 4.75 mm, for making offset printing plates; of a thickness exceeding 0.15 mm but less than 4.75 mm, not polished, coated on one side with acid-resisting material, imported for use by grinders and polishers, to be prepared for use in photo-engraving	Free	Free	Free	2.9%	8%	7.2%
7905.00.19	Other	5.5%	3.5%	3.3%	2.9%	8%	7.2%
7905.00.20	Containing by weight less than 90% of zinc	10.2%	6.5%	6.1%	2.9%	8%	7.2%
7906.00	Zinc tubes, pipes and tube or pipe fittings (for example, couplings, elbows, sleeves)	10.2%	6.5%	6.1%	2.6%	8%	4.8%
79.07	Other articles of zinc						
7907.10	Gutters, roof capping, skylight frames and other fabricated building components	10.2%	6.5%	6.1%	3.9%	8%	4.9%
7907.90	Other						
7907.90.10	Anodes for electroplating	Free	Free	Free	2.3%-3.9%	7%	5.8%
7907.90.20	Discs or slugs, containing by weight 90% or more of zinc	5.5%	3.5%	3.3%	2.3%-3.9%	7%	5.8%
7907.90.90	Other	10.2%	6.5%	6.1%	2.3%-3.9%	7%	5.8%
7907.90.90.11	Not alloyed	10.2%	6.5%	6.1%	2.3%-3.9%	7%	5.8%
7907.90.90.12	Alloyed	10.2%	6.5%	6.1%	2.3%-3.9%	7%	5.8%

Sources: Customs Tariff, effective January 1992, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States, 1991; Official Journal of the European Communities, Vol. 34, No. L259, 1991, "Conventional" column; Custom Tariff Schedules of Japan, 1991.

1 GATT rate is shown; lower tariff rates may apply circumstantially.

Note: Where there is a tariff "range," a complete match of the HS code was not available; therefore, the high and low for the product in question is shown.

Zinc

TABLE 1. CANADA, ZINC PRODUCTION AND TRADE, 1990 AND 1991, AND CONSUMPTION, 1988-90

Item No.		1990		1991p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION					
	All forms[1]				
	Newfoundland	16 463	31 724	–	–
	Nova Scotia	x	x	x	x
	New Brunswick	233 933	450 788	169 887	212 529
	Quebec	120 599	232 395	114 890	143 727
	Ontario	276 110	532 064	221 052	276 536
	Manitoba	77 507	149 355	78 628	98 364
	Saskatchewan	x	x	x	x
	British Columbia	59 346	114 359	123 265	154 205
	Yukon	168 846	325 366	142 558	178 340
	Northwest Territories	218 241	420 550	223 024	279 002
	Total	1 179 372	2 272 649	1 079 912	1 350 970
	Mine output[2]	1 203 161	. .	1 148 189	. .
	Refined[3]	591 786	. .	660 552	. .
EXPORTS				(Jan.-Sept.)	
2608.00.30	Zinc content in zinc ores and concentrates				
	Germany[4]	103 917	104 277	99 001	63 697
	Belgium	193 575	148 250	77 265	46 660
	Japan	73 079	78 588	48 507	37 054
	Spain	27 745	23 870	49 503	34 915
	Italy	53 783	50 488	31 683	20 983
	South Korea	66 227	66 196	26 914	20 631
	France	59 803	55 395	31 615	19 614
	Netherlands	38 442	33 875	22 426	12 421
	Other countries	95 245	71 401	74 752	37 302
	Total	711 816	632 340	461 666	293 277
2600.00	Zinc content in other ores and concentrates[5]	4 369	855	3 228	603
2620.11	Ash and residues containing hard zinc spelter				
	India	398	223	74	48
	South Korea	91	16	1 055	28
	United Kingdom	219	175	–	–
	France	143	120	–	–
	United States	26	44	–	–
	Other countries	60	41	–	–
	Total	937	619	1 129	77
2620.19	Ash and residues containing mainly zinc, n.e.s.				
	United States	4 817	5 080	4 155	2 932
	India	1 416	1 408	690	561
	Taiwan	175	237	429	443
	South Korea	78	91	246	280
	United Kingdom	633	734	289	209
	France	457	286	308	144
	Other countries	187	142	147	149
	Total	7 763	7 978	6 264	4 718
2817.00	Zinc oxide; zinc peroxide				
	United States	26 866	47 526	16 184	21 145
	U.S.S.R.	306	476	306	401
	Other countries	120	239	35	70
	Total	27 292	48 241	16 525	21 616
2833.26	Zinc sulphate	–	–	15	9
7901.11	Zinc, not alloyed, unwrought, containing by weight 99.99% or more of zinc				
	United States	205 700	380 229	181 763	250 808
	Taiwan	6 787	12 047	10 023	14 758
	Japan	5 429	10 426	3 903	5 731
	Singapore	647	1 255	856	1 398
	Italy	546	1 052	715	1 155
	Kenya	1 101	2 130	99	128
	Ecuador	464	895	52	83
	Philippines	216	439	–	–
	Brazil	179	348	–	–
	Portugal	239	446	–	–
	Other countries	2 142	3 742	2 242	3 015
	Total	223 450	413 009	199 653	277 076

TABLE 1 (cont'd)

Item No.		1990 (tonnes)	1990 ($000)	1991p (tonnes)	1991p ($000)
IMPORTS (cont'd)					
2620.19	Ash and residues containing mainly zinc, n.e.s.	567	439	279	159
2817.00	Zinc oxides; zinc peroxide	2 440	3 314	2 188	2 458
2833.26	Zinc sulphate	2 477	1 333	2 873	1 522
7901.11	Zinc, not alloyed, unwrought, containing by weight 99.99% or more of zinc	2 416	4 683	471	671
7901.12	Zinc, not alloyed, unwrought, containing by weight less than 99.99% of zinc	2 398	4 736	255	366
7901.20	Zinc alloys, unwrought	4 668	9 049	2 761	4 140
7902.00	Zinc waste and scrap	1 614	1 890	311	394
7903.10	Zinc dust	555	1 203	263	437
7903.90	Zinc powders and flakes	278	648	187	391
7904.00	Zinc bars, rods, profiles and wire	2 036	4 459	952	1 625
7905.00	Zinc plates, sheets, strip and foil	690	1 900	759	1 975
7906.00	Zinc pipes or tubes and fittings	1 361	5 048	64	357
7907.90	Articles of zinc, n.e.s.	1 813	6 787	939	4 524
	Total	198 629	249 848	138 187	101 800

	1988 Primary	1988 Secondary[5]	1988 Total	1989 Primary	1989 Secondary[5]	1989 Total	1990 Primary	1990 Secondary[5]	1990 Total
	(tonnes)								
CONSUMPTION[6]									
Zinc used for or in the production of:									
Copper alloys (brass, bronze, etc.)	7 338	–	7 338	3 552	–	3 552	x	x	3 529
Galvanizing: electro	4 879	–	4 879	3 724	–	3 724r	x	x	2 243
hot dip	73 315	x	x	73 439r	x	x	x	x	61 090
Zinc die-cast alloy	22 264	x	x	21 928r	x	x	x	x	23 961
Other products (including rolled and ribbon zinc, zinc oxides)	33 993r	x	x	33 538	x	x	x	x	32 189
Total	141 789r	8 827r	150 616r	136 181r	6 590r	142 771r	116 100r	6 911r	123 011r
Consumer stocks, year-end	12 020r	1 015r	13 035r	13 344r	327	13 671r	10 091	1 098	11 189

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary; r Revised; x Confidential.
[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] Where applicable, data for East and West Germany have been combined. [5] Includes H.S. classes 2603.00.30 and 2607.00.30. [6] Consumer survey does not represent 100% of Canadian consumption and is therefore consistently less than apparent consumption.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, ZINC PRODUCTION, EXPORTS[1] AND DOMESTIC SHIPMENTS, 1975, 1980 AND 1985-91

	Production		Exports		
	All Forms[2]	Refined[3]	In Ores and Concentrates	Refined	Total
			(tonnes)		
1975	1 055 151	426 902	705 088	247 474	952 562
1980	883 697	591 565	434 178	471 949	906 127
1985	1 049 275	692 406	396 103	555 621	951 724
1986	988 173	570 981	450 249	427 176	877 425
1987	1 157 936	609 909	613 185	441 227	1 054 412
1988	1 370 000	703 206	816 884	551 521	1 368 405
1989	1 272 854	669 677	614 223r	495 061	1 109 284r
1990	1 179 372	591 786	716 185	452 070	1 168 255
1991p	1 079 912	660 552	464 894a	384 483a	849 377a

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; r Revised.
a Exports are January-September figures.
1 Beginning in 1988, exports are based on the new Harmonized System and may not be in complete accordance with previous method of reporting. Ores and concentrates include HS classes 2608.00.30, 2603.00.30 and 2607.00.30. Refined includes HS classes 7901.11 and 7901.12. 2 New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export.
3 Refined zinc produced from domestic and imported ores.

TABLE 3. WESTERN WORLD, PRIMARY ZINC STATISTICS, 1987-91

	1987	1988	1989	1990	1991
			(000 tonnes)		
Mine production (zinc content)	5 316	5 052	5 092	5 346	5 504
Metal production	5 058	5 240	5 215	5 178	5 373
Metal consumption	5 047	5 271	5 199	5 253	5 352

Source: International Lead and Zinc Study Group.

TABLE 4. WESTERN WORLD ZINC MINE PRODUCTION, 1988-91

	1988	1989	1990	1991
		(000 tonnes)		
EUROPE				
Germany[1]	75	64	59	54
Ireland	177	169	166	188
Spain	278	266	257	262
Sweden	193	163	158	155
Yugoslavia	71	75	76	74
Others	271	261	234	188
Subtotal	1 065	998	950	921
AFRICA				
South Africa	90	77	75	67
Zaire	76	73	62	50
Zambia	30	28	35	25
Others	61	71	70	72
Subtotal	257	249	242	214
OCEANIA				
Australia	739	811	884	1 038
AMERICAS				
Brazil	99	100	113	103
Canada	1 347	1 216	1 176	1 148
Mexico	288	284	299	299
Peru	485	598	577	623
United States	256	288	543	547
Others	135	170	199	243
Subtotal	2 610	2 656	2 907	2 963
ASIA				
Japan	147	132	127	133
Others	234	246	236	235
Subtotal	381	378	363	368
Total Western World	5 052	5 092	5 346	5 504

Source: International Lead and Zinc Study Group.
[1] Data prior to 1991 include former Federal Republic only.

TABLE 5. WESTERN WORLD ZINC METAL PRODUCTION, 1988-91

	1988	1989	1990	1991
		(000 tonnes)		
EUROPE				
Belgium	298	285	289	299
Finland	156	162	175	170
France	274	266	264	299
Germany[1]	356	353	338	346
Italy	242	246	248	256
Netherlands	210	203	208	201
Norway	122	121	125	125
Spain	256	257	257	274
United Kingdom	77	80	93	102
Yugoslavia	129	121	114	105
Others	31	32	21	17
Subtotal	2 151	2 125	2 142	2 194
AFRICA				
South Africa	85	85	92	92
Zaire	61	54	38	23
Others	58	41	34	31
Subtotal	204	180	164	146
AMERICAS				
Argentina	33	31	31	36
Brazil	139	156	154	157
Canada	703	670	592	661
Mexico	191	194	199	189
Peru	125	138	118	154
United States	330	358	358	355
Subtotal	1 521	1 547	1 452	1 552
ASIA				
Japan	678	665	688	731
Korea, Republic of	224	240	259	251
Others	160	164	170	175
Subtotal	1 062	1 069	1 117	1 157
OCEANIA				
Australia	302	294	303	325
Total Western World	5 240	5 215	5 178	5 374

Source: International Lead and Zinc Study Group.
[1] Data prior to 1991 include former Federal Republic only.

TABLE 6. WESTERN WORLD ZINC CONSUMPTION, 1988-91

	1988	1989	1990	1991
		(000 tonnes)		
EUROPE				
Belgium	175	174	178	200
France	290	279	284	289
Germany[1]	450	453	484	545
Italy	254	262	270	283
Spain	127	116	125	125
United Kingdom	193	194	189	183
Yugoslavia	117	107	111	105
Others	248	260	271	281
Subtotal	1 854	1 845	1 912	2 011
AFRICA				
South Africa	88	98	85	93
Others	67	69	68	71
Subtotal	155	167	153	164
OCEANIA				
Australia	90	88	82	71
New Zealand	18	23	16	16
Subtotal	108	111	98	87
AMERICAS				
Brazil	143	162	125	114
Canada	159	148	126	121
Mexico	116	105	110	109
United States	1 089	1 059	991	902
Others	166	135	126	127
Subtotal	1 673	1 609	1 478	1 373
ASIA	SIA			
India	142	135	130	122
Japan	774	769	815	844
Korea, Republic of	173	196	230	269
Others	392	367	437	482
Subtotal	1 481	1 467	1 612	1 717
Total Western World	5 271	5 199	5 253	5 352

Source: International Lead and Zinc Study Group.
[1] Data prior to 1991 include former Federal Republic only.

TABLE 7. CANADA, ZINC METAL CAPACITY, 1991

Company and Location	Annual Rated Capacity
	(000 tonnes of slab zinc)
PRIMARY	
Canadian Electrolytic Zinc Limited (CEZ) Valleyfield, Quebec	230
Falconbridge Limited Timmins, Ontario	133
Hudson Bay Mining and Smelting Co., Limited (HBMS) Flin Flon, Manitoba	82
Cominco Ltd. Trail, British Columbia	300
Total primary, Canada	745
SECONDARY	
Federated Genco Ltd. Burlington, Ontario	9
Purity Zinc Metals Co. Ltd. Stoney Creek, Ontario	8
Total secondary, Canada	17

TABLE 8. MONTHLY AVERAGE ZINC PRICES, 1990 AND 1991

	North American[1] Special High Grade	LME Special High Grade Settlement
	(US¢/lb)	
1991		
January	58.1	54.7
February	55.9	53.9
March	56.1	54.4
April	57.6	57.0
May	49.8	49.5
June	48.4	48.2
July	48.7	48.2
August	48.4	47.4
September	49.8	46.4
October	48.6	45.1
November	54.6	49.6
December	57.3	53.9
Year average	52.8	50.6
1990		
January	67.9	58.7
February	65.9	63.3
March	76.9	75.6
April	81.7	76.5
May	85.3	80.6
June	87.3	77.8
July	87.3	74.3
August	84.1	73.3
September	84.3	69.8
October	75.5	61.4
November	70.0	58.0
December	70.0	57.4
Year average	78.0	68.9

Sources: Metals Week; Reuters.
[1] 1990 prices are American Producer High Grade.

Principal Canadian Nonferrous and Precious Metal Mine Production in 1990, with Highlights for 1991

by Lo-Sun Jen and André Cadieux

The authors are with the Mineral Policy Sector, EMR Canada.
Telephone: (613) 992-0658 and (613) 992-4327, respectively.

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL MINE PRODUCTION IN 1990, WITH HIGHLIGHTS FOR 1991

Company and Mine/Mill Location	Capacity	Grades of Ore Milled: Cu	Ni	Pb	Zn	Ag	Au	Ore Milled	Metal Contained in All Concentrates Produced: Copper	Nickel	Lead	Zinc	Silver	Gold	1991 Highlights
	(tonnes per day)	(percent)				(grams/tonne)		(tonnes)	(tonnes)				(kilograms)		
NEWFOUNDLAND															
Hope Brook Gold Inc. Hope Brook mine Couteau Bay	3 495	–	–	–	–	0.41	4.56	857 594	–	–	–	–	275	3 436	The mining operation was temporarily suspended in May to retreat effluents. Royal Oak Resources Inc. signed a letter of intent to acquire this operation.
Newfoundland Zinc Mines Limited Newfoundland Zinc mine Daniel's Harbour	1 450	–	–	–	7.90	–	–	220 562	–	–	–	17 076	–	–	Mine closed in August 1990 due to exhaustion of reserves.
NOVA SCOTIA															
Rio Algom Limited East Kemptville mine Yarmouth	9 000	0.09	–	–	0.21	–	–	3 175 147	476	–	–	1 024	–	–	Mine closed on January 3, 1992, due to weak market conditions.
Westminer Canada Limited Gays River mine Gays River	1 360	–	–	3.50	7.00	–	–	131 542	–	–	4 297	8 358	–	–	Mine closed in May 1991 due to underground water problem.
NEW BRUNSWICK															
Breakwater Resources Ltd. Caribou mine Bathurst	2 500	0.30	–	3.00	6.49	96.00	1.37	551 459	898	–	6 737	26 336	16 247	154	Breakwater Resources acquired ownership in 1990 and suspended operations in October 1990 due to unfavourable market conditions.
Brunswick Mining and Smelting Corporation Limited No. 12 mine Bathurst	10 250	0.36	–	3.27	9.00	101.14	–	2 255 261	6 608	–	52 296	172 190	153 732	–	Ten-month strike ended in May 1991.
Noranda Inc. Heath Steele and Stratmat mines Bathurst	2 600	0.40	–	2.56	6.88	61.37	–	896 661	2 372	–	13 485	50 275	27 116	–	
NovaGold Resources Inc. Murray Brook mine Bathurst	1 070	–	–	–	–	49.37	2.06	388 003	–	–	–	–	2 488	560	
Stratabound Minerals Corporation CNE mine Newcastle	250	0.17	–	5.29	11.40	163.89	–	11 104	13	–	468	1 131	1 493	–	Ore milled at Noranda Minerals Inc.'s Heath Steele mill.
QUEBEC															
Abcourt Mines Inc. Abcour-Barvue mine Barraute	350	–	–	0.15	5.57	78.2	0.14	41 140	–	–	25	1 990	1 600	2	Ore milled at Noranda's Mattagami mill. Operation suspended March 1990.
Agnico-Eagle Mines Limited Joutel Division Joutel	1 630	–	–	–	–	2.02	6.51	332 236	–	–	–	–	580	1 994	The Eagle West zone was put into production in 1991.
La Ronde mine Cadillac	1 815	0.14	–	–	–	8.23	4.80	679 822	916	–	–	–	5 219	3 059	
American Barrick Resources Corporation Camflo Division Val-d'Or	1 210	–	–	–	–	0.27	3.60	374 930	–	–	–	–	100	1 253	Reserves expected to last for one more year. Exploration program is being carried out to find new reserves.
Audrey Resources Inc. Mobrun mine Rouyn-Noranda	1 450	0.76	–	–	2.26	25.37	2.47	451 764	2 697	–	–	8 513	2 884	562	Operations suspended in January 1992 due to exhaustion of ore reserves.

Aur Resources Inc. Kierens, Norlartic and Lamaque mines Val-d'Or	–	–	–	–	–	0.58	6.24	125 373	–	–	–	–	66	699	Ore milled at Belmoral Mines Ltd.'s Ferderber mill.
Aurizon Mines Ltd. Sleeping Giant mine Val-d'Or	900	–	–	–	–	11.31	8.23	132 676	–	–	–	–	1 357	1 037	
Belmoral Mines Ltd. Ferderber mine and Dumont mine Val-d'Or	1 360	–	–	–	–	0.93	6.75	238 136	–	–	–	–	193	1 510	
BP Resources Canada Limited Les Mines Selbaie OP and UG mines Joutel	6 650	1.14	–	0.12	2.06	48.69	0.48	2 649 260	28 495	–	2 117	49 400	89 098	978	
Breakwater Resources Ltd.–Brookline Minerals Inc. joint venture Estrades mine Joutel	700	1.2	–	0.98	13.6	173	4.9	71 000	483	–	210	838	6 150	104	Mine opened in 1990. Ore milled at Noranda's Mattagami mill. Operations suspended June 1991.
Cambior inc. Lucien C. Béliveau and Chimo mines Val-d'Or	1 600	–	–	–	–	0.34	4.11	565 448	–	–	–	–	104	2 069	
Campbell Resources Inc. Joe Mann, Cedar Bay and S-3 mines Chibougamau	3 175	0.29	–	–	–	5.49	7.92	323 312	847	–	–	–	1 239	2 261	The S-3 and Cedar Bay mines shut down in 1990 because of exhaustion of reserves.
Developpement Minier Aurtec Montauban Tailings	180	–	–	–	–	46.97	1.27	15 876	–	–	–	–	91	9	Mine shut down in 1991.
Deak Resources Corp. MacDonald West mine Rouyn-Noranda	1 360	0.11	–	0.23	6.26	30.5	1.16	16 300	5	–	15	885	197	8	Ore milled at Noranda's Matagami Division. No production in 1991.
Inco Gold Company Casa Berardi East and West mines La Sarre	1 200	–	–	–	–	2.61	7.89	398 980	–	–	–	–	889	2 783	
LAC Minerals Ltd.–Cambior inc. joint venture															
Doyon mine Cadillac	2 995	–	–	–	–	1.40	7.1	1 149 240	–	–	–	–	1 384	7 988	
Francoeur mine Rouyn-Noranda	400	–	–	–	–	0.80	6.17	52 680	–	–	–	–	42	365	
LAC Minerals Ltd.															
Est-Malartic Division Malartic	1 995	0.64	–	–	–	11.66	7.10	428 917	2 357	–	–	–	4 293	2 807	
Terrains Aurifères Division Cadillac	1 590	–	–	–	–	0.69	6.51	396 667	–	–	–	–	234	2 363	
Minnova Inc.															
Lake Dufault Division Ansil mine Noranda	1 450	8.20	–	–	0.08	29.90	2.40	424 998	33 908	–	–	236	10 100	898	
Lake Shortt Division Desmaraisville	1 150	–	–	–	–	0.17	4.11	348 994	–	–	–	–	55	1 333	
Opemiska Division Perry, Springer and Cooke mines Chapais	2 810	1.80	–	–	–	13.37	1.71	339 995	5 855	–	–	–	3 776	509	All Opemiska Division mines closed in 1991 due to the exhaustion of ore reserves.
Muscocho Explorations Ltd. Montauban mine Montauban	400	–	–	–	–	230.06	2.40	11 884	–	–	–	–	796	21	Mine shut down in 1990 due to exhaustion of reserves.
Noranda Minerals Inc.															
Division Mines Gaspé E zone Murdochville	10 000	2.30	–	–	–	14.67	0.07	938 936	20 662	–	–	–	11 829	16	
Matagami Division Isle Dieu and Norita mines Mattagami Lake	2 900	1.00	–	0.30	15.29	65.49	0.62	365 219	3 431	–	757	53 498	18 733	163	

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL MINE PRODUCTION IN 1990, WITH HIGHLIGHTS FOR 1991 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1991 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Lead	Zinc	Silver	Gold	
	(tonnes per day)	(percent)				(grams/tonne)		(tonnes)	(tonnes)				(kilograms)		
QUEBEC (cont'd)															
Noranda Minerals Inc.– Cambior Inc. joint venture Silidor mine Rouyn-Noranda	1 100	–	–	–	–	1.00	4.90	315 070	–	–	–	–	214	1 435	
Normetal Mining & Exploration Inc. Normetmar mine La Sarre	450	–	–	0.34	9.35	55.2	0.31	41 900	–	–	44	3 400	918	5	Ore milled at Noranda's Matagami Division. Mine closed in December 1990 due to exhaustion of reserves.
Placer Dome Inc.															
Sigma mine	1 360	–	–	–	–	0.93	4.49	482 622	–	–	–	–	360	2 062	
Kiena mine Val-d'Or	1 135	–	–	–	–	0.72	4.49	473 641	–	–	–	–	316	2 051	
Westminer Canada Limited Copper Rand and Portage mines Chibougamau	3 085	1.48	–	–	–	7.51	5.35	199 581	2 879	–	–	–	1 028	974	Company lockout resulted in closure of mines in May 1990. Portage mine re-started in October while Copper Rand mine resumed production in November.
ONTARIO															
American Barrick Resources Corporation Holt-McDermott mine Kirkland Lake	1 350	–	–	–	–	0.48	4.25	466 576	–	–	–	–	187	1 839	
Canamax Resources Inc.															
Kremzar mine Wawa	500	–	–	–	–	0.99	4.90	134 898	–	–	–	–	118	635	The Kremzar mine was put under care and maintenance because of low gold prices.
Bell Creek mine Timmins	400	–	–	–	–	0.45	6.10	135 243	–	–	–	–	52	779	The Bell Creek mine was closed in 1991. Falconbridge Gold became new owner.
Corona Corporation Renabie mine Wawa	680	–	–	–	–	1.58	6.82	241 175	–	–	–	–	256	1 503	Renabie mine closed in 1991.
Dickenson Mines Limited Arthur White mine Red Lake	910	–	–	–	–	1.37	10.97	258 548	–	–	–	–	274	2 384	
Eastmaque Gold Mines Ltd. Kirkland Lake	2 040	–	–	–	–	1.37	1.85	773 573	–	–	–	–	424	619	Eastmaque mine was shut down in 1991.
Falconbridge Limited Sudbury operations (7 mines)	9 070	1.28	1.45	–	–	5.79	0.20	2 794 129	33 687	34 442	–	–	13 751	466	East mine closed in 1990. Mining of the Falconbridge Crown Pillar suspended in 1991.
Timmins operations	13 500	3.0	–	0.10	5.0	61.71	–	3 973 469	122 435	–	2 938	177 256	211 411	–	
Kidd Creek Gold Hoyle Pond mine Owl Creek mine	600	–	–	–	–	0.24	15.43	153 314	–	–	–	–	141	2 250	
Giant Yellowknife Mines Limited Timmins Division	2 630	–	–	–	–	1.71	2.67	979 760	–	–	–	–	376	2 361	Royal Oak Resources Inc. purchased control of the Pamour Group of Companies.
GSR Mining Corp.															
Kerr and Buffonta mines	1 360	–	–	–	–	0.21	3.33	125 346	–	–	–	–	23	375	The Kerr mine was partly reactivated in 1990.
Custom milling Virginiatown	750	–	–	–	–	0.51	7.10	185 066	–	–	–	–	83	1 182	Custom milling of ore from Cheminis, Jonpol, Armistice, and 3 other mines.
Hemlo Gold Mines Inc. Golden Giant mine Marathon	2 995	–	–	–	–	1.37	11.52	1 245 100	–	–	–	–	777	13 700	

Inco Limited Sudbury and Shebandowan operations	57 520	1.02	1.18	–	–	5.47	0.33	10 653 070	103 381	102 105	–	–	40 781	2 126	Production suspended at Creighton No. 3 mine and Whistle open pit in 1991. Development of the McCreedy East mine delayed. Lower Coleman mine started production in 1991.
Lac Minerals Ltd. Golden Patricia mine Pickle Lake	350	–	–	–	–	2.85	20.95	124 284	–	–	–	–	343	2 515	
LAC Minerals Ltd. Macassa Division															
Macassa mine	455	–	–	–	–	2.61	18.69	179 124	–	–	–	–	367	3 216	
Tailing operation	680	–	–	–	–	1.51	3.02	199 321	–	–	–	–	151	432	Closed in 1990.
Minnova Inc. Winston Lake mine Winston Lake	1 000	1.10	–	–	17.70	36.62	1.41	346 000	3 567	–	–	58 860	9 351	304	
Muscocho Explorations Ltd. Magino mine Wawa	365	–	–	–	–	10.97	5.90	156 106	–	–	–	–	164	885	
Noranda Inc. Geco Division Manitouwadge	3 630	1.93	–	–	4.12	50.40	0.14	1 184 783	21 083	–	–	45 657	43 084	85	
Lyon Lake Division Ignace	2 720	1.06	–	1.26	8.77	168.00	0.55	323 865	3 160	–	3 380	27 030	46 181	138	Mine closed in May 1991 due to exhaustion of reserves.
Orofino Resources Limited Scadding mine Scadding Twp.	120	–	–	–	–	–	4.73	21 772	–	–	–	–	–	89	
Placer Dome Inc. Campbell mine Red Lake	1 090	–	–	–	–	2.02	21.19	391 904	–	–	–	–	714	7 931	
Detour Lake mine N.E. Ontario	2 495	–	–	–	–	1.78	5.01	866 361	–	–	–	–	1 337	4 056	
Dome mine South Porcupine	3 400	–	–	–	–	3.36	0.58	780 179	–	–	–	–	416	2 488	
Dona Lake mine Pickle Lake	500	–	–	–	–	0.96	7.61	183 251	–	–	–	–	162	1 346	
St. Andrew Goldfields Ltd. Stock Twp. mine	680	–	–	–	–	0.45	5.59	163 126	–	–	–	–	65	849	
Hislop East and Taylor mines Timmins	400	–	–	–	–	0.62	5.59	27 488	–	–	–	–	15	145	Custom milling of ore from Hislop East and Taylor Township mines. Hislop mine closed in September 1991.
Teck-Corona Corporation joint venture David Bell mine	1 450	–	–	–	–	0.96	21.84	466 238	–	–	–	–	399	9 894	
Williams mine Hemlo	6 350	–	–	–	–	1.23	8.54	2 280 662	–	–	–	–	1 866	18 479	
Timmins Nickel Inc. Redstone and Langmuir No. 1 mines Timmins	270	–	2.74	–	–	–	–	86 200	–	2 327	–	–	–	–	Langmuir No. 1 deposit brought into commercial production in the first quarter of 1991.
MANITOBA															
Hudson Bay Mining and Smelting Co., Limited (8 mines), including Flin Flon, Saskatchewan portion	10 520	2.03	–	0.26	4.87	20.64	1.79	1 757 217	33 510	–	3 299	76 407	25 957	2 272	Rod mine closed in September 1991.
Ruttan mine Leaf Rapids	5 200	1.17	–	–	1.28	10.63	0.45	1 732 723	19 115	–	–	19 218	12 352	417	
Hudson Bay–Outokumpu Mines Ltd. joint venture Namew Lake mine Flin Flon	1 905	0.70	1.92	–	–	–	–	495 323	3 153	8 176	–	–	–	–	
Inco Limited Thompson underground and open-pit, and Birchtree mines Thompson district	14 969	0.16	2.55	–	–	5.14	0.10	2 630 836	3 541	52 187	–	–	8 118	217	

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL MINE PRODUCTION IN 1990, WITH HIGHLIGHTS FOR 1991 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled Cu	Ni	Pb	Zn	Ag	Au	Ore Milled	Metal Contained in All Concentrates Produced Copper	Nickel	Lead	Zinc	Silver	Gold	1991 Highlights
	(tonnes per day)	(percent)				(grams/tonne)		(tonnes)	(tonnes)				(kilograms)		
SASKATCHEWAN															
Cameco Corporation Jasper mine La Ronge	200	–	–	–	–	7.89	18.17	60 509	–	–	–	–	365	1 051	
Corona Corporation Jolu mine La Ronge	400	–	–	–	–	0.48	13.85	170 641	–	–	–	–	73	2 304	Mine closed in 1991.
BRITISH COLUMBIA															
BHP - Utah Mines Ltd. Island Copper mine Port Hardy	49 895	0.32	–	–	–	1.47	0.10	18 143 695	44 848	–	–	–	13 389	888	
Brenda Mines Ltd. Peachland	27 625	0.16	–	–	–	1.54	0.02	4 281 821	6 214	–	–	–	3 330	51	Mine closed on June 8, 1990, due to rock slide and to ore exhaustion.
Cheni Gold Mines Inc. Lawyers mine North Central, B.C.	500	–	–	–	–	258.86	9.60	184 246	–	–	–	–	36 094	1 636	
Chevron Canada Resources Company–North American Metals Corp. joint venture Golden Bear mine Telegraph Creek	360	–	–	–	–	3.19	12.69	67 177	–	–	–	–	150	605	
Cominco Ltd. Sullivan mine Kimberley	9 070	–	–	4.50	5.90	28.46	–	399 596	–	–	15 308	20 494	10 563	–	
Corona Corporation Nickel Plate mine Hedley	3 175	–	–	–	–	0.93	2.50	1 141 255	–	–	–	–	846	2 373	Mine closed for much of 1990.
Gibraltar Mines Limited															
Gibraltar mine	36 290	0.30	–	–	–	1.03	–	11 701 776	28 816	–	–	–	6 010	–	
Bioleach plant McLeese Lake	19 960	0.12	–	–	–	–	–	9 896 388	3 719	–	–	–	–	–	
Highland Valley Copper Ltd. (Partnership of Cominco–Rio Algom Limited–Teck Corporation) Logan Lake	132 995	0.43	–	–	–	1.65	0.02	46 261 886	163 681	–	–	–	61 246	402	
International Shasta Resources Ltd. Shasta mine North Central, B.C.	180	–	–	–	–	243.43	4.46	58 060	–	–	–	–	12 728	240	Closed in 1991.
Minnova Inc. Samatosum mine Adams Lake	420	1.20	–	1.60	2.90	1 073.14	1.89	169 152	1 880	–	2 288	4 442	170 440	282	Decison made in 1991 to mine underground reserves.
MinVen Gold Corporation Blackdome mine Williams Lake	180	–	–	–	–	127.89	18.86	72 912	–	–	–	–	8 010	1 317	Mine closed January 1991.
Noranda Minerals Inc. Bell Copper mine Babine Lake	15 420	0.58	–	–	–	1.3	0.24	5 443 108	21 337	–	–	–	3 199	891	
Placer Dome Inc. Equity Silver mine Houston	9 000	0.28	–	–	–	115.20	1.13	3 175 147	6 270	–	–	–	229 345	2 098	Mine to close in 1992. Reclamation of mine site in progress.
Princeton Mining Corporation Similco mine Princeton	22 680	0.50	–	–	–	2.95	0.13	6 750 362	25 603	–	–	–	9 938	431	Production affected by 4-month strike during 1991.

Skyline Gold Corporation Johnny Mountain mine Iskut River	320	0.40	–	–	–	23.69	13.20	79 107	295	–	–	–	1 336	893	The Johny Mountain mine was closed in 1990.
Teck Corporation Ajax mine Kamloops	9 980	0.53	–	–	–	9.26	0.38	2 655 460	10 932	–	–	–	951	783	Production suspended in August 1991 due to high operating costs.
Beaverdell mine Beaverdell	100	–	–	0.33	0.39	346.29	–	36 224	–	–	94	115	11 469	–	Mine closed in February 1991.
Treminco Resources Ltd. Silvana mine New Denver	110	–	–	5.78	5.95	418.29	–	32 341	–	–	1 736	1 777	13 127	–	Workforce and production reduced due to low metal prices.
Westmin Resources Limited H-W, Lynx mines Buttle Lake	3 990	1.94	–	0.21	3.65	29.31	2.16	1 171 337	21 061	–	1 986	37 905	21 366	1 086	Battle and Gap zones discovered by drilling in 1991.
Premier Gold & SB Project Stewart	2 000	–	–	–	–	55.78	2.23	735 598	–	–	–	–	18 505	1 479	
YUKON TERRITORY															
Canamax Resources Inc. Ketza River	400	–	–	–	–	0.79	9.81	135 942	–	–	–	–	84	1 150	Closed in 1990.
Curragh Resources Inc. Faro mine	9 980	–	–	3.10	4.90	37.71	0.21	4 717 361	–	–	118 049	191 241	106 058	337	Grum scheduled for development in 1992.
NORTHWEST TERRITORIES															
Cominco Ltd. Polaris mine Little Cornwallis Island	2 055	–	–	4.00	14.40	–	–	1 017 589	–	–	39 626	143 539	–	–	
Echo Bay Mines Ltd. Lupin mine Contwoyto Lake	1 090	–	–	–	–	1.71	10.25	628 679	–	–	–	–	980	6 072	
Nanisivik Mines Ltd. Baffin Island	1 890	–	–	0.40	8.10	35.01	–	716 400	–	–	2 020	51 045	16 598	–	
NERCO Minerals Company Con mine Yellowknife	1 090	–	–	–	–	3.77	13.37	292 113	–	–	–	–	920	3 643	
NorthWest Gold Corp. Colomac mine	9 070	–	–	–	–	0.55	1.61	1 377 560	–	–	–	–	449	2 009	Closed in 1991.
Royal Oak Resources Ltd. Yellowknife Division Giant mine	1 090	–	–	–	–	1.95	9.91	347 089	–	–	–	–	475	3 010	The tailings operation closed in 1990 due to exhaustion of tailings materials.
Treminco Resources Ltd. Ptarmigan mine Yellowknife	230	–	–	–	–	4.11	10.97	57 153	–	–	–	–	141	414	
Total Canada	618 210	0.48	0.13	0.18	0.75	11.57	1.00	179 395 302	800 138	207 075	259 541	1 246 470	1 503 393	167 482	

OP Open-pit; UG Underground.
– Nil.
Note: Not included in the above are several small mine/mill operations and operations that were not officially in production in 1990, or for which no information was available to enable the completion of a reliable production assessment. The overall contribution to the Canadian production total in 1990 from these omitted operations is estimated to be less than one percent.

Statistical Report

CANADA, GENERAL ECONOMIC INDICATORS, 1981–90

		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990[p]
Gross domestic product, current dollars	$ million	355 994	374 442	405 717	444 735	477 988	505 666	551 597	605 147	649 102	671 577
Gross domestic product, constant dollars (1986 = 100)	"	440 127	425 970	439 448	467 167	489 437	505 666	526 730	551 423	564 990	567 541
Mining's gross domestic product (1986 = 100)	"	15 413	15 003	15 959	18 122	18 919	17 595	18 816	20 332	19 878	19 764
Manufacturing's gross domestic product (1986 = 100)	"	77 972	67 921	72 311	81 622	86 218	86 849	90 319	94 750	95 176	91 316
Industrial production's gross domestic product (1986 = 100)	"	106 674	96 204	102 436	114 883	121 273	120 356	125 721	131 996	132 100	127 626
Value of manufacturing industry shipment	"	190 851	187 409	203 019	229 848	248 673	253 343	272 037	298 254	307 106	294 061
Value of mineral production	"	32 420	33 831	38 539	43 789	44 730	32 446	36 361	36 955[r]	39 333[r]	40 778
Merchandise exports	"	84 432	84 393	90 556	111 330	119 061	120 318	126 226	138 435	141 462	146 057
Merchandise imports	"	77 140	66 739	73 098	91 493	102 669	110 374	115 119	128 321	134 528	135 259
Balance of payments, current account	"	-6 884	2 004	2 102	1 686	-3 095	-11 394	-11 601	-13 883	-20 723	-22 036
Corporation profits before taxes	"	37 654	26 848	37 072	45 855	49 490	45 355	56 571	62 692	59 965	45 145
Business investment, current dollars	"	76 672	70 808	70 832	73 309	81 312	88 993	103 831	119 274	131 091	125 569
Business investment, constant dollars (1986 = 100)	"	86 006	74 967	74 742	75 869	82 863	88 993	99 693	110 969	116 717	111 309
Population	000s	24 342	24 583[r]	24 787[r]	25 978[r]	25 165[r]	25 353	25 617	25 909[r]	26 240[r]	26 603
Labour force	"	11 899	11 926	12 109	12 316	12 532	12 746	13 011	13 275	13 503	13 681
Employed	"	11 001[r]	10 618[r]	10 675[r]	10 932[r]	11 221[r]	11 531[r]	11 861	12 245	12 486	12 572
Unemployed	"	898	1 308[r]	1 434[r]	1 384[r]	1 311[r]	1 215[r]	1 150	1 031	1 018	1 109
Unemployment rate	percent	7.5	11.0	11.8	11.2	10.5	9.5	8.8	7.8	7.5	8.1
Labour income	$ million	196 002	209 402	219 386	236 257	254 777	271 853	295 708	325 287	354 890	379 488
Consumer price index	1986 = 100	76.3	84.1	89.4	92.9	96.3	100.0	104.0	108.1	113.2	117.9

Source: Statistics Canada, Catalogue Nos. 11-210 and 26-202.
[p] Preliminary; [r] Revised.

TABLE 1. MINERAL PRODUCTION OF CANADA, 1989, 1990 AND 1991, AND AVERAGE 1987-91

	Unit of Measure	1989		1990		1991[p]		Average 1987-91	
	(000)	(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)
Metals									
Antimony	kg	2 818	6 957	565	1 188	525	1 099	2 157	5 407
Bismuth	kg	157	2 315	74	664	139	1 043	143	1 717
Cadmium	kg	1 711	28 027	1 334	11 588	1 565	7 837	1 551	17 562
Calcium	kg	x	x	x	x	x	x	279	2 931
Cesium, pollucite	kg	x	x	x	x	x	x	148	472
Cobalt	kg	2 344	45 781	2 184	49 563	2 158	61 764	2 315	49 771
Columbium (Niobium) (Cb_2O_5)	kg	x	x	x	x	x	x	3 375	21 472
Copper	kg	704 432	2 388 748	771 433	2 428 935	773 640	2 101 168	760 426	2 247 100
Germanium	kg	x	x	4	1 083	–	–	2	528
Gold	g	159 494	2 315 860	167 373	2 407 654	176 720	2 355 325	150 843	2 323 060
Ilmenite	t	x	x	554	x	400	x	494	21 469
Indium	g	x	x	x	x	x	x	9 667	2 518
Iron ore	t	39 445	1 369 193	35 670	1 258 792	35 961	1 307 888	37 742	1 330 948
Iron remelt	t	x	x	728	x	740	x	809	203 337
Lead	kg	268 887	279 643	233 372	279 346	239 558	203 864	293 236	302 747
Lithium	kg	x	x	x	x	x	x	878	3 825
Magnesium	kg	x	x	x	x	x	x	6 889	27 329
Molybdenum	kg	13 543	111 728	12 188	84 721	11 292	70 397	13 066	102 853
Nickel	kg	195 554	3 042 278	195 004	2 027 917	189 161	1 828 235	193 510	2 192 378
Platinum group	g	9 870	141 730	11 123	189 423	10 955	141 790	11 084	169 141
Rare earths	t	–	–	–	–	–	–	x	x
Rhenium	kg	x	x	x	x	x	x	1	1 242
Rubidium	kg	–	–	x	x	x	x	3	35
Selenium	kg	213	4 138	369	6 867	215	4 148	310	6 419
Silver	kg	1 312	274 737	1 381	249 746	1 240	185 261	1 350	304 016
Strontium	kg	x	x	x	x	x	x	x	x
Tantalum (Ta_2O_5)	kg	97	10 540	100	8 762	111	9 992	73	6 671
Tellurium	kg	8	591	12	994	13	1 173	13	835
Tin	kg	x	x	3 844	28 449	4 455	29 161	3 791	31 823
Tungsten (WO_3)	kg	–	–	–	–	–	–	–	–
Uranium (U)	kg	10 995	912 684	9 720	887 975	7 813	472 074	10 841	894 721
Vanadium	kg	–	–	x	x	x	x	7	38
Yttrium (Y_2O_3)	kg	x	x	x	x	–	–	54	2 101
Zinc	kg	1 272 854	2 739 182	1 179 372	2 272 649	1 079 912	1 350 970	1 212 015	2 020 524
Total metals			13 982 451		12 499 965		10 425 251		12 295 537
Nonmetals									
Arsenious trioxide	t	x	1 286	x	240	x	247	5	974
Asbestos	t	714[r]	289 153[r]	686	272 102	670	274 535	689	264 974
Barite	t	39	3 069	44	3 130	51	3 887	45	3 643
Fluorspar	t	x	x	x	x	–	–	25	3 327
Gemstones	kg	901	3 238	452	918	316	538	493	1 692
Graphite	t	x	x	x	x	x	x	7	5 756
Gypsum	t	8 180[r]	85 713[r]	7 978	80 080	7 305	74 315	8 274	82 548
Magnesite	t	x	x	x	x	x	x	177	22 982
Marl	t	x	x	x	x	x	x	2	36
Mica	t	x	x	x	x	x	x	15	5 730
Nepheline syenite	t	551	23 077	533	23 651	493	24 961	525	22 826
Peat	t	821[r]	99 666	775	89 735	737	91 675	746	87 878
Potash (K_2O)	t	7 014	1 017 525	7 345	964 920	7 012	918 994	7 439	962 839
Potassium sulphate	t	x	x	x	x	x	x	1	575
Salt	t	11 158[r]	275 618[r]	11 191	240 890	11 585	258 585	10 950	252 088
Serpentine	t	x	x	x	x	x	x	4	640
Soapstone, talc and pyrophyllite	t	145	15 108	131	13 895	115	13 260	135	14 519
Sodium sulphate	t	327	26 344	347	27 088	285	21 800	326	25 359
Sulphur in smelter gas	t	809	86 909	790	81 229	726	76 592	781	82 010
Sulphur, elemental	t	5 750	419 541	5 822	368 864	6 029	244 104	5 878	399 885
Titanium dioxide	t	x	x	x	x	x	x	718	250 229
Tremolite	t	x	x	x	x	x	x	x	46
Total nonmetals			2 663 406[r]		2 492 168		2 250 462		2 499 553
Fuels									
Coal	t	70 527	1 907 080	68 332	1 823 700	71 000	1 905 900	68 343	1 816 462
Natural gas	$000m^3$	96 117	5 394 275	98 771	5 692 025	103 393	5 190 985	93 492	5 219 881
Natural gas by-products	m^3	23 055	1 620 282	23 863	2 370 767	24 705	2 125 457	23 148	1 917 288
Petroleum, crude	m^3	90 641	10 862 909	90 279	13 103 383	89 703	10 629 463	90 714	11 180 944
Total fuels			19 784 546		22 989 875		19 851 805		20 134 575
Structural Materials									
Clay products	$	. .	200 138	. .	136 029	. .	139 411	. .	176 612
Cement	t	12 591	960 000	11 745	991 442	9 396	816 802	11 737	947 353
Lime	t	2	201 571	2 341	188 283	2 336	186 287	1 905	187 076
Sand and gravel	t	244	874 078	244 316	817 317	200 497	631 391	202 325	794 773
Stone	t	119 335[r]	667 178[r]	111 352	662 945	85 785	512 837	109 978	612 799
Total structural materials			2 902 965[r]		2 796 017		2 286 729		2 718 613
Total all minerals			39 333 368[r]		40 778 025		34 814 247		37 648 278

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[p] Preliminary; . . Not available; – Nil; x Confidential; [r] Revised.
Note: Numbers may not add to totals due to rounding. Confidential values are included in totals.

TABLE 2. CANADA, VALUE OF MINERAL PRODUCTION, PER CAPITA VALUE OF MINERAL PRODUCTION, AND POPULATION, 1962-91

	Metallics	Industrial Minerals	Fuels	Other Minerals[1]	Total	Per Capita Value of Mineral Production	Population of Canada
			($ million)			($)	(000)
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	691	973		3 365	174.44	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	214.98	20 378
1968	2 493	886	1 343		4 722	228.12	20 701
1969	2 378	893	1 465		4 736	225.51	21 001
1970	3 073	931	1 718		5 722	268.68	21 297
1971	2 940	1 008	2 014		5 963	276.46	21 568
1972	2 956	1 085	2 368		6 408	293.92	21 802
1973	3 850	1 292	3 227		8 370	379.69	22 043
1974	4 821	1 731	5 202		11 753	525.55	22 364
1975	4 795	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	794.24	23 258
1978	5 698	2 986	11 578		20 261	863.05	23 476
1979	7 951	3 514	14 617		26 081	1 101.83	23 671
1980	9 697	4 201	17 944		31 842	1 330.29	23 936
1981	8 753	4 485	19 046	136	32 420	1 331.86	24 342
1982	6 874	3 703	23 038	216	33 831	1 373.37	24 634
1983	7 399	3 741	27 154	245	38 539	1 548.68	24 885
1984	8 670	4 318	30 399	401	43 789	1 742.92	25 124
1985	8 709	4 859	31 120	41	44 730	1 763.79	25 360
1986	8 798	4 863	18 763	22	32 446	1 279.77	25 353
1987	10 962	5 125	20 274	–	36 361	1 419.39	25 617
1988	13 608	5 574	17 773	–	36 955	1 426.33	25 909
1989	13 982	5 566r	19 785	–	39 333r	1498.97r	26 240r
1990	12 500	5 288	22 990	–	40 778	1532.86	26 603
1991p	10 425	4 537	19 852	–	34 814	1289.82	26 992

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

[1] 1981-86 – Other minerals may include arsenious trioxide, bentonite, calcium, cesium, cobalt, diatomite, ilmenite, indium, iron remelt, lithium, marl, magnesium, niobium, perlite, rhenium, serpentine, sodium antimonate, strontium, tin, tungsten or yttrium for which the value of production may be confidential in that year. Beginning 1987, this category was discontinued.

p Preliminary; r Revised; – Nil.

Note: Beginning 1986, bentonite, diatomite and sodium antimonate are reported in industrial minerals. Totals may not add due to rounding.

TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCE, TERRITORY AND MINERAL CLASS, 1991p

	Metals		Industrial Minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	3 021	. . .	469 269	10.3	15 675 428	79.0	16 147 718	46.4
Ontario	3 731 424	35.8	1 248 783	27.5	81 943	0.4	5 062 151	14.5
British Columbia	1 491 808	14.3	414 725	9.1	1 843 466	9.3	3 749 999	10.8
Quebec	1 932 343	18.5	1 001 886	22.1	–	–	2 934 229	8.4
Saskatchewan	347 205	3.3	831 028	18.3	1 673 811	8.4	2 852 043	8.2
Manitoba	930 915	8.9	83 945	1.9	92 934	0.5	1 107 794	3.2
Newfoundland	755 361	7.2	37 945	0.8	–	–	793 306	2.3
Northwest Territories	529 344	5.1	15 337	0.3	212 023	1.1	756 705	2.2
New Brunswick	325 546	3.1	257 262	5.7	34 200	0.2	617 008	1.8
Nova Scotia	38 952	0.4	167 675	3.7	238 000	1.2	444 627	1.3
Yukon	339 332	3.3	6 883	0.2	–	–	346 215	1.0
Prince Edward Island	–	–	2 453	0.1	–	–	2 453	. . .
Total	10 425 251	100.0	4 537 191	100.0	19 851 805	100.0	34 814 247	100.0

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; – Nil; . . . Amount too small to be expressed.
Note: Numbers may not add to totals due to rounding.

TABLE 3a. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCE, TERRITORY AND MINERAL CLASS, 1990

	Metals		Industrial Minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	3 498	. . .	663 274	12.5	18 443 676	80.2	19 110 448	46.9
Ontario	4 883 529	39.1	1 471 138	27.8	91 158	0.4	6 445 825	15.8
British Columbia	1 622 514	13.0	468 783	8.9	1 863 095	8.1	3 954 393	9.7
Saskatchewan	310 941	2.5	895 368	16.9	1 976 192	8.6	3 182 501	7.8
Quebec	1 923 115	15.4	1 113 892	21.1	–	–	3 037 007	7.4
Manitoba	1 094 610	8.8	91 591	1.9	115 874	0.5	1 311 466	3.2
Northwest Territories	703 833	5.6	25 853	0.5	258 215	1.1	987 900	2.4
New Brunswick	584 492	4.7	256 234	4.8	37 200	0.2	877 926	2.2
Newfoundland	789 661	6.3	76 325	1.4	–	–	865 987	2.1
Yukon	531 981	4.3	9 833	0.2	–	–	541 814	1.3
Nova Scotia	51 790	0.4	203 233	3.8	204 465	0.9	459 488	1.1
Prince Edward Island	–	–	3 271	0.1	–	–	3 271	. . .
Total	12 499 965	100.0	5 288 185	100.0	22 989 875	100.0	40 778 025	100.0

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . . Amount too small to be expressed.
Note: Numbers may not add to totals due to rounding.

TABLE 4. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCE AND TERRITORY, 1985-91

	1985	1986	1987	1988	1989	1990	1991[p]
				($ million)			
Alberta	27 030	16 331	17 080	15 062[r]	16 456	19 110	16 148
Ontario	4 630	4 825	5 652	6 895[r]	7 308[r]	6 446	5 062
British Columbia	3 541	3 160	3 615	3 943[r]	4 123	3 954	3 750
Quebec	2 243	2 191	2 780	2 712[r]	2 878[r]	3 037	2 934
Saskatchewan	3 797	2 525	3 151	3 043[r]	3 017[r]	3 183	2 852
Manitoba	862	764	1 000	1 627[r]	1 668[r]	1 311	1 108
Newfoundland	870	817	743	865[r]	897[r]	866	793
Northwest Territories	865	788	870	957[r]	1 149	988	757
New Brunswick	509	502	624	911[r]	859[r]	878	617
Nova Scotia	321	367	407	446[r]	442	459	445
Yukon	60	176	437	492	534	542	346
Prince Edward Island	2	2	3	2[r]	2	3	2
Total	44 730	32 446	36 361	36 955[r]	39 333[r]	40 778	34 814

Source: Energy, Mines and Resources Canada; Statistics Canada.
[p] Preliminary; [r] Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 5. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1985-91

	1985	1986	1987	1988r	1989r	1990	1991p
Alberta	60.4	50.3	47.0	40.8	41.8	46.9	46.4
Ontario	10.4	14.9	15.5	18.7	18.6	15.8	14.5
British Columbia	7.9	9.7	9.9	10.7	10.5	9.7	10.8
Quebec	5.0	6.8	7.6	7.3	7.3	7.4	8.4
Saskatchewan	8.5	7.8	8.7	8.2	7.7	7.8	8.2
Manitoba	1.9	2.4	2.8	4.4	4.2	3.2	3.2
Newfoundland	1.9	2.5	2.0	2.3	2.3	2.1	2.3
Northwest Territories	1.9	2.4	2.4	2.6	2.9	2.4	2.2
New Brunswick	1.1	1.5	1.7	2.5	2.2	2.2	1.8
Nova Scotia	0.7	1.1	1.1	1.2	1.1	1.1	1.3
Yukon	0.1	0.5	1.2	1.3	1.4	1.3	1.0
Prince Edward Island	...	...	...	...	...	...	...
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; r Revised; ... Amount too small to be expressed.
Note: Numbers may not add to totals due to rounding.

TABLE 6. CANADA, PRODUCTION OF LEADING MINERALS, 1990 AND 1991

		Volume 1990	Volume 1991p	Percent Change 1991/1990	Value 1990	Value 1991p	Percent Change 1991/1990
		(000 tonnes except where noted)			($ millions)		
Metals							
Gold	kg	167 372.5	176 720.1	5.6	2 407.7	2 355.3	–2.2
Copper		771.4	773.6	0.3	2 428.9	2 101.2	–13.5
Nickel		195.0	189.2	–3.0	2 027.9	1 828.2	–9.8
Zinc		1 179.4	1 079.9	–8.4	2 272.6	1 351.0	–40.6
Iron ore		35 670.0	35 961.1	0.8	1 258.8	1 307.9	3.9
Uranium	tU	9 720.2	7 813.3	–19.6	888.0	472.1	–46.8
Lead		233.4	239.6	2.7	279.3	203.9	–27.0
Silver	t	1 381.3	1 239.9	–10.2	249.7	185.3	–25.8
Platinum group	kg	11 123.4	10 955.4	–1.5	189.4	141.8	–25.1
Molybdenum	t	12 188.5	11 292.0	–7.4	84.7	70.4	–16.9
Nonmetals							
Potash (K_2O)		7 344.6	7 012.0	–4.5	964.9	919.0	–4.8
Asbestos		685.6	670.4	–2.2	272.1	274.5	0.9
Salt		11 191.4	11 585.3	3.5	240.9	258.6	7.3
Sulphur, elemental		5 822.1	6 029.0	3.6	368.9	244.1	–33.8
Peat		774.6	737.1	–4.8	89.7	91.7	2.2
Sulphur, in smelter gas		789.8	726.4	–8.0	81.2	76.6	–5.7
Structurals							
Cement		11 745.2	9 395.9	–20.0	991.4	816.8	–17.6
Sand and gravel		244 315.8	200 497.1	–17.9	817.3	631.4	–22.7
Stone		111 351.8	85 784.8	–23.0	662.9	512.8	–22.6
Lime		2 340.7	2 335.8	–0.2	188.3	186.3	–1.1
Clay products		..	..	..	136.0	139.4	2.5
Fuels							
Petroleum	000 m^3	90 278.6	89 702.6	–0.6	13 103.4	10 629.5	–18.9
Natural gas	million m^3	98 770.8	103 393.4	4.7	5 692.0	5 191.0	–8.8
Natural gas by-products	000 m^3	23 862.7	24 705.1	3.5	2 370.8	2 125.5	–10.3
Coal		68 332.0	71 000.0	3.9	1 823.7	1 905.9	4.5

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; .. Not available.
Note: Figures have been rounded.

TABLE 7. VALUE OF LEADING MINERALS IN THE PROVINCES, TERRITORIES AND CANADA, 1990 AND 1991

	Value of Production			
	1990	1991p	Change 1991/1990	1991p Proportion of Provincial Total
	($ million)		(percent)	
Newfoundland				
Iron ore	708.4	737.7	4.1	93.0
Gold	x	x	x	x
Sand and gravel	14.5	11.7	–19.3	1.5
Stone	9.9	5.0	–49.5	0.6
Asbestos	29.0	4.0	–86.2	0.5
Total	866.0	793.3	–8.4	100.0
Prince Edward Island				
Sand and gravel	3.3	2.5	–24.2	100.0
Total	3.3	2.5	–24.2	100.0
Nova Scotia				
Coal	204.5	238.0	16.4	53.5
Gypsum	52.8	52.3	–0.9	11.8
Salt	x	x	x	x
Tin	28.4	29.2	2.8	6.6
Cement	x	x	x	x
Stone	39.5	23.6	–40.3	5.3
Total	459.5	444.6	–3.2	100.0
New Brunswick				
Zinc	450.8	212.5	–52.9	34.4
Potash (K_2O)	x	x	x	x
Lead	67.3	50.2	–25.4	8.1
Coal	37.2	34.2	–8.1	5.5
Peat	23.8	26.9	13.0	4.4
Total	877.9	617.0	–29.7	100.0
Quebec				
Gold	585.1	692.4	18.3	23.6
Iron ore	x	x	x	x
Copper	312.3	299.3	–4.2	10.2
Stone	243.6	206.2	–15.4	7.0
Titanium dioxide	x	x	x	x
Zinc	232.4	143.7	–38.2	4.9
Total	3 037.0	2 934.2	–3.4	100.0
Ontario				
Nickel	1 345.6	1 237.7	–8.0	24.4
Gold	1 150.3	1 025.6	–10.8	20.3
Copper	861.0	723.2	–16.0	14.3
Cement	475.2	388.5	–18.2	7.7
Zinc	532.1	276.5	–48.0	5.5
Stone	300.6	222.3	–26.0	4.4
Total	6 445.8	5 062.2	–21.5	100.0
Manitoba				
Nickel	682.3	590.6	–13.4	52.6
Copper	174.8	154.6	–11.6	13.8
Zinc	149.4	98.4	–34.1	8.8
Petroleum, crude	114.9	92.1	–19.8	8.2
Total	1 311.5	1 107.8	–16.2	100.0

TABLE 7. (cont'd)

	Value of Production			
	1990	1991p	Change 1991/1990	1991p Proportion of Provincial Total
	($ million)		(percent)	
Saskatchewan				
Petroleum, crude	1 557.8	1 259.2	–19.2	44.1
Potash (K_2O)	x	x	x	x
Uranium (U)	260.7	307.1	17.8	10.8
Natural gas	306.0	307.0	0.3	10.8
Total	3 182.5	2 852.0	–10.4	100.0
Alberta				
Petroleum, crude	10 822.5	8 783.8	–18.8	54.4
Natural gas	4 841.6	4 306.5	–11.1	26.7
Natural gas by-products	2 297.6	2 044.1	–11.0	12.7
Coal	482.0	541.1	12.3	3.4
Sulphur, elemental	319.7	200.3	–37.3	1.2
Total	19 110.4	16 147.7	–15.6	100.0
British Columbia				
Coal	1 000.6	997.3	–0.3	26.6
Copper	1 051.3	895.1	–14.9	23.9
Natural gas	491.0	519.3	5.8	13.8
Petroleum, crude	316.1	261.7	–17.2	7.0
Gold	231.7	248.7	7.3	6.6
Zinc	114.4	154.2	34.8	4.1
Sand and gravel	140.6	120.7	–14.2	3.2
Total	3 954.4	3 750.0	–5.2	100.0
Yukon				
Zinc	325.4	178.3	–45.2	51.5
Lead	124.7	81.0	–35.0	23.4
Gold	66.7	67.1	0.6	19.4
Silver	15.2	12.9	–15.1	3.7
Total	541.8	346.2	–36.1	100.0
Northwest Territories				
Zinc	420.5	279.0	–33.7	36.9
Gold	223.8	220.7	–1.4	29.2
Petroleum, crude	247.7	196.3	–20.8	25.9
Lead	55.8	26.7	–52.2	3.5
Total	987.9	756.7	–23.4	100.0
Canada				(Proportion of Canada Total)
Petroleum, crude	13 103.4	10 629.5	–18.9	30.5
Natural gas	5 692.0	5 191.0	–8.8	14.9
Gold	2 407.7	2 355.3	–2.2	6.8
Natural gas by-products	2 370.8	2 125.5	–10.3	6.1
Copper	2 428.9	2 101.2	–13.5	6.0
Coal	1 823.7	1 905.9	4.5	5.5
Nickel	2 027.9	1 828.2	–9.8	5.2
Zinc	2 272.6	1 351.0	–40.6	3.9
Iron ore	1 258.8	1 307.9	3.9	3.8
Potash (K_2O)	964.9	919.0	–4.8	2.6
Grand Total	40 778.0	34 814.2	–14.7	100.0

Source: Energy, Mines and Resources Canada.
p Preliminary; x Confidential.

TABLE 8. PRODUCTION OF LEADING MINERALS, BY PROVINCE AND TERRITORY IN CANADA, 1991p

	Unit of Measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
	(000)													
Petroleum, crude	m3	–	–	–	–	–	240	713	12 699	72 178	1 991	–	1 882	89 703
	$	–	–	–	–	–	36 437	92 104	1 259 208	8 783 753	261 685	–	196 276	10 629 463
Natural gas	000 m3	–	–	–	–	–	430	–	5 997	85 203	11 525	–	239	103 393
	$	–	–	–	–	–	45 506	–	307 031	4 306 480	519 276	–	12 692	5 190 985
Gold	g	x	–	–	x	51 949	76 953	2 498	2 885	34	18 660	5 034	16 562	176 720
	$	x	–	–	x	692 376	1 025 635	33 289	38 458	453	248 694	67 097	220 742	2 355 325
Natural gas by-products	m3	–	–	–	–	–	–	9	127	23 732	809	–	29	24 705
	$	–	–	–	–	–	–	830	12 272	2 044 095	65 205	–	3 055	2 125 457
Copper	kg	–	–	x	10 138	110 189	266 274	56 922	x	–	329 575	–	–	773 640
	$	–	–	x	27 535	299 268	723 187	154 598	x	–	895 110	–	–	2 101 168
Coal	t	–	–	4 050	500	–	–	–	9 000	32 350	25 100	–	–	71 000
	$	–	–	238 000	34 200	–	–	–	95 300	541 100	997 300	–	–	1 905 900
Nickel	kg	–	–	–	–	–	127 027	62 135	–	–	–	–	–	189 161
	$	–	–	–	–	–	1 237 668	590 567	–	–	–	–	–	1 828 235
Zinc	kg	–	–	x	169 887	114 890	221 052	78 628	x	–	123 265	142 558	223 024	1 079 912
	$	–	–	x	212 529	143 727	276 536	98 364	x	–	154 205	178 340	279 002	1 350 970
Iron ore	t	19 200	–	–	–	15 500	1 195	–	–	–	66	–	–	35 961
	$	737 704	–	–	–	x	x	–	–	–	3 095	–	–	1 307 888
Potash (K_2O)	t	–	–	–	x	–	–	–	x	–	–	–	–	7 012
	$	–	–	–	x	–	–	–	x	–	–	–	–	918 994
Cement	t	x	–	x	–	2 307	4 169	x	x	x	x	–	–	9 396
	$	x	–	x	–	142 330	388 543	x	x	x	x	–	–	816 802
Sand and gravel	t	2 784	1 075	4 876	6 843	28 790	63 748	10 537	7 924	35 663	34 864	1 542	1 853	200 497
	$	11 701	2 453	15 045	14 387	83 022	209 649	35 203	17 597	106 584	120 708	6 883	8 160	631 391
Stone	t	987	–	4 177	2 770	34 979	37 331	1 693	–	300	3 040	–	508	85 785
	$	5 015	–	23 576	18 398	206 173	222 374	7 948	–	2 892	22 725	–	3 735	512 837
Uranium (U)	kg	–	–	–	–	–	1 293	–	6 521	–	–	–	–	7 813
	$	–	–	–	–	–	165 000	–	307 074	–	–	–	–	472 074
Asbestos	t	11	–	–	–	593	–	–	–	–	67	–	–	670
	$	4 023	–	–	–	223 150	–	–	–	–	47 362	–	–	274 535
Salt	t	–	–	x	x	x	6 906	–	534	1 237	–	–	–	11 585
	$	–	–	x	x	x	142 614	–	26 759	15 410	–	–	–	258 585
Sulphur, elemental	t	–	–	–	–	–	2	–	64	5 550	413	–	–	6 029
	$	–	–	–	–	–	153	–	3 032	200 269	40 650	–	–	244 104
Lead	kg	–	–	x	59 019	–	x	2 463	–	–	49 578	95 224	31 403	239 558
	$	–	–	x	50 225	–	x	2 096	–	–	42 191	81 036	26 724	203 864
Lime	t	–	–	–	x	x	1 402	x	–	219	x	–	–	2 336
	$	–	–	–	x	x	103 550	7 199	–	20 488	x	–	–	186 287
Silver	kg	x	–	x	153	148	295	47	x	–	490	86	19	1 240
	$	x	–	x	22 869	22 159	44 070	7 022	x	–	73 240	12 856	2 876	185 261
Platinum group	g	–	–	–	–	–	x	x	–	–	–	–	–	10 955
	$	–	–	–	–	–	x	x	–	–	–	–	–	141 790
Clay products	$	x	–	x	x	x	85 279	x	x	x	14 015	–	–	139 411
Peat	t	2	–	x	280	291	–	x	x	76	–	–	–	737
	$	69	–	x	26 934	38 892	–	x	x	14 237	–	–	–	91 675
Sulphur in smelter gas	t	3	–	1	47	122	501	2	–	–	30	–	20	726
	$	566	–	144	6 547	16 756	44 115	345	–	–	4 924	–	3 195	76 592
Gypsum	t	x	–	5 717	–	–	835	x	–	–	278	–	–	7 305
	$	x	–	52 342	–	–	13 900	x	–	–	x	–	–	74 315
Total leading minerals	$	792 350	2 453	414 308	615 545	2 446 779	4 946 199	1 079 521	2 830 673	16 143 938	3 649 472	346 212	756 458	34 023 910
Total all minerals	$	793 306	2 453	444 627	617 008	2 934 229	5 062 151	1 107 794	2 852 043	16 147 718	3 749 999	346 215	756 705	34 814 247
Leading minerals as % of all minerals		99.9	100.0	93.2	99.8	83.4	97.7	97.4	99.3	100.0	97.3	100.0	100.0	97.7

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; – Nil; x Confidential.
Note: Certain minerals are not included in the leading minerals due to confidentiality constraints. Confidential values are included in totals. Numbers may not add to totals due to rounding.

TABLE 8a. PRODUCTION OF LEADING MINERALS, BY PROVINCE AND TERRITORY IN CANADA, 1990

	Unit of Measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
	(000)													
Petroleum, crude	m^3	–	–	–	–	–	247	738	12 431	73 048	1 951	–	1 864	90 279
	$	–	–	–	–	–	44 375	114 939	1 557 754	10 822 496	316 096	–	247 723	13 103 383
Natural gas	000 m^3	–	–	–	–	–	449	–	5 648	82 214	10 335	–	124	98 771
	$	–	–	–	–	–	46 783	–	305 974	4 841 594	491 035	–	6 639	5 692 025
Copper	kg	–	–	x	8 620	99 198	273 448	55 506	x	–	333 883	–	–	771 433
	$	–	–	x	27 142	312 334	860 979	174 768	x	–	1 051 262	–	–	2 428 935
Gold	g	x	–	x	x	40 675	79 968	2 680	3 374	32	16 105	4 639	15 557	167 373
	$	x	–	x	x	585 116	1 150 333	38 549	48 537	455	231 667	66 731	223 788	2 407 654
Natural gas by-products	m^3	–	–	–	–	–	–	9	125	23 047	653	–	29	23 863
	$	–	–	–	–	–	–	935	13 044	2 297 586	55 349	–	3 853	2 370 767
Zinc	kg	16 463	–	x	233 933	120 599	276 110	77 507	x	–	59 346	168 846	218 241	1 179 372
	$	31 724	–	x	450 788	232 395	532 064	149 355	x	–	114 359	325 366	420 550	2 272 649
Nickel	kg	–	–	–	–	–	128 828	66 176	–	–	–	–	–	195 004
	$	–	–	–	–	–	1 345 630	682 286	–	–	–	–	–	2 027 917
Coal	t	–	–	3 416	548	–	–	–	9 407	30 405	24 556	–	–	68 332
	$	–	–	204 465	37 200	–	–	–	99 420	482 000	1 000 615	–	–	1 823 700
Iron ore	t	18 969	–	–	–	15 306	1 294	–	–	–	100	–	–	35 670
	$	708 367	–	–	–	x	x	–	–	–	3 676	–	–	1 258 792
Cement	t	x	–	x	–	2 867	5 221	x	x	x	x	–	–	11 745
	$	x	–	x	–	166 521	475 214	x	x	x	x	–	–	991 442
Potash (K_2O)	t	–	–	–	x	–	–	–	x	–	–	–	–	7 345
	$	–	–	–	x	–	–	–	x	–	–	–	–	964 920
Uranium (U)	kg	–	–	–	–	–	4 598	–	5 123	–	–	–	–	9 720
	$	–	–	–	–	–	627 243	–	260 732	–	–	–	–	887 975
Sand and gravel	t	3 016	1 311	6 890	8 285	29 895	79 970	12 355	12 022	43 905	41 278	2 113	3 274	244 316
	$	14 456	3 271	22 945	16 405	89 533	286 391	38 384	23 462	158 198	140 585	9 833	13 856	817 317
Stone	t	1 501	–	7 271	2 711	40 634	50 418	3 737	–	313	3 271	–	1 495	111 352
	$	9 952	–	39 459	18 098	243 573	300 561	15 193	–	2 702	24 327	–	9 079	662 945
Sulphur, elemental	t	–	–	–	–	–	4	–	69	5 330	419	–	–	5 822
	$	–	–	–	–	–	400	–	5 544	319 736	43 184	–	–	368 864
Lead	kg	–	–	x	56 244	–	x	1 755	–	–	19 312	104 181	46 588	233 372
	$	–	–	x	67 324	–	x	2 101	–	–	23 117	124 704	55 766	279 346
Asbestos	t	72	–	–	–	524	–	–	–	–	89	–	–	686
	$	29 005	–	–	–	190 263	–	–	–	–	52 834	–	–	272 102
Silver	kg	x	–	x	145	164	330	41	x	–	598	84	19	1 381
	$	x	–	x	26 130	29 564	59 627	7 349	x	–	108 112	15 177	3 457	249 746
Salt	t	–	–	x	x	x	6 143	–	603	1 326	–	–	–	11 191
	$	–	–	x	x	x	116 652	–	29 874	14 809	–	–	–	240 890
Platinum group	g	–	–	–	–	–	x	x	–	–	–	–	–	11 123
	$	–	–	–	–	–	x	x	–	–	–	–	–	189 423
Lime	t	–	–	–	x	x	1 366	x	–	240	x	–	–	2 341
	$	–	–	–	x	x	102 338	6 850	–	22 336	x	–	–	188 283
Clay products	$	x	–	x	x	x	87 063	x	x	x	11 167	–	–	136 029
Peat	t	2	–	x	266	350	–	x	x	72	–	–	–	775
	$	68	–	x	23 857	41 058	–	x	x	13 268	–	–	–	89 735
Molybdenum	kg	–	–	–	–	–	–	–	–	–	12 188	–	–	12 188
	$	–	–	–	–	–	–	–	–	–	84 721	–	–	84 721
Sulphur, in smelter gas	t	3	–	1	73	99	570	2	–	–	25	–	17	790
	$	458	–	89	9 202	13 628	50 914	279	–	–	3 982	–	2 677	81 229
Total leading minerals	$	858 035	3 271	376 990	876 797	2 461 022	6 317 107	1 287 640	3 157 913	19 104 221	3 918 595	541 811	987 388	39 890 789
Total all minerals	$	865 987	3 271	459 488	877 926	3 037 007	6 445 825	1 311 466	3 182 501	19 110 448	3 954 393	541 814	987 900	40 778 025
Leading minerals as % of all minerals		99.1	100.0	82.0	99.9	81.0	98.0	98.2	99.2	100.0	99.1	100.0	99.9	97.8

Sources: Energy, Mines and Resources Canada; Statistics Canada
– Nil; . . . Amount too small to be expressed; x Confidential.
Note: Certain minerals are not included in the leading minerals due to confidentialty constraints. Confidential values are included in totals. Numbers may not add to totals due to rounding.

TABLE 9. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1985-91

	1985	1986	1987	1988r	1989r	1990	1991p
Petroleum, crude	41.2	29.6	33.4	24.8	27.6	32.1	30.5
Natural gas	18.0	17.3	12.7	14.1	13.7	14.0	14.9
Gold	2.7	5.2	6.1	6.3	5.9	5.9	6.8
Natural gas by-products	6.3	5.6	5.2	4.3	4.1	5.8	6.1
Copper	3.3	4.4	5.3	6.5	6.1	6.0	6.0
Coal	4.1	5.3	4.5	4.9	4.8	4.5	5.5
Nickel	2.7	3.0	3.5	7.6	7.7	5.0	5.3
Zinc	2.9	3.7	4.1	6.1	7.0	5.6	3.9
Iron ore	3.3	4.1	3.8	3.6	3.5	3.1	3.8
Potash (K_2O)	1.4	1.8	2.0	3.2	2.6	2.4	2.6
Cement	1.8	2.5	2.7	2.6	2.4	2.4	2.3
Sand and gravel	1.4	2.1	2.1	2.3	2.2	2.0	1.8
Stone	0.9	1.5	1.6	1.7	1.7	1.6	1.5
Uranium (U)	2.2	3.2	3.3	2.8	2.3	2.2	1.4
Asbestos	0.7	0.7	0.7	0.8	0.7	0.7	0.8
Salt	0.5	0.7	0.7	0.7	0.7	0.6	0.7
Sulphur, elemental	2.3	2.6	1.4	1.2	1.1	0.9	0.7
Lead	0.3	0.7	1.1	1.0	0.7	0.7	0.6
Lime	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Silver	0.7	0.8	1.2	1.0	0.7	0.6	0.5
Platinum group	0.3	0.6	0.5	0.5	0.4	0.5	0.4
Clay products	0.3	0.6	0.6	0.5	0.5	0.3	0.4
Peat	0.1	0.2	0.2	0.2	0.3	0.2	0.3
Sulphur in smelter gas	0.2	0.2	0.3	0.2	0.2	0.2	0.2
Gypsum	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Other minerals	1.8	2.8	2.3	2.4	2.3	2.2	2.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; r Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 10. PRODUCTION OF CANADA'S TEN LEADING[1] MINERAL COMMODITIES, 1984-91

	Unit	1984	1985	1986	1987	1988	1989	1990	1991p
	(000)								
Petroleum	m^3	83 680	85 564	85 468	89 140	93 806	90 641	90 279	89 703
Natural gas	000 m^3	78 266	84 344	71 896	78 267	90 911	96 117	98 771	103 393
Gold	g	83 446	87 562	102 899	115 818	134 813	159 494	167 373	176 720
Natural gas by-products	m^3	19 640	19 682	19 127	21 560	22 556	23 055	23 863	24 705
Copper	kg	721 826	738 637	698 527	794 149	758 478	704 432	771 433	773 640
Coal	t	57 402	60 436	57 811	61 211	70 644	70 527	68 332	71 000
Nickel	kg	173 725	169 971	163 639	189 086	198 744	195 554	195 004	189 161
Zinc	kg	1 062 701	1 049 275	988 173	1 157 936	1 370 000	1 272 854	1 179 372	1 079 912
Iron ore	t	39 930	39 502	36 167	37 702	39 934	39 445	35 670	35 961
Potash (K_2O)	t	7 527	6 661	6 753	7 668	8 154	7 014	7 345	7 012

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Based on contribution in 1991 to value of mineral production.
p Preliminary.

TABLE 11. CANADA'S WORLD ROLE AS A PRODUCER OF CERTAIN IMPORTANT MINERALS, 1990[p]

		World	Rank of Five Leading Countries 1	2	3	4	5
			Canada	Australia	United States	Namibia	France
	t	31 640	8 780[a]	3 530	3 420	3 210	2 830
Uranium (U concentrates)	% of Western World total		27.7	11.2	10.8	10.1	8.9
			Canada	Australia	U.S.S.R.	China	Peru
	000 t	7 319	1 203	931	870[e]	619	585
Zinc (mine production)	% of world total		16.4	12.7	11.9	8.5	8.0
			United States	**Canada**	Iran	China	Japan
	000 t	97 677	14 883	8 790	7 983	7 983	6 350
Gypsum	% of world total		15.2	9.0	8.2	8.2	6.5
			U.S.S.R.	**Canada**	East Germany	West Germany	United States
	000 t	27 416	9 088	6 989	2 653	2 197	1 654
Potash (K_2O equivalent)	% of world total		33.1	25.5	9.7	8.0	6.0
			U.S.S.R.	**Canada**	New Caledonia	Australia	Indonesia
	000 t	934	280	196	85	67	54
Nickel (mine production)	% of world total		30.0	21.0	9.1	7.2	5.8
			U.S.S.R	**Canada**	Brazil	Zimbabwe	China
	000 t	4 204	2 568[e]	725	200	188	165[e]
Asbestos	% of world total		61.1	17.2	4.8	4.5	3.9
			United States	Chile	**Canada**	U.S.S.R.	Mexico
	t	110 359	61 611	13 830	12 188	11 000	4 000
Molybdenum (Mo content)	% of world total		55.8	12.5	11.0	10.0	3.6
			South Africa	U.S.S.R.	**Canada**	United States	Japan
Platinum group metals	kg	286 618	138 500	125 000	11 123	7 740	2 419
(mine production)	% of world total		48.3	43.6	3.9	2.7	0.8
			United States	U.S.S.R.	**Canada**	Poland	Mexico
	000 t	38 959	10 262	6 360	5 891	4 426	2 142
Sulphur, elemental	% of world total		26.3	16.3	15.1	11.4	5.5
			United States	U.S.S.R.	**Canada**	Australia	Brazil
	000 t	18 182	4 048	2 220[e]	1 567	1 233	931
Aluminum (primary metal)	% of world total		22.3	12.1	8.6	6.8	5.1
			Zaire	Zambia	U.S.S.R.	**Canada**	Cuba
	t	24 693	10 033	4 844	2 400[e]	2 184	1 600[e]
Cobalt (mine production)	% of world total		40.6	19.6	9.7	8.8	6.5
			Australia	Norway	South Africa	Canada	Malaysia
	000 t	5 988	1 845	900	785[e]	760[eb]	502
Titanium concentrates (ilmenite)	% of world total		30.8	15.0	13.1	12.7	8.4
			Chile	United States	U.S.S.R.	**Canada**	Zambia
	000 t	9 028	1 588	1 587	900	794	496
Copper (mine production)	% of world total		17.6	17.6	10.0	8.8	5.5
			Mexico	United States	Peru	**Canada**	U.S.S.R.
	t	15 594	2 546	2 168	1 781	1 501	1 380
Silver (mine production)	% of world total		16.3	13.9	11.4	9.6	8.8
			Australia	United States	U.S.S.R.	China	**Canada**
	000 t	3 325	561	495	490[e]	315[e]	241
Lead (mine production)	% of world total		16.9	14.9	14.7	9.5	7.2
			Japan	U.S.S.R.	Belgium	United States	**Canada**
	t	19 983	2 451	2 400[e]	1 956	1 678	1 470
Cadmium (refined production)	% of world total		12.3	12.0	9.8	8.4	7.4
			South Africa	United States	U.S.S.R.	Australia	**Canada**
	t	2 032	603	290	250[e]	243	169
Gold (refined production)	% of world total		29.7	14.3	12.3	12.0	8.3

[a] Includes uranium (tU) recovered by Elliot Lake producers from refinery/conversion facility wastes; [b] Titaniferous slag with 80% TiO_2 content.
[p] Preliminary; [e] Estimated.

TABLE 12. CANADA'S WORLD ROLE AS A PRODUCER OF CERTAIN IMPORTANT MINERALS, 1989

		World	Rank of Five Leading Countries 1	2	3	4	5
			Canada	United States	Australia	France	Namibia
	t	34 400	11 350[a]	5 320	3 660	3 240	3 100
Uranium (U concentrates)	% of Western World total		33.0	15.5	10.6	9.4	9.0
			Canada	U.S.S.R.	Australia	China	Peru
	000 t	7 106	1 216	940[e]	803	620	598
Zinc (mine production)	% of world total		17.1	13.2	11.3	8.7	8.4
			United States	**Canada**	Iran	China	Japan
	000 t	99 022	15 988	9 179	8 437	8 074	6 260
Gypsum	% of world total		16.1	9.3	8.5	8.2	6.3
			U.S.S.R.	**Canada**	East Germany	West Germany	United States
	000 t	29 304	10 232	7 333	3 200	2 186	1 595
Potash (K_2O equivalent)	% of world total		34.9	25.0	10.9	7.5	5.4
			U.S.S.R.	**Canada**	New Caledonia	Australia	Indonesia
	000 t	963	280	201	96	65	60
Nickel (mine production)	% of world total		29.1	20.9	10.0	6.7	6.2
			Australia	**Canada**	Norway	South Africa	Malaysia
	000 t	6 455	1 957	1 040[eb]	930	785[e]	521
Titanium concentrates (ilmenite)	% of world total		30.3	16.1	14.4	12.2	8.1
			U.S.S.R.	**Canada**	Brazil	Zimbabwe	China
	000 t	4 347	2 600[e]	732	230	190	160[e]
Asbestos	% of world total		59.8	16.8	5.3	4.4	3.7
			United States	Chile	**Canada**	U.S.S.R.	Mexico
	t	116 799	63 105	16 550	13 543	11 500	4 189
Molybdenum (Mo content)	% of world total		54.0	14.2	11.6	9.8	3.6
			South Africa	U.S.S.R.	**Canada**	United States	Japan
Platinum group metals	kg	283 158	135 800	127 500	9 870	6 280	1 852
(mine production)	% of world total		48.0	45.0	3.5	2.2	0.7
			United States	U.S.S.R.	**Canada**	Poland	Mexico
	000 t	40 368	10 397	6 640	5 815	4 865	2 012
Sulphur, elemental	% of world total		25.8	16.4	14.4	12.1	5.0
			United States	U.S.S.R.	**Canada**	Australia	Brazil
	000 t	18 229	4 030	2 500[e]	1 555	1 241	888
Aluminum (primary metal)	% of world total		22.1	13.7	8.5	6.8	4.9
			Zaire	Zambia	U.S.S.R.	**Canada**	Cuba
	t	24 700	9 311	4 488	2 850[e]	2 344	2 000[e]
Cobalt (mine production)	% of world total		37.7	18.2	11.5	9.5	8.1
			Chile	United States	U.S.S.R.	**Canada**	Zambia
	000 t	9 092	1 609	1 498	950	723	510
Copper (mine production)	% of world total		17.7	16.5	10.4	8.0	5.6
			Japan	U.S.S.R.	Belgium	**Canada**	United States
	t	20 778	2 694	2 600[e]	1 741	1 620	1 550
Cadmium (refined production)	% of world total		13.0	12.5	8.4	7.8	7.5
			U.S.S.R.	Australia	United States	China	**Canada**
	000 t	3 305	500[e]	495	419	341[e]	276
Lead (mine production)	% of world total		15.1	15.0	12.7	10.3	8.4
			Mexico	United States	Peru	U.S.S.R.	**Canada**
	t	14 610	2 306	2 007	1 853	1 500	1 371
Silver (mine production)	% of world total		15.8	13.7	12.7	10.3	9.4
			South Africa	U.S.S.R.	United States	Australia	**Canada**
	t	1 946	605	285[e]	266	204	160
Gold (mine production)	% of world total		31.1	14.6	13.7	10.5	8.2

[a] Includes uranium (tU) recovered by Elliot Lake producers from refinery/conversion facility wastes; [b] Titaniferous slag with 80% TiO_2 content.
[e] Estimated.

TABLE 13. CANADA, CENSUS VALUE ADDED, TOTAL ACTIVITY, MINING AND MINERAL MANUFACTURING INDUSTRIES, 1983-89

	1983	1984	1985	1986	1987	1988	1989
				($ million)			
Mining							
Metallic minerals							
Nickel-copper-zinc	1 567.3	2 008.1	1 868.5	1 712.9	2 391.5	4 405.0	4 515.6
Gold	693.6	660.8	635.3	975.3	1 307.2	1 393.0	1 425.9
Silver-lead-zinc	294.2	465.7	275.3	332.2	562.0	837.8	989.9
Iron	644.6	681.4	817.1	713.8	787.2	678.2	741.3
Uranium	496.9	772.5	813.1	802.0	898.3	858.6	706.9
Miscellaneous metal mines	33.2	72.1	65.4	54.5	84.6	103.8	123.0
Total	3 729.8	4 660.6	4 474.7	4 590.7	6 030.8	8 276.4	8 502.6
Industrial minerals							
Potash	455.4	717.1	428.8	396.4	578.9	956.2	841.5
Stone	119.5	160.1	207.5	277.6	331.3	354.3	351.4
Sand and gravel	90.3	104.9	132.9	220.0	306.5	287.3	300.7
Miscellaneous nonmetals	201.8	240.5	226.8	289.1	267.9	261.7	272.7
Asbestos	254.9	252.7	217.6	157.1	147.6	137.9	208.6
Peat	43.0	47.1	63.0	74.6	93.5	77.3	86.9
Gypsum	35.1	40.2	50.7	56.6	67.2	64.1	66.0
Total	1 200.0	1 562.6	1 327.3	1 471.3	1 792.9	2 139.0	2 127.8
Fuels							
Petroleum and natural gas	22 171.3	25 008.2	25 428.7	15 044.3	15 843.7	13 405.4	14 610.0
Coal	911.1	1 314.2	1 264.5	1 110.4	1 136.4	1 279.5	1 196.7
Total	23 082.4	26 322.4	26 693.2	16 154.7	16 980.1	14 684.9	15 806.7
Total mining industry	28 012.2	32 545.6	32 495.2	22 216.7	24 803.8	25 100.3	26 437.1
Mineral Manufacturing							
Primary metal industries							
Smelting and refining	1 912.4	2 236.9	2 202.4	2 372.8	3 050.9	3 867.1	..
Primary steel	2 464.9	2 939.6	3 105.9	3 001.6	3 424.6	4 049.2	..
Wire and wire products industries[1]	554.6	704.2	812.9	848.8	821.0	855.6	..
Aluminum rolling, casting and extruding	328.2	394.7	384.3	424.9	503.3	576.2	..
Steel pipe and tube	213.4	389.6	388.2	331.0	385.4	568.2	..
Iron foundries	326.0	447.7	471.5	510.7	479.7	497.1	..
Metal rolling, casting and extruding, n.e.s.	234.1	323.1	355.2	397.1	424.9	490.0	..
Copper and alloy rolling, casting and extruding	117.7	147.8	134.7	144.0	129.6	228.1	..
Total	6 151.3	7 583.6	7 855.0	8 030.9	9 219.5	11 131.5	..
Nonmetallic Mineral Products Industries							
Other nonmetallic mineral products industries	487.6	571.5	672.4	781.7	924.7	1 052.8	..
Ready-mix concrete industries	405.0	397.5	455.3	626.3	748.4	752.7	..
Concrete products industries	333.6	376.5	463.9	522.2	590.8	721.8	..
Cement industries	407.5	421.9	490.7	500.2	558.4	601.2	..
Glass industries	403.8	460.9	466.4	482.4	532.7	507.9	..
Glass products industries	209.8	258.1	320.7	294.9	336.7	360.6	..
Clay products (domestic clay)	78.2	87.7	92.9	129.4	148.2	148.0	..
Abrasive industries	91.4	101.9	97.8	100.5	105.2	120.3	..
Clay products (imported clay)	37.2	37.3	41.4	98.6	130.4	100.1	..
Lime industries	66.2	75.4	70.1	78.0	87.4	106.1	..
Total	2 520.3	2 788.7	3 171.8	3 614.3	4 163.0	4 471.5	..
Fabricated metal products industries							
Stamped and pressed metal products industries	1 303.6	1 417.2	1 612.4	1 729.2	2 069.7	2 152.8	..
Fabricated structural metal products industries	795.3	817.4	930.9	1 111.3	1 177.6	1 301.7	..
Hardware, tool and cutlery industry	650.7	786.7	932.0	993.4	1 025.5	1 081.3	..
Other metal-fabricating industries	690.5	745.5	735.0	729.6	856.4	940.2	..
Ornamental and architectural metal products industries	491.2	519.9	608.4	722.2	813.1	911.5	..
Machine shop industry	451.3	549.5	611.2	636.6	692.4	819.6	..
Power boiler and heat exchanger industry	319.1	298.1	351.1	357.7	407.7	365.3	..
Heating equipment industry	182.0	162.6	243.9	262.6	269.5	270.4	..
Total	4 883.7	5 296.9	6 024.8	6 542.6	7 311.9	7 842.8	..

TABLE 13. (cont'd)

	1982	1983	1984	1985	1986	1987	1988
				($ million)			
Petroleum and coal products industries							
Petroleum refining	2 563.7	2 498.2	2 478.8	1 755.6	1 860.1	2 096.4	. .
Other petroleum and coal products industries	52.6	42.1	41.0	98.9	107.5	86.8	. .
Manufacturers of lubricating oil and greases	24.8	56.1	75.7	82.5	99.0	96.7	. .
Total	2 641.1	2 596.4	2 595.5	1 936.9	2 066.5	2 279.9	. .
Total mineral manufacturing	16 196.4	18 265.6	19 647.0	20 124.7	22 760.9	25 725.7	. .
Total mining and mineral manufacturing	44 208.6	50 811.2	52 142.2	42 341.4	47 564.8	50 826.0	. .

Sources: Energy, Mines and Resources Canada; Statistics Canada.
1 Wire and wire products have been included in Primary Metal Industries.
r Revised; . . Not available; n.e.s. Not elsewhere specified.
Note: Totals may not add due to rounding.

TABLE 14. CANADA, GROSS DOMESTIC PRODUCT OF INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING AT FACTOR COST AT 1986 PRICES, 1984-90

	1984	1985	1986	1987	1988	1989	1990p
				($ million)			
Total industrial production	114 882.6	121 272.9	120 363.8	126 231.0	133 117.8	132 956.3	127 192.4
Total mining	18 027.2	18 825.2	17 502.3	18 631.1	20 329.2	19 828.3	19 783.1
Metals							
Gold mines	679.0	740.1	880.6	987.1	1 205.3	1 552.9	1 609.7
Other metal mines	2 516.3	2 382.5	2 346.5	2 734.0	2 678.1	2 490.1	2 420.2
Iron mines	444.6	585.8	452.7	504.7	563.2	578.9	485.1
Fuels							
Crude oil and natural gas	9 899.3	10 593.7	9 762.6	10 379.4	11 386.3	11 332.3	11 472.7
Nonmetals							
Asbestos	124.9	110.2	102.0	103.7	104.8	120.1	108.1
All nonmetals	514.1	448.3	485.4	583.4	635.5	583.1	562.1
Potash	336.2	280.5	309.9	369.9	441.2	390.3	372.4
Salt	135.9	132.9	135.6	125.8	139.4	139.1	146.6
Coal	807.5	825.2	755.2	849.8	1 003.4	1 001.1	968.3
Quarry and sand pits	470.9	541.2	643.7	687.7	702.7	742.6	761.6
Services related to mining	2 473.8	2 663.2	1 937.7	1 675.5	1 910.5	1 288.1	1 248.7
Mineral manufacturing							
Primary metals	6 004.0	6 351.6	6 127.7	6 773.0	7 373.4	7 250.4	6 684.6
Primary steel	2 731.8	2 816.3	2 625.8	2 827.1	3 034.2	3 022.4	2 689.0
Steel pipe and tube mills	305.0	342.1	277.7	328.7	449.8	403.9	385.1
Iron foundries	435.7	439.2	460.8	424.5	454.4	421.3	366.8
Nonferrous smelting and refining	1 855.1	1 989.0	1 954.7	2 301.1	2 475.1	2 412.2	2 334.5
Nonmetallic mineral products	2 607.7	2 845.4	2 971.3	3 257.0	3 338.9	3 321.5	3 004.9
Cement	354.2	387.0	384.0	431.0	429.7	424.0	399.5
Concrete products	350.7	422.7	448.4	476.7	534.3	552.1	468.8
Ready-mix concrete	392.9	448.4	507.1	568.6	536.4	528.9	441.1
Glass and glass products	647.1	689.3	647.8	694.5	683.0	709.1	653.0
Miscellaneous nonmetallic products	740.6	769.3	787.0	867.7	974.8	961.7	916.4
Petroleum and coal products	1 792.8	1 746.0	1 731.5	1 823.8	1 849.0	1 901.4	1 941.6

Source: Statistics Canada.
p Preliminary.

TABLE 15. CANADA, GROSS DOMESTIC PRODUCT BY INDUSTRIY AT FACTOR COST AT 1986 PRICES, 1984-90

	1984	1985	1986	1987	1988	1989	1990p
				($ million)			
Gross domestic product, all industries	418 716.4	438 450.1	451 845.3	471 522.9	493 265.0	505 937.9	507 514.2
Agriculture	9 814.3	9 404.2	11 056.7	9 966.1	9 438.7	10 222.0	11 470.1
Fishing and trapping	776.7	945.2	980.2	885.5	936.1	983.8	931.7
Forestry	2 720.3	2 635.3	2 690.8	3 008.2	3 027.4	2 945.1	2 835.0
Mines (including milling), quarries and oil wells	18 027.2	18 825.2	17 502.3	18 631.1	20 329.2	19 828.3	19 783.1
Manufacturing	81 552.0	86 150.2	86 797.1	90 973.1	95 699.3	95 964.4	90 838.3
Construction	25 012.7	26 953.0	28 081.7	29 686.5	31 355.2	32 786.6	32 984.8
Transportation and storage	19 356.4	19 763.4	20 253.8	21 660.1	22 662.3	22 553.2	22 521.0
Communications	11 954.3	12 634.8	13 247.9	14 139.5	15 144.1	16 953.9	18 442.4
Electric power, gas and water utilities	13 793.5	14 885.1	15 197.7	15 755.4	16 190.4	16 249.0	15 643.0
Trade, wholesale	19 358.2	21 765.8	23 312.0	25 131.4	26 992.3	27 047.5	26 341.9
Trade, retail	25 982.5	27 375.2	28 269.2	29 928.9	31 154.2	31 067.1	30 580.4
Finance, insurance and real estate	61 786.9	65 747.8	69 033.9	71 931.3	74 823.1	78 568.6	80 024.2
Community, business and personal services	46 960.0	48 776.9	52 119.0	55 102.3	59 206.2	62 476.6	64 876.4
Government services	30 773.9	30 954.5	31 365.5	31 418.1	31 872.0	32 549.2	33 221.2

Source: Statistics Canada.
p Preliminary.

TABLE 16. CANADA, GROSS DOMESTIC PRODUCT AT FACTOR COST IN CURRENT DOLLARS FOR SELECTED INDUSTRIES BY PROVINCE, 1987

	Newfound-land	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon and N.W.T.	Canada
	($ million)											
Agriculture and related services industries	18.4	68.3	151.9	106.8	1 618.3	2 713.7	900.2	2 043.5	1 935.9	560.0	0.2	10 117.2
Logging and forestry industries	76.8	4.3	76.8	230.2	586.6	670.0	48.3	42.9	35.3	1 486.6	3.0	3 260.8
Fishing and trapping industries	209.6	51.6	374.8	85.1	102.8	54.2	24.0	9.7	9.3	307.4	5.7	1 234.2
Mining, quarrying and oil well industries[1]	267.1	0.0	100.2	178.7	1 130.4	2 725.7	492.4	2 031.8	11 022.4	1 660.9	689.1	20 298.7
Manufacturing industries	683.0	109.6	1 545.5	1 596.5	24 338.5	49 835.0	2 387.9	1 026.7	4 268.7	8 695.1	11.7	94 498.2
Construction industries	546.0	114.1	831.8	648.4	7 412.6	12 724.8	1 220.0	1 282.3	3 621.3	3 720.1	271.4	32 392.8
Electric power systems industry, gas distribution systems industry and other utilities industries	347.9	37.9	301.5	545.1	4 661.5	5 564.1	649.5	586.8	1 636.1	1 574.4	87.6	15 992.4
Goods–producing industries	2 148.8	385.8	3 382.5	3 390.8	39 850.7	74 287.5	5 722.3	7 023.7	22 529.0	18 004.5	1 068.7	177 794.3

Source: Statistics Canada Catalogue No. 15-203.
1 Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing."
Note: Totals may not add due to rounding.

TABLE 16a. CANADA, GROSS DOMESTIC PRODUCT AT FACTOR COST IN CURRENT DOLLARS FOR SELECTED INDUSTRIES BY PROVINCE, 1986[r]

	Newfound-land	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon and N.W.T.	Canada
	($ million)											
Agriculture and related services industries	19.0	125.1	149.4	113.6	1 788.7	2 521.1	877.3	2 505.6	2 372.5	584.4	0.1	11 056.8
Logging and forestry industries	57.2	2.2	87.3	213.8	527.7	659.7	33.7	32.6	27.9	1 047.7	1.3	2 691.1
Fishing and trapping industries	143.0	42.9	293.3	70.6	76.6	46.3	18.2	7.7	6.6	271.0	3.9	980.1
Mining, quarrying and oil well industries[1]	341.4	0.1	141.1	139.5	851.9	2 144.9	277.7	1 503.9	10 215.4	1 370.2	516.2	17 502.3
Manufacturing industries	562.6	93.6	1 659.3	1 337.9	21 650.1	46 891.7	2 080.1	995.0	4 181.7	7 325.8	11.7	86 789.5
Construction industries	500.1	111.1	847.6	594.3	6 197.2	10 280.6	1 149.8	1 206.1	3 565.9	3 342.5	286.8	28 082.0
Electric power systems industry, gas distribution systems industry and other utilities industries	343.9	44.8	271.1	539.6	4 410.5	5 037.1	655.4	467.1	1 831.2	1 525.5	71.3	15 198.1
Goods–producing industries	1 967.2	419.8	3 449.7	3 009.3	35 502.7	67 581.4	5 092.2	6 718.0	22 201.2	15 467.1	891.3	162 299.9

Source: Statistics Canada Catalogue No. 15-203.
1 Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing."
r Revised.
Note: Totals may not add due to rounding.

TABLE 17. CANADA, GROSS DOMESTIC PRODUCT AT FACTOR COST IN CURRENT DOLLARS FOR MINING[1] BY PROVINCE, 1978-87

	Newfound-land	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon and N.W.T.	Canada
						($ million)						
1978	249.2	0.1	83.1	113.7	774.5	1 255.8	190.5	855.7	5 191.2	942.8	294.6	9 951.2
1979	475.6	0.1	102.4	206.4	989.5	1 600.8	354.5	1 014.2	7 409.6	1 621.4	440.4	14 214.8
1980	445.1	0.1	116.1	96.2	1 223.1	2 476.9	428.6	1 304.4	10 033.1	1 479.5	516.7	18 119.5
1981	471.8	0.1	124.9	125.9	1 099.6	1 883.6	290.3	1 298.5	10 593.0	1 264.6	358.4	17 510.6
1982	313.0	0.1	190.0	124.5	866.5	1 356.1	282.2	1 294.3	12 531.2	1 209.7	412.8	18 580.3
1983	367.8	0.1	277.4	94.2	853.6	1 689.4	352.6	1 640.9	14 648.1	1 319.5	443.9	21 687.6
1984	363.0	0.5	224.9	200.9	793.8	2 186.4	414.7	2 528.3	16 472.6	1 865.3	515.2	25 565.6
1985	399.7	1.0	166.7	109.2	857.9	1 994.1	430.3	2 523.8	18 388.8	1 698.3	543.9	27 113.7
1986[r]	341.4	0.1	141.1	139.5	851.9	2 144.9	277.7	1 503.9	10 215.4	1 370.2	516.2	17 502.3
1987	267.1	0.0	100.2	178.7	1 130.4	2 725.7	492.4	2 031.8	11 022.4	1 660.9	689.1	20 298.7

Source: Statistics Canada Catalogue No. 15-203.
[1] Cement, lime, clay and clay products (domestic clays) industries are not included (see manufacturing).
[r] Revised.
Note: Totals may not add due to rounding.

TABLE 18. CANADA, GROSS DOMESTIC PRODUCT AT FACTOR COST IN CURRENT DOLLARS FOR MINERAL MANUFACTURING INDUSTRIES BY PROVINCE, 1987

	Primary Metal Industries	Nonmetallic Mineral Products Industries	Fabricated Metal Products Industries	Petroleum and Coal Products Industries	Mineral Manufacturing Industries
		($ million)			
Newfoundland	x	x	9.8	x	77.7
Prince Edward Island	–	1.7	5.2	–	6.9
Nova Scotia	x	41.9	46.8	x	146.7
New Brunswick	x	x	53.3	x	149.6
Quebec	2 274.3	756.7	1 468.7	82.4	4 582.0
Ontario	4 018.3	1 982.6	4 169.9	421.1	10 591.9
Manitoba	177.5	88.9	167.2	x	x
Saskatchewan	x	61.3	60.7	x	255.0
Alberta	215.5	259.2	345.2	212.5	1 032.4
British Columbia	400.3	224.8	441.4	68.7	1 135.2
Yukon and Northwest Territories	–	x	–	x	x
Canada	7 242.0	3 475.6	6 768.2	931.1	18 416.9

Source: Statistics Canada.
x Confidential, included in total; – Nil.

TABLE 18a. CANADA, GROSS DOMESTIC PRODUCT AT FACTOR COST IN CURRENT DOLLARS FOR MINERAL MANUFACTURING INDUSTRIES BY PROVINCE, 1986r

	Primary Metal Industries	Nonmetallic Mineral Products Industries	Fabricated Metal Products Industries	Petroleum and Coal Products Industries	Mineral Manufacturing Industries
		($ million)			
Newfoundland	x	19.9	7.3	x	2.8
Prince Edward Island	–	1.1	3.7	–	4.8
Nova Scotia	x	39.8	42.6	x	382.6
New Brunswick	x	x	44.4	x	253.9
Quebec	1 683.6	x	1 223.5	38.2	x
Ontario	3 494.8	1 650.0	3 906.9	554.2	9 605.9
Manitoba	147.8	77.4	141.3	x	x
Saskatchewan	x	57.1	49.9	x	272.4
Alberta	250.4	252.6	357.4	413.9	1 274.3
British Columbia	426.2	205.0	367.3	x	x
Yukon and Northwest Territories	–	x	–	x	–
Canada	6 127.8	2 970.9	6 144.3	1 731.6	16 974.7

Source: Statistics Canada.
x Confidential, included in total; – Nil; r Revised.

TABLE 19. CANADA, EXPORTS OF MINERAL COMMODITIES BY COUNTRY AND BY COMMODITY AS DEFINED BY THE HARMONIZED SYSTEM (H.S.), 1990 REVISED

H.S. Chapter[1]	Description	United States		EEC[2]		Japan		Mexico		Other		Total	
		($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)
25	Salts; sulphur; earths or stone, plastering material, lime and cement	524 056	35.8	182 702	12.5	61 296	4.2	42 352	2.9	651 934	44.6	1 462 317	100
26	Ores, slag and ash	540 145	17.4	1 217 132	39.3	964 204	31.1	2 486	0.1	371 465	12.0	3 095 432	100
27	Mineral fuels, oils and products of their distillation; bituminous substances; mineral waxes[3]	12 823 788	84.5	236 469	1.6	1 487 316	9.8	5 146	–	631 495	4.2	15 184 214	100
28	Inorganic chemicals; compounds of precious metals, radioactive elements, etc.	1 347 343	83.6	134 873	8.4	28 422	1.8	543	–	100 025	6.2	1 611 206	100
31	Fertilizers	990 137	59.6	56 645	3.4	76 647	4.6	2 015	0.1	536 669	32.3	1 662 113	100
68	Articles of stone, plaster, cement, asbestos, mica or similar materials	307 096	92.2	11 394	3.4	2 775	0.8	275	0.1	11 529	3.5	333 069	100
69	Ceramic products	45 066	78.2	2 175	3.8	780	1.4	26	–	9 596	16.6	57 643	100
70	Glass and glassware	316 532	84.0	39 636	10.5	1 917	0.5	138	–	18 824	5.0	377 047	100
71	Natural/cultured pearls, precious stones and metals, coins, etc.	915 394	34.1	391 540	14.6	237 490	8.8	3 798	0.1	1 136 339	42.3	2 684 561	100
72	Iron and steel	1 564 307	73.9	182 481	8.6	14 356	0.7	56 548	2.7	300 086	14.2	2 117 778	100
73	Articles of iron or steel	1 494 177	89.5	40 202	2.4	6 599	0.4	11 206	0.7	117 522	7.0	1 669 706	100
74	Copper and articles thereof	879 950	62.3	420 665	29.8	6 732	0.5	569	–	105 110	7.4	1 413 026	100
75	Nickel and articles thereof	783 643	53.4	256 234	17.5	27 287	1.9	2 226	0.2	398 301	27.1	1 467 691	100
76	Aluminum and articles thereof	2 478 437	70.9	280 088	8.0	356 175	10.2	849	–	380 237	10.9	3 495 786	100
78	Lead and articles thereof	74 698	62.8	23 671	19.9	8 945	7.5	–	–	11 588	9.7	118 902	100
79	Zinc and articles thereof	737 341	82.6	24 812	2.8	40 215	4.5	474	0.1	89 364	10.0	892 206	100
80	Tin and articles thereof	6 989	78.1	185	2.1	104	1.2	–	–	1 674	18.7	8 952	100
81	Other base metals; cermets; and articles thereof	133 840	69.0	23 768	12.3	4 213	2.2	–	–	32 030	16.5	193 851	100
	TOTAL MINERAL EXPORTS	25 962 916	68.6	3 524 672	9.3	3 325 473	8.8	128 651	0.3	4 903 788	13.0	37 845 500	100
	TOTAL DOMESTIC EXPORTS	105 452 876	74.4	11 712 651	8.3	8 186 387	5.8	643 369	0.5	15 724 844	11.1	141 720 127	100
	PERCENTAGE MINERAL TO DOMESTIC	24.6		30.1		40.6		20.0		31.2		26.7	

Source: Statistics Canada, Catalogue #65-003 (Quarterly).
[1] H.S. Chapter refers to a group of commodities covered in a specified chapter of the "Harmonized Commodity Description and Coding System", as of January 1, 1988. Canadian external trade statistics are classified according to the Harmonized System. [2] EEC: European Economic Community. [3] Value of coal exports included in chapter 27 is $2 276 million.

TABLE 20. CANADA, IMPORTS OF MINERAL COMMODITIES BY COUNTRY AND BY COMMODITY AS DEFINED BY THE HARMONIZED SYSTEM (H.S.), 1990 REVISED

H.S. Chapter[1]	Description	United States		EEC[2]		Japan		Mexico		Other		Total	
		($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)
25	Salts; sulphur; earths or stone, plastering material, lime and cement	343 748	76.6	10 036	2.2	2 882	0.6	18 281	4.1	74 061	16.5	449 008	100
26	Ores, slag and ash	423 006	54.9	48 337	6.3	–	–	2 578	0.3	296 693	38.5	770 814	100
27	Mineral fuels, oils and products of their distillation; bituminous substances; mineral waxes[3]	2 454 809	28.4	2 328 223	26.9	336	–	56 800	0.7	3 807 608	44.0	8 647 776	100
28	Inorganic chemicals; compounds of precious metals, radioactive elements, etc.	741 794	57.2	88 561	6.8	35 443	2.7	318	–	430 622	33.2	1 296 738	100
31	Fertilizers	183 751	83.7	20 482	9.3	927	0.4	–	–	14 455	6.6	219 615	100
68	Articles of stone, plaster, cement, asbestos, mica or similar materials	243 678	64.6	101 378	26.9	3 873	1.0	2 371	0.6	25 833	6.8	377 133	100
69	Ceramic products	192 474	35.2	202 697	37.1	50 218	9.2	4 886	0.9	96 102	17.6	546 377	100
70	Glass and glassware	773 629	77.1	93 721	9.3	42 944	4.3	24 092	2.4	68 656	6.8	1 003 042	100
71	Natural/cultured pearls, precious stones and metals, coins, etc.	842 271	63.6	159 831	12.1	6 481	0.5	4 790	0.4	311 519	23.5	1 324 892	100
72	Iron and steel	1 213 561	60.1	406 260	20.1	102 421	5.1	4 980	0.2	291 171	14.4	2 018 393	100
73	Articles of iron or steel	1 742 880	69.4	273 801	10.9	174 201	6.9	17 099	0.7	304 098	12.1	2 512 079	100
74	Copper and articles thereof	408 102	77.6	40 396	7.7	7 536	1.4	1 366	0.3	68 303	13.0	525 703	100
75	Nickel and articles thereof	68 704	36.5	42 239	22.5	878	0.5	6	–	76 185	40.5	188 012	100
76	Aluminum and articles thereof	1 324 840	86.1	129 268	8.4	7 570	0.5	1 100	0.1	75 646	4.9	1 538 424	100
78	Lead and articles thereof	23 833	84.8	486	1.7	28	0.1	3 625	12.9	122	0.4	28 094	100
79	Zinc and articles thereof	25 712	66.3	2 282	5.9	96	0.2	499	1.3	10 180	26.3	38 769	100
80	Tin and articles thereof	11 230	25.7	4 697	10.7	1	–	28	0.1	27 751	63.5	43 707	100
81	Other base metals; cermets; and articles thereof	141 126	73.7	20 394	10.6	5 858	3.1	–	–	24 171	12.6	191 549	100
	TOTAL MINERAL IMPORTS	11 159 148	51.4	3 973 089	18.3	441 693	2.0	142 819	0.7	6 003 176	27.6	21 719 925	100
	TOTAL DOMESTIC IMPORTS	87 875 319	64.5	15 667 994	11.5	9 525 225	7.0	1 748 583	1.3	21 427 927	15.7	136 245 048	100
	PERCENTAGE MINERAL TO DOMESTIC	12.7		25.4		4.6		8.2		28.0		15.9	

Source: Statistics Canada, Catalogue No. 65-006 (Quarterly).
[1] H.S. Chapter refers to a group of commodities covered in a specified chapter of the "Harmonized Commodity Description and Coding System," as of January 1, 1988. Canadian external trade statistics are classified according to the Harmonized System. [2] EEC: European Economic Community. [3] Total value of coal imports included in Chapter 27 is $684 million.
– Nil.

TABLE 21. CANADA, VALUE OF EXPORTS OF MINERALS, METALS AND THEIR PRODUCTS FOR 1991 (9 MONTHS)

H.S. Chapter[1]	Description	United States		EEC[2]		Japan		Mexico		Other		Total	
		($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)
25	Salts; sulphur; earths or stone, plastering material, lime and cement	385 557	37.9	113 504	11.2	47 919	4.7	26 049	2.6	443 314	43.6	1 016 343	100
26	Ores, slag and ash	292 006	16.1	775 746	42.7	540 551	29.8	1 155	0.1	205 769	11.3	1 815 227	100
27	Mineral fuels, oils and products of their distillation; bituminous substances; mineral waxes[3]	9 786 844	84.2	341 430	2.9	905 061	7.8	16 161	0.1	580 018	5.0	11 629 514	100
28	Inorganic chemicals; compounds of precious metals, radioactive elements, etc.	941 404	81.8	105 590	9.2	17 648	1.5	230	–	86 596	7.5	1 151 468	100
31	Fertilizers	717 325	60.8	19 680	1.7	47 102	4.0	2 463	0.2	392 722	33.3	1 179 292	100
68	Articles of stone, plaster, cement, asbestos, mica or similar materials	230 672	92.8	9 775	3.9	1 489	0.6	164	0.1	6 440	2.6	248 540	100
69	Ceramic products	25 619	78.7	886	2.7	307	0.9	38	0.1	5 693	17.5	32 543	100
70	Glass and glassware	216 147	81.4	30 309	11.4	4 103	1.5	35	–	15 050	5.7	265 644	100
71	Natural/cultured pearls, precious stones and metals, coins, etc.	1 255 948	60.8	116 902	5.7	37 612	1.8	711	–	654 329	31.7	2 065 502	100
72	Iron and steel	1 052 224	65.8	64 266	4.0	20 520	1.3	28 661	1.8	432 804	27.1	1 598 475	100
73	Articles of iron or steel	1 113 834	88.8	23 174	1.8	2 412	0.2	969	0.1	114 295	9.1	1 254 684	100
74	Copper and articles thereof	594 028	54.3	364 172	33.3	9 284	0.8	141	–	126 352	11.5	1 093 977	100
75	Nickel and articles thereof	564 015	52.0	173 837	16.0	17 268	1.6	673	0.1	329 463	30.4	1 085 256	100
76	Aluminum and articles thereof	1 849 880	71.0	276 272	10.6	238 733	9.2	143	–	241 648	9.3	2 606 676	100
78	Lead and articles thereof	40 650	69.9	7 336	12.6	3 707	6.4	–	–	6 497	11.2	58 190	100
79	Zinc and articles thereof	425 875	74.2	16 927	2.9	22 365	3.9	–	–	109 065	19.0	574 232	100
80	Tin and articles thereof	4 939	83.7	233	3.9	212	3.6	–	–	518	8.8	5 902	100
81	Other base metals; cermets; and articles thereof	85 246	61.5	14 032	10.1	1 965	1.4	6	–	37 430	27.0	138 679	100
	TOTAL MINERAL IMPORTS	19 582 213	70.4	2 454 071	8.8	1 918 258	6.9	77 599	0.3	3 788 003	13.6	27 820 144	100
	TOTAL DOMESTIC IMPORTS	76 770 220	74.8	8 393 455	8.2	5 345 647	5.2	275 106	0.3	11 914 853	11.6	102 699 281	100
	PERCENTAGE MINERAL TO DOMESTIC	25.5		29.2		35.9		28.2		31.8		27.1	

Source: Statistics Canada, Catalogue 65-003 (Quarterly).
[1] Chapter refers to a group of commodities covered in a specified chapter of the "Harmonized Commodity Description and Coding System", as of January 1, 1988. Canadian external trade statistics are classified according to the Harmonized System. [2] EEC: European Economic Community. [3] Total value of coal exports included in Chapter 27 is $1617 million.
– Nil.

TABLE 22. CANADA, VALUE OF IMPORTS OF MINERALS, METALS AND THEIR PRODUCTS FOR 1991 (9 MONTHS)

H.S. Chapter[1]	Description	United States		EEC[2]		Japan		Mexico		Other		Total	
		($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)	($000)	(%)
25	Salts; sulphur; earths or stone, plastering material, lime and cement	221 612	80.0	8 841	3.2	872	0.3	6 842	2.5	38 687	14.0	276 854	100
26	Ores, slag and ash	308 350	61.9	55 769	11.2	45	–	703	0.1	133 330	26.8	498 197	100
27	Mineral fuels, oils and products of their distillation; bituminous substances; mineral waxes[3]	965 137	20.9	1 281 483	27.7	338	–	78 323	1.7	2 301 873	49.7	4 627 154	100
28	Inorganic chemicals; compounds of precious metals, radioactive elements, etc.	574 400	59.2	62 318	6.4	30 891	3.2	506	0.1	302 650	31.2	970 765	100
31	Fertilizers	138 127	87.7	16 882	10.7	474	0.3	36	–	1 930	1.2	157 449	100
68	Articles of stone, plaster, cement, asbestos, mica or similar materials	180 229	68.7	60 619	23.1	3 639	1.4	1 893	0.7	16 104	6.1	262 484	100
69	Ceramic products	136 559	35.2	145 331	37.5	31 972	8.2	3 929	1.0	70 258	18.1	388 049	100
70	Glass and glassware	593 179	77.0	63 304	8.2	34 283	4.4	27 949	3.6	51 896	6.7	770 611	100
71	Natural/cultured pearls, precious stones and metals, coins, etc.	531 270	63.0	101 623	12.0	2 551	0.3	1 004	0.1	207 443	24.6	843 891	100
72	Iron and steel	854 053	63.1	219 625	16.2	92 502	6.8	935	0.1	185 878	13.7	1 352 993	100
73	Articles of iron or steel	1 313 394	69.2	214 134	11.3	130 873	6.9	14 839	0.8	225 928	11.9	1 899 168	100
74	Copper and articles thereof	277 942	83.7	23 508	7.1	4 546	1.4	399	0.1	25 648	7.7	332 043	100
75	Nickel and articles thereof	51 975	23.9	36 247	16.7	265	0.1	82	–	129 091	59.3	217 660	100
76	Aluminum and articles thereof	912 261	87.1	87 530	8.4	3 536	0.3	1 193	0.1	42 499	4.1	1 047 019	100
78	Lead and articles thereof	14 422	91.8	147	0.9	12	0.1	1 120	7.1	16	0.1	15 717	100
79	Zinc and articles thereof	16 136	87.1	245	1.3	106	0.6	–	–	2 034	11.0	18 521	100
80	Tin and articles thereof	6 410	25.7	1 148	4.6	1	–	6	–	17 358	69.6	24 923	100
81	Other base metals; cermets; and articles thereof	85 219	56.2	24 058	15.9	1 413	0.9	–	–	40 901	27.0	151 591	100
	TOTAL MINERAL IMPORTS	7 180 675	51.8	2 402 812	17.3	338 319	2.4	139 759	1.0	3 793 524	27.4	13 855 089	100
	TOTAL DOMESTIC IMPORTS	64 435 057	64.1	10 786 401	10.7	7 584 335	7.5	1 815 947	1.8	15 833 897	15.8	100 455 637	100
	PERCENTAGE MINERAL TO DOMESTIC	11.1		22.3		4.5		7.7		24.0		13.8	

Source: Statistics Canada, Catalogue 65-006 (Quarterly).
[1] Chapter refers to a group of commodities covered in a specified chapter of the "Harmonized Commodity Description and Coding System", as of January 1, 1988. Canadian external trade statistics are classified according to the Harmonized System. [2] EEC: European Economic Community. [3] Total value of coal imports included in Chapter 27 is $306 million.

TABLE 23. CANADA, APPARENT CONSUMPTION[1] OF SOME MINERALS AND RELATION TO PRODUCTION,[2] 1988-90

	1988			1989			1990p		
	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production
	(tonnes)			(tonnes)			(tonnes)		
Quartz silica	3 541 506r	2 806 775	126.2r	3 117 854r	2 491 000r	125.2r	2 921 496	2 081 170	140.4
Salt	8 859 275	10 687 180	82.9	11 381 522r	11 158 411r	102.0r	11 388 892	11 191 385	101.8
Lime	2 435 666	2 517 982	96.7	2 512 602	2 551 934	98.5	2 266 328	2 340 737	96.8
Cement[3]	9 374 314r	12 349 873	75.9r	10 724 725r	12 590 637	85.2r	9 559 867	11 745 152	81.4
Iron ore	14 206 084	39 933 862	35.6	14 590 583	39 445 047	37.0	12 742 240	35 670 008	35.7
Gypsum	3 437 391r	8 813 760r	39.0r	3 113 906r	8 179 588r	38.1r	2 538 472	7 977 685	31.8
Asbestos	25 664	710 358	3.6	4 607r	714 036r	0.6r	36 268	685 627	5.3
Potash (K_2O)	507 278	8 154 428	6.2	341 970r	7 014 074	4.9r	354 635	7 344 620	4.8

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] "Apparent consumption" is production, plus imports, less exports. [2] "Production" refers to producers' shipments. [3] Apparent consumption contains clinker cement in the trade data.
p Preliminary; r Revised.

TABLE 24. CANADA, REPORTED CONSUMPTION OF MINERALS AND RELATION TO PRODUCTION, 1988–90

	Unit of Measure	1988 Consumption	1988 Production	1988 Consumption as % of Production	1989 Consumption	1989 Production	1989 Consumption as % of Production	1990p Consumption	1990p Production	1990p Consumption as % of Production
Metals										
Aluminum[1]	t	488 471r	1 534 499	31.8r	503 310r	1 554 753	32.4r	464 493	1 567 395	29.6
Antimony	kg	585 600r	3 171 482	18.5r	442 942r	2 817 810	15.7r	294 321	564 527	52.1
Bismuth	kg	6 709	180 907	3.7	16 158	156 727	10.3	12 032	74 300	16.2
Cadmium	kg	19 988	1 663 978	1.2	28 826r	1 710 527	1.7r	35 194	1 333 664	2.6
Chromium (chromite)	t	18 546r	–	. .	21 066	–	. .	19 921	–	. .
Cobalt	kg	159 290	2 398 345	6.6	147 299	2 344 389	6.3	194 205	2 183 620	8.9
Copper[2]	t	236 280	758 478	31.2	218 571	704 432	31.0	184 480	771 433	23.9
Lead[3]	t	88 041	351 148	25.1	87 715r	268 887	32.6r	71 745	233 372	30.7
Magnesium	t	14 066	x	x	15 407	x	x	15 125	x	x
Manganese ore	t	160 146	–	. .	203 574	–	. .	253 233	–	. .
Mercury	kg	27 039r	–	. .	31 914r	–	. .	33 907	–	. .
Molybdenum (Mo content)	t	1 213	13 535	9.0	1 383r	13 543r	10.2r	1 179	12 188	9.7
Nickel	t	9 250	198 744	4.7	10 423	195 554	5.3	8 451	195 004	4.3
Selenium	kg	13 541	321 202	4.2	14 806	212 794	7.0	13 798	369 193	3.7
Silver	kg	457 698	1 443 166	31.7	531 046	1 312 433	40.5	579 407	1 381 257	41.9
Tellurium	kg	x	19 178	x	x	7 562	x	x	12 212	x
Tin	t	3 489	x	x	3 567	x	x	3 600	3 844	93.7
Tungsten (W content)	kg	385 917	–	. .	345 018r	–	. .	289 625	–	. .
Zinc[3]	t	150 616r	1 370 000	11.0r	142 771r	1 272 854	11.2r	123 011	1 179 372	10.4
Nonmetals										
Barite	t	22 631	51 450	44.0	16 495r	38 511	42.8r	17 164	43 906	39.1
Feldspar	t	2 574	–	. .	2 049	–	. .	2 177	–	. .
Fluorspar	t	179 238r	x	x	162 528r	x	x	140 569	x	x
Mica	kg	4 117r	x	x	10 228r	x	x	8 002	x	x
Nepheline syenite	t	91 005r	539 835	16.9r	88 660	551 324	16.1	72 258	532 911	13.6
Phosphate rock	t	2 027 850	–	. .	1 884 742	–	. .	1 392 043	–	. .
Potash (K_2O)	t	221 881r	8 154 428	2.7r	213 523	7 014 074	3.0	262 484	7 344 620	3.6
Sodium sulphate	t	187 846r	330 971	56.8r	223 135r	327 444	68.1r	184 045	346 607	53.1
Sulphur	t	1 135 152r	6 837 991	16.6r	1 082 380r	6 558 584	16.5r	967 273	6 611 933	14.6
Talc, etc.	t	70 583	146 493	48.2	72 447r	144 828	50.0r	70 004	130 861	53.5
Fuels										
Coal	000 t	54 390	70 644	77.0	53 881	70 527	76.4	49 039	68 332	71.8
Crude oil[4]	000 m^3	85 972	93 806	91.6	87 789	90 641	96.9	90 207	90 279	99.9
Natural gas[5]	million m^3	49 058	90 911	54.0	52 336	96 117	54.5	50 586	98 771	51.2

Source: Energy, Mines and Resources Canada.

[1] Consumption of primary aluminum ingot and alloys, secondary ingot and scrap, reported by consumers. [2] Consumption defined as domestic shipments of refined copper plus imports of refined copper. [3] Consumption of primary and secondary refined metal. [4] Consumption defined as refinery receipts. [5] Consumption defined as domestic sales.

p Preliminary; r Revised; – Nil; . . Not available; x Confidential.

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.

TABLE 25. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION,[1] 1984–90

	Unit of Measure	1984	1985	1986	1987	1988	1989	1990[p]
Aluminum								
Domestic consumption[2]	t	379 249	346 033	388 879	413 237	488 471[r]	503 310[r]	464 493
Production	t	1 221 985	1 282 316	1 355 161	1 540 439	1 534 499	1 554 753	1 567 395
Consumption of production	%	31.0	27.0	28.7	26.8	31.8[r]	32.4[r]	29.6
Copper								
Domestic consumption[3]	t	231 039	222 466	225 586	231 288	236 280[r]	218 571[r]	184 480
Production	t	504 262	499 626	493 445	491 124	528 723	515 216	515 835
Consumption of production	%	45.8	44.5	45.7	47.1	44.7[r]	42.4[r]	35.8
Lead								
Domestic consumption[4]	t	111 642	104 447	94 680	97 281	88 041	87 715[r]	71 745
Production	t	174 987	173 220	169 934	139 475	179 461	157 330	87 180
Consumption of production	%	63.8	60.3	55.7	69.7	49.1	55.8[r]	82.3
Zinc								
Domestic consumption[4]	t	119 573	123 256	126 115	131 659	150 616[r]	142 771[r]	123 011
Production	t	682 976	692 406	570 981	609 909	703 206	669 677	591 786
Consumption of production	%	17.5	17.8	22.1	21.6	21.4[r]	21.3[r]	20.8

Source: Energy, Mines and Resources Canada.
[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Consumption of primary refined metal, reported by consumers. [3] Consumption defined as domestic shipments of refined copper plus imports of refined copper. [4] Consumption of primary and secondary refined metal, reported by consumers.
[p] Preliminary; [r] Revised.

TABLE 26. AVERAGE ANNUAL PRICES[1] OF SELECTED MINERALS, 1985-91

	Unit of Measure	1985	1986	1987	1988	1989	1990	1991
Aluminum, London Metal Exchange	¢/lb	47.850	52.179	71.004	115.394	88.242	74.361	59.066
Antimony, New York dealer	$/lb	1.311	1.219	1.116	1.039	0.943	0.818	0.828
Asbestos, No. 4T cement fibre	C$/t	1 083.000	1 083.000	1 083.000	1 080.000	1 080.000	1 080.000	1 080.000
Bismuth, New York dealer	$/lb	4.932	3.017	3.629	5.726	5.657	3.474	2.969
Cadmium, New York dealer[2]	$/lb	1.208	1.248	1.768	7.031	6.277	3.378	1.974
Calcium, metal crowns (Producer Price List)	$/lb	3.504	3.920	3.850	3.850	3.850	3.850	3.850
Chrome, U.S. metal, 9% carbon	$/lb	4.450	3.021	2.700	2.700	3.621	4.241	4.437
Cobalt, metal, shot/cathode/250 kg	$/lb	11.700	11.242	7.000	7.532	8.400	8.400	11.000
Columbium, pyrochlore	$/lb	3.209	2.600	3.250	2.600	2.600	2.800	2.800
Copper, electrolytic cathode, COMEX	¢/lb	60.988	61.649	77.837	119.183	129.454	124.085	108.211
Gold, London[3]	C$/troy oz	433.227	510.628	592.011	538.024	451.691	383.466	362.183
Iridium, New York dealer[4]	$/troy oz	600.000	600.000	513.750	301.813[r]	302.667[r]	307.313	281.354
Iron ore, taconite pellets	¢/ltu	80.500	80.500	77.548	72.441	72.450	72.450	72.450
Lead, producer	C¢/lb	26.179	30.885	47.985	46.013	47.171	53.181	38.556
Magnesium, U.S. primary ingot (Producer Price List)	$/lb	1.480	1.530	1.530	1.563	1.630	1.613	1.430
Manganese, U.S. metal, regular	¢/lb	80.000	79.450	80.687	86.417	91.000	92.896	104.000
Mercury, New York dealer	$/flask (76 lb)	310.957	232.785	295.503	335.517	287.722	249.218	122.424
Molybdenum, dealer, oxide	$/lb	3.247	2.871	2.899	3.449	3.341	2.807	2.349
Nickel, New York dealer, cathode	$/lb	2.260	1.855	2.278	6.122	5.982	4.074	3.796
Osmium, New York dealer	$/troy oz	913.125	698.854	632.458	588.750	547.917	413.438	400.000
Palladium, London PM fix	$/troy oz	126.905	117.002[r]	131.399[r]	124.256[r]	144.578[r]	114.915	88.290
Platinum, London PM fix	$/troy oz	475.000	464.989[r]	555.956[r]	530.777[r]	509.636[r]	471.583	376.083
Potash, coarse, major producer, 60% contained, K_2O[5]	$/st	55.729	46.750	68.000	86.000	88.000	88.000	87.500
Rhodium, New York dealer[6]	$/troy oz	892.708	1 194.583	1 240.000	1 275.000	1 275.000	3 565.185	3 739.126
Ruthenium, New York dealer	$/troy oz	100.269	73.423	69.796	62.204	62.258	60.917	55.233
Selenium, New York dealer	$/lb	7.248	5.596	6.479	10.085	7.451	5.676	5.241
Silver, Handy & Harman, Toronto	C$/troy oz	6.142	5.470	7.009	6.535	5.499	4.820	4.039
Sulphur, elemental, North American deliveries	C$/t	100.775	107.959	88.234	71.050	72.060	62.030	56.814
Tantalum, tantalite ore, spot	$/lb	26.292	18.008	20.542	37.700	35.302	30.077	28.538
Tin, New York dealer	$/lb	5.279	2.941	3.156	3.309	3.973	2.877	2.588
Tungsten, U.S. spot ore[7]	$/ltu	64.925	42.554	41.687[r]	50.346[r]	45.525	34.721	53.417
Uranium, U_3O_8	US$/lb	26.000	25.000	23.000[r]	25.000[r]	24.000	24.000	21.000
Zinc, special high grade	C¢/lb	56.876	55.129	57.794	74.988	97.538	68.850	50.647

Sources: Alberta Energy Resource Industries Monthly Statistics (Sulphur); "Engineering and Mining Journal" (Asbestos); " Industrial Minerals" (Potash); "Metals Week"; "Northern Miner"; Energy, Mines and Resources Canada.

[1] Prices, except where noted, are in U.S. currency. [2] 1985-86 U.S. producer price. [3] Average afternoon fixings of London bullion dealers, converted to Canadian dollars. [4] The Impala producer price is given for the years 1985-87. [5] Annual average not available, indicative price given. [6] The Impala producer price is given for the years 1985-89. [7] LMB ore is given for the years 1985-86.

[r] Revised; .. Not available; [e] Estimated; x Confidential.

TABLE 27. CANADIAN AVERAGE ANNUAL PRICES OF SELECTED MINERALS, 1985-91

	Unit of Measure	1985	1986	1987	1988	1989	1990	1991
Aluminum, London Metal Exchange	$/kg	1.440	1.598	2.076	3.131	2.304	1.913	1.492
Antimony, New York dealer	$/kg	3.947	3.734	3.262	2.819	2.462	2.104	2.092
Asbestos, No. 4T cement fibre	$/t	1 083.000	1 083.000	1 083.000	1 080.000	1 080.000	1 080.000	1 080.000
Bismuth, New York dealer	$/kg	14.847	9.241	10.609	15.538	14.768	8.936	7.500
Cadmium, New York dealer[1]	$/kg	3.637	3.823	5.168	19.079	16.387	8.689	4.986
Calcium, metal crowns (Producer Price List)	$/kg	10.549	12.007	11.255	10.447	10.051	9.904	9.725
Chrome, U.S. metal, 9% carbon	$/kg	13.396	9.254	7.893	7.327	9.453	10.909	11.208
Cobalt, metal, shot/cathode/250 kg	$/kg	35.222	34.436	20.463	20.439	21.930	21.608	27.787
Columbium, pyrochlore	$/kg	9.660	7.964	9.501	7.055	6.788	7.203	7.073
Copper, electrolytic cathode, COMEX	$/kg	1.836	1.888	2.275	3.234	3.380	3.192	2.733
Gold, London[2]	$/g	13.929	16.417	19.034	17.298	14.522	12.329	11.644
Iridium, New York dealer[3]	$/g	26.341	26.802	21.902	11.944[r]	11.523[r]	11.528	10.365
Iron ore, taconite pellets	¢/mtu	108.187	110.082	101.204	87.757	84.440	83.200	81.702
Lead, producer	¢/kg	57.715	68.090	105.789	101.441	103.994	117.244	85.001
Magnesium, U.S. primary ingot (Producer Price List)	$/kg	4.455	4.687	4.473	4.241	4.255	4.149	3.612
Manganese, U.S. metal, regular	$/kg	2.408	2.434	2.359	2.345	2.376	2.390	2.627
Mercury, New York dealer	$/kg	12.317	9.382	11.366	11.980	9.884	8.435	4.069
Molybdenum, dealer, oxide	$/kg	9.775	8.794	8.475	9.359	8.722	7.221	5.934
Nickel, New York dealer, cathode	$/kg	6.804	5.682	6.659	16.613	15.617	10.480	9.589
Osmium, New York dealer	$/g	40.088	31.218	26.963	23.299	20.861	15.510	14.735
Palladium, London PM fix	$/g	5.571	5.227[r]	5.602[r]	4.917[r]	5.505[r]	4.311	3.252
Platinum, London PM fix	$/g	20.853	20.771[r]	23.701[r]	21.005[r]	19.403[r]	17.691	13.854
Potash, coarse, major producer, 60% contained, K_2O[4]	$/t	83.884	71.601	99.392	116.685	114.871	113.184	110.515
Rhodium, New York dealer[5]	$/g	39.192	53.363	52.863	50.456	48.543	133.743	137.743
Ruthenium, New York dealer	$/g	4.402	3.280	2.976	2.462	2.370	2.285	2.035
Selenium, New York dealer	$/kg	21.820	17.142	18.940	27.367	19.452	14.601	13.239
Silver, Handy & Harman, Toronto	$/kg	269.646	244.349	298.804	258.611	209.363	180.815	148.790
Sulphur, elemental, North American deliveries	$/t	100.775	107.959	88.234	71.050	72.060	62.030	56.814
Tantalum, tantalite ore, spot	$/kg	79.150	55.161	60.050	102.302	92.163	77.369	72.089
Tin, New York dealer	$/kg	15.892	9.009	9.226	8.979	10.372	7.401	6.537
Tungsten, U.S. spot ore[6]	$/tu	88.656	59.125	54.403[r]	60.990[r]	53.059[r]	39.873	60.239
Uranium, U	$/kg	91.000	89.000	79.000	79.000	74.000	71.000	61.000
Zinc, special high grade	$/kg	1.254	1.215	1.274	1.653	2.150	1.518	1.117

Sources: Alberta Energy Resource Industries Monthly Statistics (Sulphur); "Engineering and Mining Journal" (Asbestos); "Industrial Minerals" (Potash); "Metals Week"; "Northern Miner"; Energy, Mines and Resources Canada.

[1] U.S. producer price for 1985-86. [2] Average afternoon fixings of London bullion dealers, converted to Canadian dollars. [3] The Impala producer price is given for the years 1985-87. [4] Annual average not available, indicative price given. [5] The Impala producer price is given for the years 1985-89. [6] LMB ore is given for the years 1985-86.

[r] Revised; . . Not available; [e] Estimated; x Confidential.

TABLE 29. CANADA, SELLING PRICE INDEXES OF MINERAL RAW MATERIALS, 1984-90

Base (1986=100)	1984	1985	1986	1987	1988	1989	1990p
Metallic minerals							
Copper concentrates	90.3	96.7	100.0	118.7	158.7	165.3	153.0
Iron ore	94.8	98.7	100.0	96.4	91.0	85.5	82.8
Lead concentrates	108.0	83.7	100.0	156.9	151.9	154.1	170.4
Nickel concentrates	106.4	114.0	100.0	111.1	263.3	251.6	166.0
Other base metals	108.3	98.0	100.0	107.0	130.6	119.4	96.0
Precious metals	98.0	89.2	100.0	114.5	103.9	87.8	85.4
Gold and alloys in primary form	96.5	88.8	100.0	114.2	103.9	87.8	85.9
Platinum	73.4	62.1	100.0	116.5	101.8	95.5	86.9
Silver	137.3	110.1	100.0	121.9	106.2	86.4	74.7
Radio-active concentrates	104.4	100.9	100.0	97.9	86.8	60.0	57.8
Zinc concentrates	116.4	103.3	100.0	106.2	138.8	184.8	165.7
Nonmetal materials							
Asbestos fibres	102.5	100.3	100.0	100.1	100.9	107.2	109.0
Other crude minerals	97.3	98.7	100.0	100.4	106.0	105.7	104.6
Potash (muriate)	108.1	101.6	100.0	107.7	145.3	140.8	133.5
Quartz and silica sand	93.9	97.0	100.0	100.5	107.6	106.8	109.8
Sand and gravel	96.5	97.6	100.0	104.6	114.2	125.2	126.8
Stone	91.8	96.3	100.0	102.9	107.9	109.6	114.5
Building	93.5	97.4	100.0	103.5	106.5	111.4	117.2
Crushed	89.1	94.9	100.0	104.2	109.1	110.5	116.2
Other	93.5	97.4	100.0	103.5	106.5	111.4	117.2
Sulphur	63.9	93.4	100.0	81.4	65.8	65.9	56.8
Mineral fuels							
Coal (thermal)	99.4	100.2	100.0	100.7	89.7	90.0	89.7
Crude mineral oil	164.5	173.4	100.0	110.6	86.5	99.0	122.3
Natural gas	101.7	101.9	100.0	96.7	89.1	85.0	85.9

Source: Statistics Canada, Catalogue No. 62-011.
p Preliminary.

TABLE 30. CANADA, PRINCIPAL STATISTICS OF THE MINERALS INDUSTRY,[1] 1989

	Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-Hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Metals											
Nickel-copper-zinc	27	14 374	31 561	644 216	228 734	1 914 018	6 617 321	4 474 570	19 837	920 213	4 515 629
Gold	70	10 130	22 117	469 884	120 501	530 195	2 079 569	1 428 873	12 631	588 283	1 425 910
Silver-lead-zinc	15	3 105	7 127	138 782	59 653	709 046	1 749 389	980 690	4 487	208 358	989 947
Iron	7	4 786	10 421	220 108	177 860	416 147	1 351 098	757 091	6 303	298 824	741 271
Uranium	5	4 123	8 570	197 028	51 756	155 290	916 419	709 372	4 839	238 520	706 903
Miscellaneous metal mines[3]	6	933	2 035	37 635	14 125	56 319	188 295	117 850	1 308	53 693	123 027
Total	130	37 451	81 830	1 707 653	652 629	3 781 017	12 902 092	8 468 446	49 405	2 307 891	8 502 686
Industrials											
Potash	11	2 887	6 361	108 302	98 387	142 716	1 074 242	833 139	3 893	155 976	841 515
Stone	125	2 410	5 652	82 514	36 563	134 571	513 922	342 788	3 145	111 334	351 350
Sand and gravel	139	1 836	4 256	60 228	29 039	94 583	403 824	280 202	2 736	95 190	300 712
Miscellaneous nonmetals[4]	33	1 697	3 775	60 012	28 485	62 756	364 285	273 044	2 343	85 618	272 714
Asbestos	4	2 128	5 021	82 386	34 673	63 208	303 737	205 856	2 800	113 296	208 599
Peat	56	1 355	3 018	27 992	5 721	30 177	120 324	84 427	1 713	38 635	86 872
Gypsum	10	663	1 452	19 316	7 852	20 381	90 768	62 535	965	32 258	66 026
Total	378	12 976	29 534	440 750	240 720	548 391	2 871 102	2 081 991	17 595	632 308	2 127 787
Fuels											
Oil, crude and natural gas	725	9 675	19 706	431 989	336 559	1 352 711	16 109 679	14 415 409	33 712	1 793 393	14 610 015
Coal	29	9 541	19 292	425 785	121 342	412 254	1 662 017	1 160 500	11 239	518 304	1 196 695
Total	754	19 216	38 998	857 774	457 901	1 764 965	17 771 696	15 575 909	44 951	2 311 697	15 806 710
Total minerals industry	1 262	69 643	150 362	3 006 177	1 351 250	6 094 373	33 544 890	26 126 346	111 951	5 251 896	26 437 183

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Total activity includes sales and head offices.
[3] Includes molybdenum. [4] Includes salt.
[r] Revised.
Note: Totals may not add due to rounding.

TABLE 31. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1988

		Mineral Manufacturing Activity									
		Production and Related Workers			Costs				Total Activity[1]		
	Establish-ments	Employees	Person-Hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metal industries											
Primary steel	61	37 557	80 616	1 454 000	526 900	5 055 700	9 234 400	3 880 200	48 259	1 943 700	3 867 100
Smelting and refining	34	21 170	43 705	853 900	484 900	2 602 000	7 013 200	3 973 300	30 099	1 285 000	4 049 200
Wire and wire products industries[2]	318	12 041	25 034	317 800	41 500	1 044 800	1 889 700	825 300	15 154	427 200	855 600
Aluminum rolling, casting and extruding	72	4 922	10 766	161 900	33 900	1 475 000	2 079 600	577 000	6 124	213 600	576 200
Iron foundries	97	6 902	14 751	204 800	46 900	328 500	877 300	500 300	8 095	254 700	497 100
Metal rolling, casting and extruding n.e.s.	146	5 900	12 410	160 000	32 000	741 300	1 251 000	487 200	7 049	208 300	490 000
Steel pipe and tube	53	4 895	10 431	164 600	17 700	1 023 900	1 557 500	568 400	6 008	211 300	568 200
Copper and alloy rolling, casting and extruding	38	2 580	5 333	70 100	15 800	471 400	702 600	230 600	3 040	92 500	228 100
Total	819	95 967	203 046	3 387 100	1 199 600	12 742 600	24 605 300	11 042 300	123 828	4 636 300	11 131 500
Nonmetallic mineral products industries											
Ready-mix concrete	634	10 568	22 604	298 900	65 200	1 068 800	1 874 200	739 800	12 461	366 200	752 700
Cement	22	2 202	4 857	93 600	158 200	189 600	938 300	598 200	3 388	143 300	601 200
Primary glass and glass containers	20	5 391	11 629	165 600	58 800	194 500	758 300	512 800	6 981	232 600	507 900
Glass products	181	5 250	10 849	140 400	16 800	318 000	689 500	353 700	6 355	180 400	360 600
Gypsum products	31	1 493	3 293	47 200	30 400	197 000	534 100	307 300	2 271	75 200	316 500
Mineral insulating products	46	2 314	5 005	73 300	37 500	183 900	458 100	241 100	3 644	126 900	393 900
Other concrete products	263	5 447	11 708	125 500	20 500	252 400	569 700	305 700	6 001	151 900	321 900
Structural concrete products	75	2 684	5 665	80 200	6 200	114 500	353 700	237 100	3 302	102 800	235 300
Clay products (domestic)	32	1 199	2 647	36 500	23 900	26 300	186 600	143 800	1 654	53 800	148 000
Other nonmetallic mineral products	170	2 576	5 430	61 800	10 900	101 600	271 500	160 600	2 940	77 900	162 400
Concrete pipe	50	1 704	3 730	49 400	6 100	114 200	274 400	163 300	2 083	65 100	164 600
Clay products (imported)	53	1 375	2 750	32 700	6 400	39 100	141 300	99 200	1 607	39 800	100 100
Refractory products	30	1 183	2 480	32 400	7 500	102 000	245 300	139 200	1 760	54 200	153 600
Abrasives	33	1 421	2 914	37 000	41 000	116 300	275 000	118 600	1 917	55 500	120 300
Lime	13	679	1 515	23 800	41 500	32 200	180 200	106 900	873	33 400	106 100
Asbestos products industry	10	488	1 048	11 300	2 000	26 300	51 400	23 500	600	15 200	26 400
Total	1 663	45 974	98 124	1 309 600	532 900	3 076 700	7 803 600	4 250 800	57 837	1 774 200	4 471 500

Fabricated metal products industries											
Stamped and pressed metal products industries	1 041	30 827	65 462	759 500	81 800	3 240 400	5 412 300	2 084 400	36 976	985 000	2 152 800
Fabricated structural metal products industries	455	15 877	32 621	415 500	32 600	1 256 200	2 535 500	1 273 900	19 689	556 400	1 301 700
Hardware, tool and cutlery industry	926	20 213	42 990	516 100	26 800	675 900	1 758 200	1 061 100	23 042	623 000	1 081 300
Other metal fabricating industries	580	14 702	30 505	365 200	35 900	971 800	1 903 600	907 100	17 887	480 400	940 200
Ornamental and architectural metal products industries	824	17 420	36 226	380 700	25 500	1 095 800	1 992 700	883 400	20 795	498 400	911 500
Machine shop industry	1 660	21 858	45 436	518 700	27 500	570 400	1 406 700	814 500	22 681	558 800	819 600
Power boiler and heat exchanger industry	45	3 064	6 384	92 700	5 600	205 000	507 300	294 400	6 182	204 400	365 300
Heating equipment industry	155	5 226	10 586	111 700	5 500	278 500	540 600	259 600	6 390	148 400	270 400
Total	5 686	129 187	270 209	3 172 100	241 200	8 294 000	16 056 900	7 578 400	153 642	4 054 800	7 842 800
Petroleum and coal products industries											
Petroleum refining products	33	5 527	12 535	278 400	279 300	10 936 100	13 708 800	2 092 500	13 358	654 300	2 096 400
Other petroleum and coal products	73	646	1 332	18 200	10 600	166 100	247 400	70 500	1 161	33 400	86 800
Lubricating oils and greases	35	664	1 451	22 000	4 800	221 200	317 600	90 900	1 091	38 000	96 700
Total	141	6 837	15 318	318 600	294 700	11 323 400	14 273 800	2 253 900	15 610	725 700	2 279 900
Total mineral manufacturing industries	8 309	277 965	586 697	8 187 400	2 268 400	35 436 700	62 739 600	22 871 500	350 917	11 191 000	25 725 700

Source: Statistics Canada, Catalogue No. 31-203.
[1] Total activity includes sales and head offices. [2] Wire and wire products have been included in the primary metal industries group.
n.e.s. Not elsewhere specified.
Note: Totals may not add due to rounding.

TABLE 32. CANADA, PRINCIPAL STATISTICS OF THE MINERALS INDUSTRY[1] BY REGION, 1989

	Mines, Quarries and Oil Well Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establish-ments	Employees	Person-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)
Atlantic provinces[3]	87	9 174	19 579	326 695	138 804	665 979	1 778 138	975 114	11 116	412 951	977 783
Quebec[3]	191	11 055	24 356	455 928	200 889	741 327	2 255 701	1 313 484	15 196	643 051	1 353 497
Ontario	158	18 775	41 405	832 217	250 902	1 466 418	6 096 815	4 374 495	25 028	1 140 468	4 411 358
Prairie provinces	613	17 892	36 928	757 963	512 479	1 927 423	18 575 724	16 144 395	44 584	2 249 883	16 312 645
British Columbia[4]	178	10 525	22 643	505 687	200 002	990 952	3 455 069	2 285 856	12 925	633 762	2 317 522
Yukon and Northwest Territories[5]	35	2 222	5 451	127 687	48 173	302 270	1 383 443	1 032 999	3 102	171 782	1 064 380
Total	1 262	69 643	150 362	3 006 177	1 351 250	6 094 373	33 544 890	26 126 346	111 951	5 251 896	26 437 183

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Total activity includes sales and head offices.
[3] Includes eastern Canada offshore. [4] Includes western Canada offshore. [5] Includes Arctic Islands.
[r] Revised.
Note: Totals may not add due to rounding.

TABLE 32a. CANADA, PRINCIPAL STATISTICS OF THE MINERALS INDUSTRY[1] BY REGION, 1988

	Mines, Quarries and Oil Well Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establish-ments	Employees	Person-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)
Atlantic provinces[3]	94	8 410	17 543	283 993	131 867	622 521	1 694 351	939 962	10 627[r]	370 665[r]	943 300
Quebec[3]	190	10 830	23 704	423 694	191 792	671 234	2 069 761	1 206 735	14 581	584 060	1 231 278
Ontario	169	18 264	40 526	750 277	230 470	1 423 250	5 670 115	4 016 395	24 936[r]	1 051 918[r]	4 048 410
Prairie provinces	672	17 352[r]	35 886[r]	707 123[r]	501 102	1 770 983	17 653 414	15 381 357	44 504[r]	2 123 747[r]	15 573 006
British Columbia[4]	177	9 915[r]	20 693[r]	450 425[r]	193 139	889 595	3 502 788	2 420 054	12 468[r]	584 770[r]	2 446 837
Yukon and Northwest Territories[5]	38	1 949	4 910	102 040	48 384	307 453	1 186 961	831 124	2 979[r]	149 842[r]	857 510
Total	1 340	66 720[r]	143 263[r]	2 717 554[r]	1 296 757	5 685 034	31 777 388	24 795 628	110 095[r]	4 865 003[r]	25 100 343

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Total activity includes sales and head offices.
[3] Includes eastern Canada offshore. [4] Includes western Canada offshore. [5] Includes Arctic Islands.
[r] Revised.
Note: Totals may not add due to rounding.

TABLE 33. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES BY REGION, 1988

		Mineral Manufacturing Activity								Total Activity[1]		
		Production and Related Workers			Costs							
	Establish-ments	Employees	Person-Hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metals industry											
Atlantic provinces	9	x	x	x	x	x	x	x	x	x	x
Quebec	139	19 910	41 914	748 900	450 600	3 417 000	7 465 600	3 675 800	28 045	1 126 700	3 699 700
Ontario	232	50 322	108 544	1 873 800	530 800	6 577 800	11 903 400	5 015 300	63 704	2 495 700	5 000 900
Prairie provinces	67	x	x	x	x	x	x	x	x	x	x
British Columbia	54	5 689	10 770	196 700	24 600	448 600	1 241 900	774 700	7 318	268 800	860 000
Yukon and Northwest Territories	–	–	–	–	–	–	–	–	–	–	–
Canada	501	83 926	178 012	3 069 300	1 158 100	11 697 800	22 715 600	10 217 000	108 674	4 209 100	10 275 900
Nonmetallic mineral products industry											
Atlantic provinces	114	2 010	4 226	50 300	21 600	103 400	269 700	142 700	2 432	64 200	140 800
Quebec	437	11 985	25 249	317 000	135 900	729 200	1 837 500	993 700	14 620	415 000	1 032 200
Ontario	597	23 074	49 855	677 900	277 100	1 576 000	4 159 200	2 335 200	29 354	934 000	2 501 200
Prairie provinces	331	5 482	11 871	154 500	58 500	397 000	928 600	480 400	7 006	210 300	486 000
British Columbia	184	3 423	6 923	109 800	39 700	271 100	608 500	298 700	4 425	150 800	311 000
Yukon and Northwest Territories	–	–	–	–	–	–	–	–	–	–	–
Canada	1 663	45 974	98 124	1 309 600	532 900	3 076 700	7 803 600	4 250 800	57 837	1 774 200	4 471 500
Fabricated metal products industry[2]											
Atlantic provinces	189	2 865	6 173	68 400	5 100	176 100	335 300	157 800	3 493	86 800	167 100
Quebec	1 418	32 450	67 844	769 800	66 500	2 009 400	3 980 800	1 917 400	38 882	986 700	1 952 700
Ontario	3 091	84 707	177 241	2 109 200	171 800	5 785 500	10 943 600	5 038 100	100 771	2 707 600	5 247 400
Prairie provinces	718	12 864	26 883	308 800	22 300	781 700	1 529 800	730 800	15 534	398 300	749 000
British Columbia	588	8 342	17 101	233 700	16 900	586 200	1 156 800	559 800	10 116	302 600	582 000
Yukon and Northwest Territories	–	–	–	–	–	–	–	–	–	–	–
Canada	6 004	141 228	295 243	3 489 900	282 700	9 338 800	17 946 600	8 403 700	168 796	4 482 000	8 698 400
Petroleum and coal products industry											
Atlantic provinces	9	x	x	x	x	x	x	x	x	x	x
Quebec	30	1 118	2 289	50 500	70 200	2 299 600	2 700 200	235 300	1 732	71 900	246 200
Ontario	52	2 811	6 771	133 900	123 000	4 142 000	5 376 200	970 800	7 635	376 600	964 000
Prairie provinces	38	x	x	x	x	x	x	x	x	x	x
British Columbia	11	688	1 351	32 500	18 500	1 118 200	1 473 500	307 800	979	48 700	318 400
Yukon and Northwest Territories	1	x	x	x	x	x	x	x	x	x	x
Canada	141	6 837	15 318	318 600	294 700	11 323 400	14 273 800	2 253 900	15 610	725 700	2 279 900
Total mineral manufacturing industries											
Atlantic provinces	321	x	x	x	x	x	x	x	x	x	x
Quebec	2 024	65 463	137 296	1 886 200	723 200	8 455 200	15 984 100	6 822 200	83 279	2 600 300	6 930 800
Ontario	3 972	160 914	342 411	4 794 800	1 102 700	18 081 300	32 382 400	13 359 400	201 464	6 513 900	13 713 500
Prairie provinces	1 154	x	x	x	x	x	x	x	x	x	x
British Columbia	837	18 142	36 145	572 700	99 700	2 424 100	4 480 700	1 941 000	22 838	770 900	2 071 400
Yukon and Northwest Territories	1	x	x	x	x	x	x	x	x	x	x
Canada	8 309	277 965	586 697	8 187 400	2 268 400	35 436 700	62 739 600	22 871 500	350 917	11 191 000	25 725 700

Source: Statistics Canada, Catalogue No. 31-203.
[1] Total activity includes sales and head offices. [2] For reasons of confidentiality, SIC 305 (Wire and wire products), normally included in Primary metals is included in Fabricated metal products.
x Confidential; – Nil; SIC Standard Industrial Classification.

TABLE 34. CANADA, PRINCIPAL STATISTICS OF THE MINERALS INDUSTRY,[1] 1982-89

	Mines, Quarries and Oil Well Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establish-ments	Employees	Person-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)
1982	1 247	74 178	141 070	2 008 439	956 296	3 768 771	29 101 618	24 376 549	123 486	3 648 004	24 427 308
1983	1 407	66 629	131 406	1 963 773	1 022 417	3 756 625	32 771 401	27 992 357	113 831	3 687 911	28 012 167
1984	1 381	69 650	140 567	2 295 256	1 204 008	4 290 972	37 976 019	32 481 039	115 790	4 106 049	32 545 525
1985	1 385	67 308	140 780	2 357 868	1 264 619	4 442 358	38 127 807	32 420 830	117 161	4 413 258	32 495 098
1986	1 507	64 275	134 885	2 366 813	1 240 371	4 649 767	27 785 615	21 895 474	109 974	4 418 118	22 224 015
1987	1 276	64 276	138 047	2 440 174	1 233 806	4 870 150	30 652 347	24 548 391	107 663	4 458 693	24 803 839
1988	1 340	66 720[r]	143 263[r]	2 717 554[r]	1 296 757	5 685 034	31 777 388	24 795 628	110 095[r]	4 865 003[r]	25 100 343
1989	1 262	69 643	150 362	3 006 177	1 351 250	6 094 373	33 544 890	26 126 346	111 951	5 251 896	26 437 183

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Total activity includes sales and head offices.
[r] Revised.

TABLE 35. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES,[1] 1980-88

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establish-ments	Employees	Person-Hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1980	7 229	270 529	565 988	4 991 451	1 411 101	28 394 177	43 895 507	14 758 224	366 120	7 262 688	15 160 467
1981	7 196	261 364	546 732	5 393 636	1 720 151	34 570 420	51 870 979	16 791 049	361 883	8 076 300	17 200 686
1982	5 687	229 518	475 378	5 333 201	1 728 740	34 241 605	50 045 037	14 497 245	321 785	8 126 238	14 823 990
1983	7 370	216 944	447 947	5 420 307	1 905 777	34 720 416	52 773 875	15 861 491	301 112	8 143 674	16 196 749
1984	7 511	223 816	470 367	5 948 626	2 125 032	37 738 117	57 207 764	17 980 271	304 309	8 719 151	18 265 131
1985	7 625	238 544	506 377	6 507 081	2 229 270	39 497 925	61 241 939	19 305 730	313 850	9 271 447	19 646 938
1986	7 841	248 039	524 184	6 829 899	2 096 145	31 806 478	54 521 641	19 788 464	319 950	9 563 918	20 124 687
1987	7 598	. .	. .	. .	2 155 505	38 040 112	63 607 352	. .	333 009	10 170 081	22 760 931
1988	8 309	277 965	586 697	8 187 400	2 268 400	35 436 700	62 739 600	22 871 500	350 917	11 191 000	25 725 700

Source: Statistics Canada.
[1] Includes the following industries: Primary metals, Nonmetallic mineral products, Fabricated metal products, and Refined petroleum and coal products. [2] Total activity includes sales and head offices.
. . Not available.

TABLE 36. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERALS INDUSTRY,[1] 1989

	Unit	Metals	Industrials[2]	Total
Coal	000 t	224	–	224
	$000	15 621	–	15 621
Gasoline	000 litres	22 684	17 289	39 973
	$000	9 437	7 547	16 984
Fuel oil, kerosene, diesel oil	000 litres	780 507	278 185	1 058 692
	$000	163 939	73 386	237 325
Liquefied petroleum gas	000 litres	120 591	12 154	132 745
	$000	21 107	2 362	23 469
Natural gas	000 m^3	253 425	653 744	907 169
	$000	25 106	42 472	67 578
Other fuels[3]	$000	19 232	1 845	21 077
Total value of fuels	$000	254 442	127 612	382 054
Electricity purchased	million kWh	13 396	2 548	15 944
	$000	398 188	113 108	511 296
Total value of fuels and electricity purchased in the nonfuel minerals industry	$000	652 629	240 720	893 349
Consumption of fuels and electricity purchased in the fuel industry	$000	..	..	457 901
Total value of fuels and electricity purchased in the minerals industry, all reporting companies	$000	..	..	1 351 250

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Includes structural materials. [3] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
– Nil; .. Not available.
Note: Totals may not add due to rounding.

TABLE 37. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERALS INDUSTRY,[1] 1983-89

	Unit	1983	1984	1985	1986	1987	1988	1989
Metals								
Fuel	$000	270 098	331 231	337 445	276 894	249 932	251 343	254 442
Electricity purchased	million kWh	9 659	11 672	11 504	12 066	12 128	13 264	13 396
	$000	238 458	272 932	281 373	320 828	345 068	368 369	398 188
Total cost of fuel and electricity	$000	508 556	604 163	618 818	597 722	595 000	619 712	652 629
Industrials[2]								
Fuel	$000	157 872	169 486	165 665	153 442	137 873	139 126	127 612
Electricity purchased	million kWh	1 928	2 120	2 122	2 107	2 237	2 510	2 548
	$000	64 052	76 884	82 114	86 571	96 876	107 496	113 108
Total cost of fuel and electricity	$000	221 924	246 370	247 779	240 013	234 749	246 622	240 720
Total nonfuel minerals industry								
Fuel	$000	427 970	500 717	503 110	430 336	387 805	390 469	382 054
Electricity purchased	million kWh	11 587	13 792	13 626	14 173	14 365	15 774	15 944
	$000	302 510	349 816	363 487	407 399	441 944	475 865	511 296
Total cost of fuel and electricity	$000	730 480	850 533	866 597	837 735	829 749	866 334	893 349
Fuels								
Fuel	$000	68 800	89 237	101 049	73 426	67 103	68 654	. .
Electricity purchased	million kWh	4 958	5 840	6 569	7 183	7 822	8 726	. .
	$000	223 136	264 233	296 973	329 208	336 952	371 632	. .
Total cost of fuel and electricity	$000	291 936	353 470	398 022	402 634	404 055	440 286	457 901
Total minerals industry								
Fuel	$000	496 770	589 954	604 159	503 762	454 908	459 123	. .
Electricity purchased	million kWh	16 545	19 632	20 195	21 356	22 187	24 501	. .
	$000	525 646	614 049	660 460	736 607	778 896	847 497	. .
Total cost of fuel and electricity	$000	1 022 416	1 204 003	1 264 619	1 240 369	1 233 804	1 306 620	1 351 250

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Includes structural materials.
. . Not available.

TABLE 38. CANADA, EMPLOYMENT IN THE MINERALS INDUSTRY, STAGE I - MINERAL EXTRACTION AND CONCENTRATING (TOTAL ACTIVITY),[1] 1961-91

	Metal Mines	Nonmetal Mines	Structural Materials	Nonfuel Mining	Coal	Crude Oil and Natural Gas	Total Nonfuel and Fuel
SIC#	061	062	081, 082	061, 062 081, 082	063	071	
				(number)			
1961	58 591	11 003	5 235	74 829	10 302	11 184	96 315
1962	58 243	11 408	5 514	75 165	9 897	11 232	96 294
1963	57 119	11 661	5 686	74 466	9 828	11 237	95 531
1964	57 648	11 727	6 044	75 419	9 796	11 242	96 457
1965	60 942	12 116	6 248	79 306	9 697	11 817	100 820
1966	61 670	12 422	6 312	80 404	9 281	12 378	102 063
1967	61 728	13 077	5 779	80 584	8 981	13 113	102 678
1968	63 369	13 673	5 836	82 878	8 427	13 611	104 916
1969	60 550	14 322	5 692	80 564	7 371	14 153	102 088
1970	66 590	15 150	5 510	87 250	7 874	14 970	110 094
1971	66 012	15 105	5 328	86 445	8 069	15 896	110 410
1972	61 994	14 866	5 154	82 014	8 704	16 604	107 322
1973	66 134	15 391	5 276	86 801	7 856	16 786	111 443
1974	70 038	16 198	6 197	92 433	8 142	18 155	118 730
1975	69 161	13 703	6 382	89 246	8 416	18 053	115 715
1976	68 269	15 649	5 685	89 603	8 995	19 096	117 694
1977	67 242	16 608	5 190	89 040	9 781	20 240	119 061
1978	56 447	16 035	4 847	77 329	10 574	22 045	109 948
1979	58 960	16 770	4 692	80 422	10 269	24 554	115 245
1980	66 118	16 979	4 461	87 558	11 416	27 448	126 422
1981	68 712	16 391	4 183	89 286	11 182	28 783	129 251
1982	61 503	13 680	3 491	78 674	13 113	31 699	123 486
1983	52 194	13 170	3 403	68 767	11 646	33 418	113 831
1984	52 683	13 698	3 560	69 941	11 905	33 944	115 790
1985	48 672	12 974	3 941	65 587	12 076	39 498	117 161
1986	46 487	12 376	4 887	63 750	10 747	35 477	109 974
1987	45 496	12 181	5 738	63 415	10 406	33 842	107 663r
1988	48 277	11 679	5 917	65 873	11 122	33 100r	110 095r
1989	49 405	11 714	5 881	67 000	11 239	33 712	111 951
1990p	46 084	11 694	5 410	63 188	11 685	33 482	108 355
1991f	43 134	11 583	4 990	59 707	12 045	34 258	106 010

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Total activity includes sales and head offices.
p Preliminary; f Forecast; r Revised.
SIC: 1980 Standard Industrial Classification.

TABLE 39. CANADA, EMPLOYMENT IN THE NONFUEL MINERALS INDUSTRY, STAGE I – MINERAL EXTRACTION AND CONCENTRATING (TOTAL ACTIVITY),[1] 1961-91

	Gold	Uranium	Iron	Nickel, Copper, Zinc	Silver, Lead, Zinc	Other Nonferrous	Asbestos	Peat	Gypsum	Potash	Other Nonmetal	Stone Quarries	Sand and Gravel	Total Nonfuel Mining
SIC #	0611	0616	0617	0612, 0613	0614	0615, 0619	0621	0622	0623	0624	0625, 0629	081	082	
							(number)							
1961	15 994	(2)	8 446	23 351	4 524	6 276	6 773	1 207	549	(3)	2 424	3 173	2 062	74 829
1962	15 425	(2)	9 181	23 383	4 669	5 585	6 936	1 220	594	(3)	2 658	3 221	2 293	75 165
1963	14 639	(2)	9 608	22 703	5 163	5 006	6 828	1 303	677	(3)	2 853	3 477	2 209	74 466
1964	14 012	(2)	9 544	23 848	5 898	4 346	6 544	1 290	710	(3)	3 183	3 718	2 326	75 419
1965	13 155	(2)	11 739	25 892	6 121	4 035	6 536	1 201	646	1 050	2 683	3 511	2 737	79 306
1966	11 656	(2)	11 464	27 651	6 356	4 543	6 736	1 254	585	1 195	2 652	3 701	2 611	80 404
1967	10 355	(2)	10 899	29 288	6 030	5 156	6 931	1 261	505	1 724	2 656	3 381	2 398	80 584
1968	9 001	(2)	11 342	30 557	6 320	6 149	7 213	1 306	489	2 086	2 579	3 340	2 496	82 878
1969	8 221	(2)	10 490	28 679	6 467	6 693	7 242	1 156	657	2 713	2 554	3 252	2 440	80 564
1970	7 185	(2)	11 336	36 253	7 103	4 713	7 664	1 195	671	2 837	2 783	3 023	2 487	87 250
1971	6 148	(2)	11 524	37 713	6 506	4 121	8 101	1 269	603	2 519	2 613	2 832	2 496	86 445
1972	5 579	(2)	10 842	36 012	6 057	3 504	7 843	1 114	670	2 440	2 799	2 803	2 351	82 014
1973	5 603	(2)	13 395	37 602	6 112	3 422	8 027	1 236	676	2 684	2 768	3 097	2 179	86 801
1974	5 665	(2)	15 019	38 876	6 722	3 756	8 131	1 288	671	3 224	2 884	3 458	2 739	92 433
1975	5 798	(2)	16 155	35 538	7 362	4 308	6 042	1 303	576	3 351	2 431	3 544	2 838	89 246
1976	5 051	3 430	16 765	34 049	7 351	1 623	7 900	1 168	591	3 270	2 720	3 217	2 468	89 603
1977	4 643	4 140	15 550	33 703	7 512	1 694	8 302	1 244	652	3 628	2 782	3 004	2 186	89 040
1978	4 943	4 965	12 103	25 610	7 073	1 753	7 752	1 295	683	3 708	2 597	2 876	1 971	77 329
1979	5 013	5 858	14 563	25 116	7 081	1 329	8 067	1 372	738	3 905	2 688	2 860	1 832	80 422
1980	5 839	6 304	13 753	31 063	7 349	1 810	8 055	1 308	715	4 160	2 741	2 660	1 801	87 558
1981	6 809	6 869	12 397	33 246	7 740	1 651	6 829	1 441	711	4 661	2 749	2 418	1 765	89 286
1982	7 350	6 035	10 676	28 851	6 837	1 754	4 973	1 323	614	4 076	2 694	2 028	1 463	78 674
1983	7 956	5 390	8 236	24 953	5 073	586	4 617	1 301	682	3 696	2 874	1 980	1 423	68 767
1984	8 450	6 249	7 843	24 000	5 165	976	4 177	1 369	770	4 508	2 874	2 256	1 304	69 941
1985	7 862	5 989	7 077	22 073	4 724	947	3 569	1 363	753	4 488	2 801	2 340	1 601	65 587
1986	8 562	5 608	6 379	20 616	4 162	1 160	2 766	1 468	990	4 315	2 837	2 627	2 260	63 750
1987	9 757	5 289	6 039	18 979	4 372	1 060	2 858	1 510	929	4 094	2 790	2 911	2 827	63 415
1988	12 594	5 103	6 095	18 881	4 443	1 161	2 720	1 581	956	3 970	2 452	2 981	2 936	65 873
1989	12 631	4 839	6 303	19 837	4 487	1 308	2 800	1 713	965	3 893	2 343	3 145	2 736	67 000
1990p	12 003	3 669	5 820	19 581	3 921	1 090	2 699	1 735	967	3 822	2 471	2 977	2 433	63 188
1991f	12 341	2 516	5 721	17 960	3 596	1 000	2 397	1 947	820	3 898	2 520	2 170	2 820	59 707

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Total activity includes sales and head offices. (2) Included in "Other Nonferrous." (3) Included in "Other Nonmetal."
p Preliminary; f Forecast.
SIC: 1980 Standard Industrial Classification.

TABLE 40. CANADA, EMPLOYMENT IN THE MINERALS INDUSTRY, STAGE II - SMELTING AND REFINING (TOTAL ACTIVITY),[1] 1961-91

	Smelting/ Refining	Iron and Steel Mills	Total Primary Metals	Petroleum Refineries	Total Smelting and Refining
SIC#	295	291	291, 295	3611	
			(number)		
1961	29 938	34 749	64 687	10 660	75 347
1962	29 693	36 593	66 286	10 184	76 470
1963	28 516	38 196	66 712	9 734	76 446
1964	30 153	41 505	71 658	9 547	81 205
1965	31 835	44 274	76 109	8 976	85 085
1966	34 237	45 999	80 236	8 996	89 232
1967	34 764	44 203	78 967	9 147	88 114
1968	34 710	44 634	79 344	9 091	88 435
1969	33 376	42 954	76 330	8 765	85 095
1970	37 298	49 169	86 467	14 725	101 192
1971	36 445	49 601	86 046	14 506	100 552
1972	33 829	49 758	83 587	14 376	97 963
1973	32 396	53 008	85 404	14 843	100 247
1974	35 249	54 253	89 502	15 967	105 469
1975	35 577	54 003	89 580	15 624	105 204
1976	34 246	51 978	86 224	15 105	101 329
1977	35 647	52 709	88 356	16 464	104 820
1978	32 652	56 669	89 321	18 958	108 279
1979	32 869	59 167	92 036	18 037	110 073
1980	36 137	61 238	97 375	18 743	116 118
1981	38 011	56 543	94 554	21 325	115 879
1982	33 215	52 330	85 545	20 155	105 700
1983	31 788	47 693	79 481	17 557	97 038
1984	31 752	48 899	80 651	15 847	96 498
1985	30 567	47 685	78 252	15 326	93 578
1986	29 058	46 461	75 519	13 287	88 806
1987	29 397	46 493	75 890	13 252	89 142
1988[r]	31 322	48 259	78 358	13 358	91 716
1989[e]	31 222	47 828	79 050	13 241	92 291
1990[p]	30 427	40 223	70 650	12 465	83 115
1991[f]	28 519	38 072	66 591	12 276	78 867

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Total activity includes sales and head offices.
[p] Preliminary; [r] Revised; [f] Forecast; [e] Estimate.
SIC: 1980 Standard Industrial Classification.

TABLE 41. CANADA, EMPLOYMENT IN THE MINERALS INDUSTRY, STAGE III - SEMI-FABRICATION (TOTAL ACTIVITY),[1] 1961-91

	Total Nonfuel Semi-Fabrication	Miscellaneous Petroleum and Coal Products	Lubricating Oil and Greases	Total Semi-Fabrication
SIC#[2]		369	3612	
		(number)		
1961	77 063	581	331	77 975
1962	80 606	608	352	81 566
1963	82 420	635	354	83 409
1964	87 843	726	373	88 942
1965	93 912	531	408	94 851
1966	98 602	585	424	99 611
1967	96 033	546	407	96 986
1968	96 375	518	397	97 290
1969	99 438	532	438	100 408
1970	96 144	499	423	97 066
1971	95 831	561	450	96 842
1972	101 109	555	478	102 142
1973	105 884	757	487	107 128
1974	109 818	954	514	111 286
1975	104 296	984	656	105 936
1976	103 411	982	602	104 995
1977	101 257	716	669	102 642
1978	107 234	683	712	108 629
1979	111 231	461	695	112 387
1980	105 902	532	798	107 232
1981	103 192	584	729	104 505
1982	90 194	571	792	91 557
1983	86 814	503	857	88 174
1984	91 405	521	896	92 822
1985	94 515	513	900	95 928
1986	96 744	778	1 001	98 523
1987	99 963	894	1 002	101 859
1988[r]	103 307	1 161	1 091	105 559
1989[e]	100 358	1 067	1 002	102 427
1990[p]	91 280	1 001	940	93 220
1991[f]	79 345	855	804	81 005

Source: Annual Census of Manufactures.
SIC: 1980 Standard Industrial Classification.
[1] Includes sales and head offices. [2] 1970 SIC for years 1961-82.
[p] Preliminary; [f] Forecast; [r] Revised; [e] Estimate.

TABLE 42. CANADA, EMPLOYMENT IN THE MINERALS INDUSTRY, STAGE III - NONFUEL SEMI-FABRICATION (TOTAL ACTIVITY),[1] 1961-91

	Steel Pipe and Tube	Iron Foundries	Aluminum Rolling, Casting, Extruding	Copper Rolling, Casting, Extruding	Other Rolling, Casting, Extruding	Wire and Wire Products	Clay and Clay Products	Cement	Concrete Products	Ready-Mix Concrete	Glass and Glass Products[2]	Abrasives	Lime	Other Non-metallic Products	Total Nonfuel Semi-Fabrication
SIC#	292	294	296	297	299	305	351	352	354	355	356	357	358	359	
								(number)							
1961	3 407	8 178	5 095	3 482	2 731	12 227	5 327	3 590	8 503	4 232	9 802	2 481	847	7 161	77 063
1962	3 676	8 546	5 118	3 492	2 770	13 045	5 468	3 679	9 156	4 886	10 042	2 577	949	7 202	80 606
1963	3 840	8 216	5 164	3 651	3 038	13 743	5 376	3 566	9 317	5 411	10 346	2 464	886	7 402	82 420
1964	4 437	9 620	4 834	3 849	3 382	14 850	5 582	3 592	10 225	6 171	10 362	2 580	815	7 544	87 843
1965	4 799	11 714	4 654	3 620	3 736	16 099	5 675	3 837	10 988	6 559	10 873	2 821	800	7 737	93 912
1966	4 795	13 027	4 943	4 199	4 103	16 391	5 876	4 053	11 090	7 349	11 248	3 044	785	7 699	98 602
1967	5 012	11 970	5 468	4 027	4 287	16 060	5 559	3 972	10 321	7 137	11 388	2 734	724	7 374	96 033
1968	5 441	11 131	5 491	3 947	4 585	16 082	5 515	3 747	10 166	7 440	11 992	2 617	662	7 559	96 375
1969	5 146	11 582	6 028	3 922	4 856	17 014	5 383	3 778	11 011	7 509	12 031	2 697	707	7 774	99 438
1970	5 314	10 663	6 297	3 744	4 060	16 598	4 938	3 887	9 562	7 340	11 654	2 559	660	8 868	96 144
1971	5 306	9 897	5 612	3 608	3 845	16 272	4 682	3 954	10 719	7 997	11 672	2 310	670	9 287	95 831
1972	6 268	9 948	6 200	3 740	4 215	17 651	4 695	4 732	10 817	8 240	12 045	2 367	651	9 540	101109
1973	5 288	10 965	6 206	3 736	4 863	18 877	5 001	4 871	10 790	9 233	12 840	2 555	724	9 935	105 884
1974	5 845	12 054	6 162	3 779	4 877	19 535	5 289	4 666	11 602	9 219	12 915	2 676	840	10 359	109 818
1975	5 785	11 480	5 672	3 240	4 573	17 614	5 042	4 577	11 201	9 541	11 779	2 318	790	10 684	104 296
1976	5 546	10 365	6 255	3 297	5 354	17 573	4 791	4 517	10 773	9 128	11 836	2 535	804	10 637	103 411
1977	5 634	10 459	6 884	3 183	4 703	17 886	4 553	4 265	10 001	8 521	11 204	2 557	828	10 579	101 257
1978	6 289	10 472	7 060	3 586	5 268	18 823	4 366	4 520	10 486	9 520	11 595	2 678	784	11 787	107 234
1979	6 480	10 520	7 698	3 728	6 292	19 765	4 947	4 828	9 766	9 332	11 835	2 660	925	12 455	111 231
1980	6 514	9 245	6 627	3 230	5 749	18 529	4 875	4 791	9 280	9 348	11 967	2 628	1 003	12 116	105 902
1981	7 531	8 358	6 512	3 031	5 182	17 309	4 145	4 726	9 121	10 053	12 003	2 571	968	11 682	103 192
1982	6 017	8 163	6 255	2 541	4 694	14 575	3 004	4 317	8 245	8 034	11 016	2 170	895	10 268	90 194
1983	4 521	7 364	6 415	2 744	4 827	13 493	3 008	4 057	7 286	8 390	11 896	1 852	862	10 099	86 814
1984	5 482	7 911	6 661	2 971	5 274	14 212	3 070	3 771	7 657	8 802	12 754	1 949	876	10 015	91 405
1985	5 978	7 750	6 196	3 012	5 620	15 354	2 727	3 533	8 336	9 210	12 872	1 895	783	11 249	94 515
1986	4 829	7 547	6 200	3 059	6 357	15 262	3 770	3 514	9 174	10 422	13 448	1 827	778	10 557	96 744
1987	4 964	7 860	6 143	2 828	6 403	14 943	3 930	3 646	10 309	11 910	13 605	1 693	784	10 945	99 963
1988r	6 008	8 095	6 124	3 040	7 049	15 154	3 261	3 388	11 386	12 461	13 336	1 917	873	11 215	103 307
1989•	5 526	7 184	6 022	2 812	7 150	15 154	2 830	3 175	11 983	12 862	12 285	2 037	934	10 403	100 358
1990p	5 213	6 143	5 412	2 419	6 045	13 645	2 548	3 023	11 202	11 337	11 020	1 703	934	10 635	91 280
1991f	5 048	5 420	6 313	2 160	4 742	10 860	2 081	2 524	9 611	9 998	9 784	1 202	833	8 768	79 345

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes sales and head offices. [2] Includes sealed window manufacturers until 1969; thereafter these are included in Stage IV - Ornamental Metal Products.
p Preliminary; f Forecast; r Revised; • Estimate.

TABLE 43. CANADA, EMPLOYMENT IN THE MINERAL INDUSTRY, STAGE IV - METALLIC MINERAL MANUFACTURING (TOTAL ACTIVITY),[1] 1961-91

	Boilers	Structural Metal Products	Ornamental Metal Products	Stamped, Pressed and Coated Products	Hardware Tool and Cutlery	Heating Equipment	Machine Parts	Other Metal Fabricating	Total Mineral Manufacturing
SIC#	301	302	303	304	306	307	308	309	
					(number)				
1961	4 709	14 231	10 641	21 156	9 135	5 137	7 756	15 249	88 014
1962	4 886	14 802	11 640	23 606	10 223	5 349	8 603	16 283	95 392
1963	5 350	14 212	12 459	24 024	11 112	5 586	9 179	16 627	98 549
1964	5 429	14 602	12 808	25 192	13 110	5 673	10 137	18 088	105 039
1965	6 496	18 072	13 439	27 925	13 570	5 711	11 618	20 017	116 848
1966	7 239	21 038	13 488	29 577	14 326	5 464	13 235	21 431	125 798
1967	6 622	18 547	12 994	29 830	14 056	5 461	13 810	21 007	122 327
1968	7 962	17 150	12 664	29 560	14 166	4 930	13 501	20 825	120 758
1969	7 494	18 203	12 784	30 463	14 401	5 059	14 517	20 895	123 816
1970	7 661	19 104	12 417	29 709	15 241	4 670	14 221	20 543	123 566
1971	7 847	17 556	12 614	28 710	14 920	4 749	13 097	20 755	120 248
1972	8 136	17 113	13 611	27 939	16 386	4 238	11 731	21 504	120 658
1973	8 013	18 164	13 937	30 026	18 819	4 453	10 138	22 494	126 044
1974	8 681	20 020	14 470	31 276	20 234	4 930	10 936	23 663	134 210
1975	10 211	19 101	15 241	30 273	18 990	4 717	10 922	23 810	133 265
1976	10 704	18 056	15 541	31 487	19 316	4 977	10 764	23 704	134 549
1977	9 660	17 209	14 800	30 888	17 867	4 538	10 762	23 298	129 022
1978	9 124	16 759	16 753	34 181	18 856	5 086	12 029	24 904	137 692
1979	9 477	18 676	18 018	33 548	21 090	5 818	13 081	23 705	143 413
1980	10 374	17 700	17 890	32 266	20 830	5 993	13 449	24 217	142 719
1981	11 215	18 445	17 603	32 459	19 575	5 806	14 297	22 123	141 523
1982	10 965	17 021	15 228	29 865	17 342	5 317	13 083	18 167	126 988
1983	5 413	18 437	13 537	27 947	16 609	5 032	12 881	16 044	115 900
1984	4 548	17 162	13 538	27 758	17 308	4 220	14 200	16 256	114 990
1985	4 455	18 083	15 598	31 021	19 297	5 607	15 356	14 927	124 344
1986	4 990	19 213	17 462	31 584	21 164	5 779	17 259	15 170	132 621
1987	4 816	18 615	19 770	35 329	22 129	6 252	18 398	16 358	141 667
1988[r]	6 182	19 689	20 795	36 976	23 042	6 390	22 681	17 887	153 642
1989[e]	6 447	21 153	23 257	34 779	19 851	6 630	22 813	18 255	153 184
1990[p]	6 375	18 565	21 466	30 560	19 128	5 781	21 759	17 559	141 193
1991[f]	6 828	14 221	14 172	26 641	15 191	4 490	16 861	13 940	112 344

Sources: Energy, Mines and Resources Canada; Statistics Canada.
SIC: 1980 Standard Industrial Classification.
[1] Total activity includes sales and head offices.
[p] Preliminary; [f] Forecast; [r] Revised; [e] Estimate.

TABLE 44. CANADA, EMPLOYMENT FOR SERVICES INCIDENTAL TO MINES, QUARRIES AND OIL WELLS, 1961-91

	Petroleum and Natural Gas Contract Drilling	Mining Diamond Drilling	Other Services Incidental to Mines, Quarries and Oil Wells	Total
		(number)		
1961	4 144	2 025	1 409	7 578
1962	3 800	1 926	1 720	7 446
1963	4 179	2 201	1 491	7 871
1964	4 158	2 401	2 077	8 636
1965	4 648	2 776	3 137	10 561
1966	4 428	2 887	4 317	11 632
1967	4 249	2 669	5 425	12 343
1968	4 434	2 985	6 350	13 769
1969	4 821	3 109	6 967	14 897
1970	4 267	3 207	7 894	15 368
1971	4 093	2 514	7 710	14 317
1972	4 817	2 083	6 139	13 039
1973	5 680	2 123	5 193	12 996
1974	5 054	2 317	5 017	12 388
1975	5 096	1 899	4 139	11 134
1976	5 486	1 548	5 043	12 077
1977	6 054	1 682	5 723	13 459
1978	7 419	1 681	7 492	16 592
1979	9 076	2 420	8 436	19 932
1980	11 097	2 959	9 327	23 383
1981	8 448	2 721	9 856	21 025
1982	6 882	1 880	7 752	16 514
1983	12 032	1 575	12 254	25 861
1984	9 250	1 684	15 433	26 367
1985	13 150	1 625	19 358	34 133
1986	9 800	2 198	18 958	30 956
1987	8 883	3 353	23 267	35 503
1988	9 408	3 201	23 208	35 818
1989	7 108	2 072	21 233	30 414
1990p	7 283	1 856	19 583	28 723
1991f	8 533	1 856	21 200	31 589

Sources: Energy, Mines and Resources Canada; Statistics Canada.
p Preliminary; f Forecast.

TABLE 45. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERALS INDUSTRY,[1] 1983-89

	Unit	1983	1984	1985	1986	1987	1988	1989
Metals								
Production and related workers	Number	37 270	39 181	36 618	34 941	34 329	36 140	37 451
Salaries and wages	$000	1 110 308	1 296 157	1 288 990	1 308 956	1 327 119	1 539 838	1 707 653
Annual average salary and wage	$	29 791	33 081	35 201	37 462	38 659	42 608	45 597
Administrative and office workers	Number	14 924	13 502	12 054	11 546	11 167	12 137	11 954
Salaries and wages	$000	533 517	518 644	487 398	489 402	489 609	561 205	600 238
Annual average salary and wage	$	35 749	38 412	40 435	42 387	43 844	46 239	50 212
Total metals								
Employees	Number	52 194	52 683	48 672	46 487	45 496	48 277	49 405
Salaries and wages	$000	1 643 825	1 814 801	1 776 388	1 798 358	1 816 728	2 101 043	2 307 891
Annual average salary and wage	$	31 495	34 448	36 497	38 685	39 932	43 521	46 714
Industrials[2]								
Production and related workers	Number	12 768	13 008	12 535	12 376	12 989	12 969	12 976
Salaries and wages	$000	329 201	356 828	354 460	361 039	401 626	429 111	440 750
Annual average salary and wage	$	25 783	27 431	28 278	29 173	30 920	33 087	33 967
Administrative and office workers	Number	3 805	4 250	4 380	4 887	4 930	4 627	4 619
Salaries and wages	$000	115 378	138 012	148 090	169 237	183 979	189 650	191 558
Annual average salary and wage	$	30 323	32 473	33 811	34 630	37 318	40 988	41 472
Total industrials								
Employees	Number	16 573	17 258	16 915	17 263	17 919	17 596	17 595
Salaries and wages	$000	444 579	494 840	502 550	530 276	585 605	618 761	632 308
Annual average salary and wage	$	26 825	28 673	29 710	30 717	32 681	35 165	35 937
Fuels								
Production and related workers	Number	16 591	17 461	18 155	16 958	16 958	17 611r	19 216
Salaries and wages	$000	524 264	642 271	714 418	696 818	711 429	748 605r	857 774
Annual average salary and wage	$	31 599	36 783	39 351	41 091	41 952	42 508	44 639
Administrative and office workers	Number	28 473	28 388	33 419	29 266	27 290	26 611	25 735
Salaries and wages	$000	1 075 245	1 154 137	1 419 903	1 392 666	1 344 931	1 396 594	1 453 923
Annual average salary and wage	$	37 764	40 656	42 488	47 586	49 283	52 482	56 496
Total fuels								
Employees	Number	45 064	45 849	51 574	46 224	44 248	44 222r	44 951
Salaries and wages	$000	1 599 509	1 796 408	2 134 321	2 089 484	2 056 360	2 145 199r	2 311 697
Annual average salary and wage	$	35 494	39 181	41 384	45 203	46 474	48 510	51 427
Total minerals industry								
Production and related workers	Number	66 629	69 650	67 308	64 275	64 276	66 720	69 643
Salaries and wages	$000	1 963 773	2 295 256	2 357 868	2 366 813	2 440 174	2 717 554	3 006 177
Annual average salary and wage	$	29 473	32 954	35 031	36 823	37 964	40 731	43 166
Administrative and office workers	Number	47 202	46 140	49 853	45 699	43 387	43 375	42 308
Salaries and wages	$000	1 724 140	1 810 793	2 055 391	2 051 305	2 018 519	2 147 448	2 245 719
Annual average salary and wage	$	36 527	39 246	41 229	44 887	46 524	49 509	53 080
Total mining industry								
Employees	Number	113 831	115 790	117 161	109 974	107 663	110 095r	111 951
Salaries and wages	$000	3 687 913	4 106 049	4 413 259	4 418 118	4 458 693	4 865 003	5 251 896
Annual average salary and wage	$	32 398	35 461	37 668	40 174	41 413	44 189	46 912

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Includes structural materials.
r Revised.
Note: Totals may not add due to rounding.

TABLE 46. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES, 1982-88

	Unit	1982	1983	1984	1985	1986	1987	1988
Primary metal industries								
Production and related workers	Number	92 621	87 769	92 336	92 695	90 035	..	95 967
Salaries and wages	$000	2 368 939	2 445 267	2 818 413	2 940 777	2 924 986	..	3 387 100
Annual average salary and wage	$	25 577	27 860	30 523	31 725	32 487	..	35 294
Administrative and office workers	Number	34 563	31 076	30 826	29 467	28 738	..	27 861
Salaries and wages	$000	1 104 327	1 055 120	1 131 842	1 159 060	1 182 287	..	1 249 200
Annual average salary and wage	$	31 951	33 953	36 717	39 334	41 140	..	44 837
Total primary metal industries[1]								
Employees	Number	127 184	118 845	123 162	122 162	118 773	119 372	123 828
Salaries and wages	$000	3 473 266	3 500 387	3 950 387	4 099 837	4 107 273	4 244 950	4 636 300
Annual average salary and wage	$	27 309	29 453	32 074	33 561	34 581	35 561	37 441
Nonmetallic mineral products industries								
Production and related workers	Number	33 997	34 097	36 155	38 763	42 011	..	45 974
Salaries and wages	$000	751 915	800 755	883 604	1 001 780	1 121 460	..	1 309 600
Annual average salary and wage	$	22 117	23 485	24 439	25 844	26 694	..	28 486
Administrative and office workers	Number	13 952	13 353	12 738	11 842	11 479	..	11 863
Salaries and wages	$000	383 405	391 901	394 620	397 131	406 427	..	464 600
Annual average salary and wage	$	27 480	29 349	30 980	33 536	35 406	..	39 164
Total nonmetallic mineral products								
Employees	Number	47 949	47 450	48 893	50 605	53 490	56 822	57 837
Salaries and wages	$000	1 135 320	1 192 656	1 278 224	1 398 911	1 527 887	1 668 869	1 774 200
Annual average salary and wage	$	23 678	25 135	26 143	27 644	28 564	29 370	30 676
Fabricated metal products industries								
Production and related workers	Number	94 779	87 661	88 787	100 650	109 634	..	129 167
Salaries and wages	$000	1 946 325	1 910 181	1 983 782	2 298 665	2 518 297	..	3 172 100
Annual average salary and wage	$	20 535	21 791	22 343	22 838	22 970	..	24 554
Administrative and officer workers	Number	30 372	28 239	26 203	23 694	22 987	..	24 455
Salaries and wages	$000	803 920	785 881	778 057	751 973	746 041	..	882 700
Annual average salary and wage	$	26 469	27 830	29 693	31 737	32 455	..	36 095
Total fabricated metal products industries								
Employees	Number	125 151	115 900	114 990	124 344	132 621	141 667	153 642
Salaries and wages	$000	2 750 245	2 696 062	2 761 839	3 050 638	3 264 338	3 547 954	4 054 800
Annual average salary and wage	$	21 975	23 262	24 018	24 534	24 614	25 044	26 391
Petroleum and coal products industries								
Production and related workers	Number	8 121	7 417	6 538	6 436	6 359	..	6 837
Salaries and wages	$000	266 022	264 104	262 827	265 859	265 156	..	318 600
Annual average salary and wage	$	32 757	35 608	40 200	41 308	41 698	..	46 599
Administrative and office workers	Number	13 380	11 500	10 726	10 303	8 707	..	8 773
Salaries and wages	$000	501 385	490 465	466 006	456 202	399 264	..	407 100
Annual average salary and wage	$	37 473	42 649	43 446	44 279	45 856	..	46 404
Total petroleum and coal products								
Employees	Number	21 501	18 917	17 264	16 739	15 066	15 148	15 610
Salaries and wages	$000	767 407	754 569	728 833	722 061	664 420	708 308	725 700
Annual average salary and wage	$	35 692	39 888	42 217	43 136	44 101	46 759	46 489
Total mineral manufacturing industries								
Production and related workers	Number	229 518	216 944	223 816	238 544	248 039	..	277 965
Salaries and wages	$000	5 333 201	5 420 307	5 948 626	6 507 081	6 829 899	..	8 187 400
Annual average salary and wage	$	23 237	24 985	26 578	27 278	27 536	..	29 455
Administrative and office workers	Number	92 267	84 168	80 493	75 306	71 911	..	72 952
Salaries and wages	$000	2 793 037	2 723 367	2 770 525	2 764 366	2 734 019	..	3 003 600
Annual average salary and wage	$	30 271	32 356	34 419	36 708	38 019	..	41 172
Total mineral manufacturing industries								
Employees	Number	321 785	301 112	304 309	313 850	319 950	333 009	350 917
Salaries and wages	$000	8 126 238	8 143 674	8 719 151	9 271 447	9 563 918	10 170 081	11 191 000
Annual average salary and wage	$	25 254	27 045	28 652	29 541	29 892	30 540	31 891

Source: Statistics Canada.
[1] Wire and wire products have been included in the primary metal industries group.
.. Not available.

TABLE 47. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE NONFUEL MINERALS INDUSTRY (SURFACE, UNDERGROUND AND MILL), 1983-89

	1983	1984	1985	1965	1987	1988	1989
Metals							
Surface	9 970	9 724	10 093	9 674	9 557	9 637	9 358
Underground	15 861	16 668	14 798	13 982	13 747	14 968	16 116
Mill	11 439	12 789	11 727	11 285	11 025	11 535	11 977
Total	37 270	39 181	36 618	34 941	34 329	36 140	37 451
Industrials							
Surface	4 951	4 948	4 921	5 396	5 771	5 908	5 744
Underground	2 192	2 487	2 337	2 112	2 234	2 173	2 251
Mill	5 625	5 573	5 277	4 868	4 984	4 888	4 981
Total	12 768	13 008	12 535	12 376	12 989	12 969	12 976
Total nonfuel minerals industry							
Surface	27 111	29 064	30 115	15 070	15 328	15 545	15 102
Underground	20 949	20 973	18 761	16 094	15 981	17 141	18 367
Mill	18 569	19 613	18 432	16 153	16 009	16 423	16 958
Total	66 629	69 650	67 308	47 317	47 318	49 109	50 427

Sources: Energy, Mines and Resources Canada; Statistics Canada.
Note: Totals may not add due to rounding.

TABLE 48. CANADA, MINE AND MILL WORKERS, BY SEX, EMPLOYED IN THE NONFUEL MINING INDUSTRY, 1989

	Mine Workers							
	Underground		Surface		Mill Workers		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
Metallic minerals								
Nickel–copper–zinc[1]	6 575	14	4 219	126	3 325	115	14 119	255
Gold	5 602	40	1 716	88	2 601	83	9 919	211
Iron ore	74	–	1 132	11	3 437	132	4 643	143
Uranium	2 136	20	951	21	927	68	4 014	109
Silver–lead–zinc	1 509	1	618	24	938	15	3 065	40
Miscellaneous metal mines[2]	145	–	447	5	318	18	910	23
Total	16 041	75	9 083	275	11 546	431	36 670	781
Industrial minerals								
Potash	1 411	9	67	2	1 361	37	2 839	48
Stone	–	–	2 147	22	239	2	2 386	24
Asbestos	174	–	676	11	1 222	45	2 072	56
Sand and gravel	–	–	1 442	32	361	1	1 803	33
Miscellaneous nonmetals[3]	475	3	300	2	888	29	1 663	34
Peat	–	–	618	20	695	22	1 313	42
Gypsum	179	–	405	–	78	1	662	1
Total	2 239	12	5 655	89	4 844	137	12 738	238
Mining total[4]	18 280	87	14 738	364	16 390	568	49 408	1 019

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes copper–zinc and nickel–copper mines. [2] Includes molybdenum mines. [3] Includes salt mines. [4] Coal no longer included. Beginning in 1986, the count of employees for coal, broken down by surface, underground and mill workers by sex, is no longer available.
– Nil.

TABLE 49. CANADA, LABOUR COSTS FOR METAL MINES IN RELATION TO TONNES MINED, 1987-89

	Number of Wage Earners	Total Wages	Average Annual Wage	Tonnage of Ore Mined	Average Annual Tonnes Mined per Wage Earner	Wage Cost per Tonne Mined
		($000)	($)	(kilotonnes)		($)
1987						
Uranium	3 591	152 184	42 379	6 383	1 778	23.84
Gold	5 381	218 960	40 691	15 326	2 848	14.29
Silver–lead–zinc	1 934	76 664	39 640	15 147	7 832	5.06
Nickel–copper–zinc[1]	10 703	397 886	37 175	130 452	12 188	3.05
Miscellaneous metals[2]	507	15 970	31 499	11 787	23 248	1.35
Iron ore	1 188	48 729	41 018	87 077	73 297	0.56
Total	23 304	910 393	39 066	266 172	11 422	3.42
1988						
Uranium	3 476	159 469	45 877	6 337	1 823	25.16
Gold	7 021	303 270	43 195	18 746	2 670	16.18
Silver–lead–zinc	1 954	83 297	42 629	12 758	6 529	6.53
Nickel–copper–zinc[1]	10 395	444 952	42 804	127 119	12 229	3.50
Miscellaneous metals[2]	530	17 595	33 198	47 747	27 824	1.19
Iron ore	1 229	56 953	46 341	102 392	83 313	0.56
Total	24 605	1 065 535	43 306	282 098	11 465	3.78
1989						
Uranium	3 128	149 763	47 878	6 405	2 048	23.38
Gold	7 446	356 905	47 933	20 335	2 731	17.55
Silver–lead–zinc	2 152	93 697	43 539	12 784	5 941	7.33
Nickel–copper–zinc[1]	10 934	491 909	44 989	126 169	11 539	3.90
Miscellaneous metals[2]	597	25 599	42 879	18 135	30 377	1.41
Iron ore	1 217	62 907	51 690	99 962	82 138	0.63
Total	25 474	1 180 780	46 352	283 790	11 140	4.16

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes copper–zinc and nickel–copper mines. [2] Includes molybdenum mines.

TABLE 50. CANADA, PERSON-HOURS PAID FOR PRODUCTION AND RELATED WORKERS, AND TONNES OF ORE MINED AND ROCK QUARRIED IN METAL MINES AND OTHER MINERAL OPERATIONS, 1983-89

	Unit	1983	1984	1985	1986	1987	1988	1989
Metal mines[1]								
Ore mined	Mt	219.0	246.4	245.0	256.3	266.2	282.1	283.8
Person–hours paid[2]	million	71.8	78.2	77.1	73.6	74.9	79.1	81.8
Person–hours paid per tonne mined	number	0.33	0.32	0.31	0.29	0.28	0.28	0.29
Tonnes mined per person–hour paid	t	3.05	3.15	3.18	3.48	3.55	3.57	3.47
Other mineral operations[3]								
Ore mined and rock quarried	Mt	101.6	132.3	138.2	127.4	134.7r	152.5r	147.7
Person–hours paid[2]	million	32.2	34.0	31.3	28.9	29.9	30.4	32.1
Person–hours paid per tonne mined	number	0.32	0.26	0.23	0.23	0.22r	0.20r	0.22
Tonnes mined per person–hour paid	t	3.16	3.89	4.42	4.41	4.50r	5.01r	4.60

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Excludes placer mining. [2] Person–hours paid for production and related workers only. [3] Includes asbestos, potash, gypsum and coal.
r Revised.

TABLE 51. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED (INCLUDING OVERTIME) FOR HOURLY-RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1985-90

	1985	1986	1987	1988	1989	1990
Mining						
Average hours per week	39.6	39.7	40.0	40.7	39.9	40.2
Average weekly wage ($)r	620.84	630.11	644.52	694.57	733.41	767.89
Metals						
Average hours per week	39.1	39.6	39.6	39.9	39.7	40.3
Average weekly wage ($)	639.89	657.62	678.84	739.20	793.06	842.18
Mineral fuels						
Average hours per week	40.8	40.9	41.6	42.1	41.5	41.9
Average weekly wage ($)	716.79	711.40	729.26	774.72	831.14	881.69
Nonmetals						
Average hours per week	39.2	39.6	39.7	39.7	39.7	39.5
Average weekly wage ($)	554.88	581.84	595.98	623.08	653.47	677.11
Manufacturing						
Average hours per week	38.8	38.8	38.8	38.8	38.6	38.2
Average weekly wage ($)r	449.99	462.93	474.40	498.14	522.81	546.09
Construction						
Average hours per week	37.8	37.9	38.4	38.5	38.2	38.3
Average weekly wage ($)r	525.30	530.98	560.43	578.01	614.43	655.16

Source: Statistics Canada.

r Revised.

Note: The average weekly wages for Mining, Manufacturing and Construction have been revised for the years 1985-89. On previous tables, these data reflected average weekly wages for "all employees" rather than "hourly-rated employees."

TABLE 52. CANADA, AVERAGE WEEKLY WAGES (INCLUDING OVERTIME) OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1986 DOLLARS,[1] 1985-90

	1985	1986	1987	1988	1989	1990
Current dollars						
All mining	620.84[r]	630.11[r]	644.82[r]	694.57[r]	733.41[r]	767.89
Metals	639.89	657.62	678.84	739.20	793.06	842.18
Mineral fuels	716.79	711.40	729.26	774.72	831.14	881.69
Coal	697.30	718.82	729.54	766.60	806.24	840.39
Industrial minerals	554.88	581.84	595.98	623.08	653.47	677.11
1986 dollars (CPI)[1]						
All mining	646.71[r]	630.11[r]	617.64[r]	639.57[r]	643.35[r]	642.59
Metals	666.55	657.62	650.23	680.66	695.67	704.75
Mineral fuels	746.66	711.40	698.52	713.37	729.07	737.82
Coal	726.35	718.82	698.79	705.89	707.23	703.26
Industrial minerals	578.00	581.84	570.86	573.74	573.22	566.62

Source: Statistics Canada.
[1] Consumer Price Index – all items.
[r] Revised.

TABLE 53. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS BY INDUSTRY GROUP,[1] 1987-89

	Fatalities[2]			Number of Workers			Rate per 1000 Workers		
	1987	1988	1989p	1987	1988	1989p	1987	1988	1989p
		(number)			(000)				
Agriculture	12	9	11	179	164	381	0.07	0.05	0.03
Forestry	61	62	57	62	65	66	0.98	0.95	0.86
Fishing[3]	24	12	8	15	18	30	1.60	0.67	0.27
Mining[4]	116	85	58	181	185	165	0.64	0.46	0.35
Manufacturing[5]	118	124	71	2 017	2 097	2 069	0.06	0.06	0.03
Construction	120	125	109	565	613	751	0.21	0.20	0.15
Transportation[6]	117	108	101	848	860	947	0.14	0.13	0.11
Trade	45	42	35	1 928	1 997	2 231	0.02	0.02	0.02
Finance[7]	5	9	4	661	691	738	0.01	0.01	0.01
Service[8]	41	48	44	3 501	3 631	4 212	0.01	0.01	0.01
Public administration[9]	38	40	30	814	820	790	0.05	0.05	0.04
Unknown	10	7	10	..	..	..	..	..	..
Total	707	671	538	10 771	11 141	12 380	0.07	0.06	0.04

Source: Labour Canada.

1 Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. 2 Excludes the Province of Quebec for which data are unavailable. 3 Includes trapping and hunting. 4 Includes quarrying and oil wells. 5 Includes deaths of workers who were on pension for an earlier disabling injury. 6 Includes storage, communication, electric power and water utilities, and highway maintenance. 7 Includes insurance and real estate. 8 Includes community, business and personal services. 9 Includes defence.

p Preliminary; .. Not available.

Note: 1990 data not available at time of publication.

TABLE 54. CANADA, RATE OF INDUSTRIAL FATALITIES[1] PER THOUSAND WORKERS BY INDUSTRY GROUP,[2] 1983-89

	1983	1984	1985	1986	1987	1988	1989[p]
Agriculture	0.13	0.13	0.12	0.05	0.07	0.05	0.03
Forestry	0.97	0.88	1.08	0.90	0.98	0.95	0.86
Fishing[3]	1.07	1.93	2.17	1.00	1.60	0.67	0.27
Mining[4]	0.63	0.57	0.69	0.59	0.64	0.46	0.35
Manufacturing[5]	0.08	0.07	0.07	0.06	0.06	0.06	0.03
Construction	0.25	0.31	0.28	0.27	0.21	0.20	0.15
Transportation[6]	0.17	0.15	0.16	0.14	0.14	0.13	0.11
Trade	0.03	0.03	0.04	0.03	0.02	0.02	0.02
Finance[7]	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Service[8]	0.03	0.02	0.02	0.01	0.01	0.01	0.01
Public administration[9]	0.07	0.08	0.07	0.07	0.05	0.05	0.04
Total	0.08	0.08	0.09	0.07	0.07	0.06	0.04

Source: Labour Canada.

[1] Excludes the Province of Quebec for which data are unavailable. [2] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes deaths of workers who were on pension for an earlier disabling injury. [6] Includes storage, communication, electric power and water utilities and highway maintenance. [7] Includes insurance and real estate. [8] Includes community, business and personal services. [9] Includes defence.

[p] Preliminary.

Note: 1990 data not available at time of publication.

TABLE 55. CANADA, INDUSTRIAL FATALITIES[1] BY OCCUPATIONAL INJURIES AND ILLNESSES,[2] 1987-89

	Occupational Injuries			Occupational Illnesses			Total		
	1987	1988	1989p	1987	1988	1989p	1987	1988	1989p
Agriculture	12	9	11	–	–	–	12	9	11
Forestry	61	61	56	–	1	1	61	62	57
Fishing[3]	24	12	8	–	–	–	24	12	8
Mining[4]	64	46	35	52	39	23	116	85	58
Manufacturing[5]	73	91	58	45	33	13	118	124	71
Construction	101	96	86	19	29	23	120	125	109
Transportation[6]	112	102	94	5	6	7	117	108	101
Trade	42	36	31	3	6	4	45	42	35
Finance[7]	5	7	4	–	2	–	5	9	4
Service[8]	39	46	41	2	2	3	41	48	44
Public administration[9]	31	35	26	7	5	4	38	40	30
Unknown	7	5	5	3	2	5	10	7	10
Total	571	546	455	136	125	83	707	671	538

Source: Labour Canada.
[1] Excludes the Province of Quebec for which data are unavailable. [2] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes deaths of workers who were on pension for an earlier disabling injury. [6] Includes storage, communication, electric power and water utilities, and highway maintenance. [7] Includes insurance and real estate. [8] Includes community, business and personal services. [9] Includes defence.
p Preliminary; – Nil.
Note: 1990 data not available at time of publication.

TABLE 56. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRY, 1988-90

	1988			1989			1990p		
	Strikes and Lockouts	Workers Involved	Duration in Person-Days	Strikes and Lockouts	Workers Involved	Duration in Person-Days	Strikes and Lockouts	Workers Involved	Duration in Person-Days
Agriculture	1	18	4 610	1	107	2 030	–	–	–
Forestry	4	963	19 520	2	410	53 170	1	50	810
Fishing and trapping	–	–	–	3	3 897	35 650	–	–	–
Mines	13	4 229	134 410	17	7 106	186 740	15	7 381	396 510
Manufacturing	257r	50 543r	1 310 601r	245	42 194	1 165 970	237	66 591	2 442 990
Construction	22r	34 656r	645 030r	33	32 661	133 950	25	123 767	1 149 890
Transportation and utilities	47	38 338	1 996 840	69	29 710	518 070	50	23 194	420 320
Trade	80	4 178	175 780	71	4 459	202 910	73	3 907	155 630
Finance, insurance and real estate	9	462	23 780	12	463	4 040	15	867	19 700
Service	93	38 361	425 118	138	271 802	1 176 970	127	37 438	459 080
Public administration	22	35 039	169 620	37	51 727	243 810	37	7 313	68 030
Various industries	–	–	–	–	–	–	–	–	–
All industries	548	206 787	4 905 309	628	444 536	3 723 310	580	270 508	5 112 960

Source: Labour Canada.
p Preliminary; r Revised; – Nil.

TABLE 57. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING INDUSTRIES, 1988-90

	1988			1989			1990p		
	Strikes and Lockouts	Workers Involved	Duration in Person-Days	Strikes and Lockouts	Workers Involved	Duration in Person-Days	Strikes and Lockouts	Workers Involved	Duration in Person-Days
Mines	13	4 229	134 410	17	7 106	186 740	15	7 381	396 510
Metals	8	3 488	93 430	7	2 978	113 510	11	4 393	292 270
Mineral fuels	–	–	–	4	3 261	36 320	2	2 313	59 810
Nonmetals	3	691	40 460	5	832	36 100	2	675	44 430
Quarries	2	50	520	1	35	810	–	–	–
Mineral manufacturing	27r	7 981r	198 200r	32	3 202	150 660	44	25 372	1 334 450
Primary metals	15	6 178	157 990	5	994	96 130	24	23 426	1 296 580
Nonmetallic mineral products	12r	1 803r	40 210r	23	1 737	49 740	19	1 656	29 790
Petroleum and coal products	–	–	–	4	471	4 790	1	290	8 080

Source: Labour Canada.
p Preliminary; r Revised; – Nil.

TABLE 58. CANADA, MINING WAGES AND SALARIES BY CLASS, 1988 AND 1989

	1988					1989				
	Metals	Nonmetals	Mineral Fuels	Quarries and Sand Pits	Total	Metals	Nonmetals	Mineral Fuels	Quarries and Sand Pits	Total
			($000)					($000)		
Newfoundland	116 080	14 791	–	1 291	132 162	130 439	16 317	–	1 215	147 971
Prince Edward Island	–	–	–	–	–	–	–	–	–	–
Nova Scotia	10 522	22 615	82 194	6 414	121 745	x	x	89 699	6 929	129 476
New Brunswick	62 211	x	6 869	x	112 568	x	x	7 161	x	131 102
Quebec	421 748	104 512	–	57 800	584 060	462 191	116 306	–	64 554	643 051
Ontario	870 317	68 050	8 007[r]	105 544	1 051 918[r]	969 112	63 368	7 026	100 962	1 140 468
Manitoba	157 651	4 521	4 080[r]	6 208	172 460[r]	176 040	4 597	3 030	6 097	189 764
Saskatchewan	54 718	136 404	x	x	254 451[r]	52 968	133 566	x	x	253 603
Alberta	630	x	x	8 858	1 696 836[r]	x	x	x	7 713	1 806 516
British Columbia	278 737	18 410	275 183[r]	12 440	584 770[r]	296 440	18 608	304 655	14 059	633 762
Yukon and Northwest Territories	128 430	–	21 412[r]	–	149 842[r]	133 252	–	38 530	–	171 782
Offshore	–	–	4 189[r]	–	4 189[r]	–	–	4 402	–	4 402
Total	2 101 043	415 695	2 145 199[r]	203 066	4 865 003[r]	2 307 891	425 783	2 311 697	206 525	5 251 896
Services incidental to mining[1]					1 227 695					1 107 203
Grand total					6 092 698[r]					6 359 099

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes establishments primarily engaged in providing contract drilling and other services to petroleum and natural gas industries.
x Confidential; – Nil; [r] Revised.

TABLE 59. CANADA, SOURCE OF ORES HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1987-89

Mines	1987 Underground	1987 Open-Pit	1987 Total	1988 Underground	1988 Open-Pit	1988 Total	1989 Underground	1989 Open-Pit	1989 Total
					(kilotonnes)				
Nickel-copper-zinc	28 040	102 412	130 452	26 177	100 942	127 119	27 070	99 099	126 169
Iron ore	1 434	85 644	87 077	1 346	101 045	102 392	1 310	98 652	99 962
Coal	4 206	73 245	77 452	5 286	83 970	89 256	4 015	83 668	87 683
Potash	34 875	–	34 875	38 965	–	38 965	34 494	–	34 494
Gold	11 593	3 733	15 326	13 768	4 977	18 746	16 795	3 540	20 335
Silver-lead-zinc	7 321	7 826	15 147	8 297	4 461	12 758	7 736	5 049	12 785
Asbestos	1 089	12 437	13 526	288	15 085	15 373	1 390	15 757	17 147
Gypsum	1 435	8 004	9 439	1 597[r]	7 607[r]	9 204[r]	1 572	7 927	9 499
Rock salt	7 091	–	7 091	7 960	–	7 960	8 560	–	8 560
Miscellaneous metals	909	10 878	11 787	1 006	13 741	14 747	1 187	16 948	18 135
Uranium	5 716	667	6 383	5 791	546	6 337	5 797	607	6 404
Miscellaneous nonmetals	192	3 372	3 564	233	1 504	1 737	401	1 584	1 985
Total	103 902	308 217	412 119	110 715[r]	333 877[r]	444 592[r]	110 327	332 831	443 159
Percentage	25.2	74.8	100.0	24.9	75.1	100.0	24.9	75.1	100.0

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available.
Note: Totals may not add due to rounding.

TABLE 60. CANADA, SOURCE OF MATERIAL HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1989

	Underground		Open-Pit			
	Ore	Waste	Ore	Waste	Over-burden	Tailings
	(kilotonnes)					
Nickel-copper-zinc	27 070	5 133	99 099	98 015	3 390	118 280
Iron ore	1 310	2	98 652	30 272	11 446	58 364
Coal	4 015	. .	83 668	. .	. .	. .
Potash	34 494	43	. .	. .	. .	22 491
Gold	16 795	2 731	3 540	17 246	352 352	20 684
Silver-lead-zinc	7 736	128	5 049	2 733	108	10 827
Asbestos	1 390	–	15 757	32 997	1 362	8 549
Gypsum	1 572	92	7 927	2 283	3 312	595
Rock salt	8 560	26	–	–	–	1 514
Miscellaneous metals	1 187	5	16 948	9 787	133	13 635
Uranium	5 797	320	607	6 839	1 460	6 390
Miscellaneous nonmetals	401	33	1 584	1 084	798	589
Total	110 327	8 513	332 831	201 256	374 361	261 918

Sources: Energy, Mines and Resources Canada; Statistics Canada.
– Nil; . . Not available.
Note: Totals may not add due to rounding.

TABLE 61. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1983-89

	1983	1984	1985	1986	1987	1988	1989
				(kilotonnes)			
Metals							
Nickel-copper-zinc	116 532	124 682	117 169	126 298	130 452	127 119	126 169
Iron	74 597	89 210	94 587	88 231	87 077	102 392	99 962
Gold	9 553	11 225	11 997	14 072	15 326	18 746	20 335
Silver-lead-zinc	9 157	10 084	9 970	12 083	15 147	12 758	12 784
Miscellaneous metals	2 133	3 627	4 067	8 361	11 787	14 747	18 135
Uranium	7 073	7 608	7 182	6 933	6 383	6 337	6 404
Total	219 045	246 436	244 972	255 978	266 172	282 098	283 790
Nonmetals							
Potash	24 222	36 542	34 843	33 563	34 875	38 965	34 494
Asbestos	15 035	15 726	17 118	11 808	13 526	15 373	17 147
Gypsum	7 540	8 869	9 608	9 175	9 439	9 204	9 499
Rock salt	5 996	6 706	7 101	8 460	7 091	7 960	8 560
Miscellaneous nonmetals	2 922	3 825	3 036	3 397	3 564	1 737	1 985
Total	55 715	71 668	71 706	66 403	68 496	73 239	71 685
Structural materials							
Stone, all kinds quarried[1]	67 651	81 754	86 632	112 693	128 969	135 010	135 395
Stone used to make cement	10 154	10 101	8 467	11 535	12 543[r]	12 539	13 899
Stone used to make lime	3 446	4 260	5 137	3 556	3 134[r]	2 346	2 162
Total	81 251	96 115	100 236	127 784	144 646	149 895	151 456
Fuels							
Coal	54 817	71 207	76 667	72 736	77 452	89 256	87 683
Total ore mined and rock quarried	410 828	485 426	493 581	522 901	556 765	594 487	594 615

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Excludes stone used to manufacture cement and lime in Canada.
[r] Revised.
Note: Totals may not add due to rounding.

TABLE 62. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1] BY PROVINCE AND TERRITORY, 1989-91

		Capital						Repair			
		Construction									
		On-Property Exploration	On-Property Development	Structures	Sub-Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair
		($ million)									
Newfoundland	1989	x	41.6	x	68.0	30.6	98.6	10.5	133.4	143.9	242.5
	1990p	x	34.1	x	44.1	47.4	91.5	8.9	151.5	160.4	251.9
	1991i	x	45.7	x	50.2	70.6	120.8	9.3	157.3	166.6	287.4
Prince Edward Island	1989	–	–	–	–	–	–	–	–	–	–
	1990p	–	–	–	–	–	–	–	–	–	–
	1991i	–	–	–	–	–	–	–	–	–	–
Nova Scotia	1989	x	18.3	x	22.1	32.3	54.4	3.5	37.3	40.8	95.2
	1990p	x	22.5	x	31.3	39.1	70.4	3.0	38.6	41.6	112.0
	1991i	x	30.2	x	55.1	73.1	128.2	3.2	40.5	43.7	171.9
New Brunswick	1989	1.4	16.1	13.4	30.9	72.1	103.0	9.0	79.5	88.5	191.5
	1990p	1.1	33.0	16.9	51.0	29.5	80.5	9.1	74.3	83.4	163.9
	1991i	x	x	x	45.3	33.1	78.4	11.9	91.4	103.3	181.7
Quebec	1989	34.4	256.3	74.2	364.9	152.0	516.9	27.4	233.3	260.7	777.6
	1990p	25.2	205.4	20.3	250.9	129.5	380.4	41.3	264.6	305.9	686.3
	1991i	17.7	196.5	51.4	265.6	114.8	380.4r	38.4	268.5	306.9	687.3
Ontario	1989	42.9	335.5	132.0	510.4	236.4	746.8	65.1	428.9	494.0	1 240.8
	1990p	21.6	274.8	71.8	368.2	211.1	579.3	69.0	427.3	496.3	1 075.6
	1991i	26.8	231.2	41.6	299.6	201.9	501.5	54.9	403.6	458.5	960.0
Manitoba	1989	7.9	53.9	23.9	85.7	34.1	119.8	16.0	60.2	76.2	196.0
	1990p	x	x	x	125.5	39.1	164.6	2.5	49.7	52.2	216.8
	1991i	x	x	x	80.0	23.7	103.7	3.3	50.7	54.0	157.7
Saskatchewan	1989	6.5	71.4	41.1	119.0	50.8	169.8	8.9	122.0	130.9	300.7
	1990p	11.3	90.2	33.6	135.1	43.9	179.0	14.0	165.6	179.6	358.6
	1991i	17.1	113.2	17.4	147.7	59.9	207.6	15.6	170.0	185.6	393.2
Alberta	1989	x	x	2.9	17.3	23.0	40.3	1.3	133.1	134.4	174.7
	1990p	2.9	27.0	4.9	34.8	60.9	95.7	2.3	152.0	154.3	250.0
	1991i	3.2	20.8	3.2	27.2	49.0	76.2	3.7	150.1	153.8	230.0
British Columbia	1989	13.9	292.1	92.7	398.7	150.7	549.4	39.7	444.3	484.0	1 033.4
	1990p	12.5	263.5	39.5	315.5	121.9	437.4	23.3	432.1	455.4	892.8
	1991i	5.7	248.4	27.6	281.7	127.3	409.0	24.8	426.1	450.9	859.9

Yukon	1989	1.8	x	x	18.2	0.9	19.1	6.6	28.4	35.0	54.1
	1990p	x	x	x	34.5	22.5	57.0	2.3	14.2	16.5	73.5
	1991i	x	34.4	x	40.4	31.3	71.7	1.3	9.0	10.3	82.0
Northwest Territories	1989	5.8	45.7	86.6	138.1	65.8	203.9	5.8	44.2	50.0	253.9
	1990p	x	102.5	x	110.3	12.2	122.5	2.0	36.6	38.6	161.1
	1991i	xr	33.7	x	40.1	9.6	49.7	2.9	36.7	39.6	89.3
Canada	1989	117.5	1 157.6	498.6	1 773.7	848.7	2 622.4	193.6	1 744.7	1 938.3	4 560.7
	1990p	92.6	1 182.9	225.4	1 500.9	757.0	2 257.9	177.7	1 806.6	1 984.3	4 242.2
	1991i	87.6	1 047.2	198.0	1 332.8	794.4	2 127.2	169.4	1 803.8	1 973.2	4 100.4

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

1 Excludes crude oil and natural gas industries.

p Preliminary; i Intentions; – Nil; x Confidential, included in total; r Revised.

Note: Totals may not add due to rounding.

TABLE 63. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1] BY TYPE OF MINING, 1989-91

		Capital						Repair			
		Construction									
		On-Property Exploration	On-Property Development	Structures	Sub-Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair
		($ million)									
Metal mines											
Copper-gold-silver	1989	22.8	85.6	83.7	192.1	102.3	294.4	27.6	253.3	280.9	575.3
	1990p	22.6	139.9	41.5	204.0	99.4	303.4	25.4	273.3	298.7	602.1
	1991i	14.0	109.9	36.2	160.1	81.5	241.6	24.7	272.1	296.8	538.4
Gold	1989	53.2	361.6	248.8	663.6	184.4	848.0	39.4	187.6	227.0	1 075.0
	1990p	32.5	289.3	61.2	383.0	93.2	476.2	31.5	180.0	211.5	687.7
	1991i	31.8	186.8	49.5	268.1	96.0	364.1	31.2	181.4	212.6	576.7
Iron	1989	x	x	x	73.3	62.8	136.1	16.0	227.8	243.8	379.9
	1990p	x	x	x	101.7	92.7	194.4	15.3	225.6	240.9	435.3
	1991i	x	x	x	117.0	127.3	244.3	14.5	230.9	245.4	489.7
Silver-lead-zinc	1989	9.0	53.3	23.2	85.5	79.6	165.1	20.4	112.7	133.1	298.2
	1990p	10.7	71.7	21.5	103.9	41.3	145.2	13.0	74.6	87.6	232.8
	1991i	7.6	73.9	25.1	106.6	60.0	166.6	14.5	94.2	108.7	275.3
Uranium	1989	x	x	13.8	94.6	10.9	105.5	8.3	122.0	130.3	235.8
	1990p	x	x	x	81.2	17.9	99.1	7.6	121.0	128.6	227.7
	1991i	x	x	x	69.5	18.5	88.0	8.8	106.4	115.2	203.2
Other metal mining[2]	1989	19.8	175.2	52.2	247.2	138.7	385.9	41.1	158.8	199.9	585.8
	1990p	13.4	182.2	36.5	232.1	135.3	367.4	48.1	178.1	226.2	593.6
	1991i	x	178.5	x	211.6	122.2	333.8	34.5	160.7	195.2	529.0
Total metal mining	1989	108.5	822.6	425.2	1 356.3	578.7	1 935.0	152.9	1 062.2	1 215.1	3 150.1
	1990p	81.4	838.2	186.2	1 105.8	479.7	1 585.5	140.9	1 052.5	1 193.4	2 778.9
	1991i	68.6	712.2	152.3	933.1	505.5	1 438.6	128.2	1 045.7	1 173.9	2 612.5
Nonmetal mines											
Asbestos	1989	x	70.3	x	75.5	2.0	77.5	1.9	36.5	38.4	115.9
	1990p	x	49.6	x	51.1	5.7	56.8	4.9	51.0	55.9	112.7
	1991i	x	x	1.7	21.9	4.2	26.1	4.8	46.0	50.8	76.9

Coal	1989	3.1	181.5	19.5	204.1	97.9	302.0	22.4	390.7	413.1	715.1
	1990[p]	3.2	198.0	10.4	211.6	126.4	338.0	16.8	461.0	477.8	815.8
	1991[i]	4.1	238.6	29.8	272.5	158.9	431.4	18.5	467.1	485.6	917.0
Other nonmetal mining[3]	1989	x	83.3	x	137.9	170.1	308.0	16.4	255.3	271.7	579.7
	1990[p]	x	97.1	x	132.5	145.2	277.7	15.2	242.1	257.3	535.0
	1991[i]	x	x	14.2	105.4	125.7	231.1	17.9	245.0	262.9	494.0
Total nonmetal mining	1989	9.0	335.0	73.4	417.4	270.0	687.4	40.7	682.4	723.1	1 410.5
	1990[p]	11.2	344.7	39.2	395.1	277.3	672.4	36.8	754.1	790.9	1 463.3
	1991[i]	19.1	335.1	45.7	399.9	288.9	688.8	41.2	758.1	799.3	1 488.1
Total mining	1989	117.5	1 157.6	498.6	1 773.7	848.7	2 622.4	193.6	1 744.7	1 938.3	4 560.7
	1990[p]	92.6	1 182.9	225.4	1 500.9	757.0	2 257.9	177.7	1 806.6	1 984.3	4 242.2
	1991[i]	87.6	1 047.2	198.0	1 332.8	794.4	2 127.2	169.4	1 803.8	1 973.2	4 100.4

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

[1] Excludes expenditures in the petroleum and natural gas industries. [2] Includes nickel-copper mines, silver-cobalt mines and other metal mines. [3] Includes gypsum mines, salt mines, potash mines, quarries, sand and gravel pits and other nonmetal mines.

[p] Preliminary; [i] Intentions; .. Not available; x Confidential, included in total.

Note: Totals may not add due to rounding.

TABLE 64. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRACTORS, 1987-89

		1987			1988			1989		
		Exploration	Other	Total	Exploration	Other	Total	Exploration	Other	Total
						(metres)				
Metal mines										
Gold	Own equipment	36 101	49 276	85 377	39 604	23 941	63 545	70 359	35 936	106 295
	Contractors	565 311	–	565 311	672 825	–	672 825	735 297	123 330	858 627
	Total	601 412	49 276	650 688	712 429	23 941	736 370	805 656	159 266	964 922
Iron	Own equipment	15 000	226 782	241 782	10 038	365 123	375 161	241 854	–	241 854
	Contractors	6 771	–	6 771	–	–	–	309 652	–	309 652
	Total	21 771	226 782	248 553	10 038	365 123	375 161	551 506	–	551 506
Nickel-copper-zinc	Own equipment	154 123	–	154 123	127 441	–	127 441	6 886	377 764	384 650
	Contractors	349 386	–	349 386	233 841	9 000	242 841	25 920	–	25 920
	Total	503 509	–	503 509	361 282	9 000	370 082	32 806	377 764	410 570
Silver-lead-zinc	Own equipment	54 667	–	54 667	60 858	–	60 858	51 287	–	51 287
	Contractors	70 624	–	70 624	72 280	–	72 280	47 866	–	47 866
	Total	125 291	–	125 291	133 138	–	133 138	99 153	–	99 153
Uranium	Own equipment	30 619	49 485	80 104	34 175	–	34 175	32 379	–	32 379
	Contractors	11 718	–	11 718	10 250	–	10 250	31 507	–	31 507
	Total	42 337	49 485	91 822	44 425	–	44 425	63 886	–	63 886
Miscellaneous metal mining	Own equipment	–	–	–	–	–	–	–	–	–
	Contractors	18 636	–	18 636	13 878	–	13 878	31 906	–	31 906
	Total	18 636	–	18 636	13 878	–	13 878	31 906	–	31 906
Total metal mining	Own equipment	290 510	325 543	616 053	272 116	389 064	661 180	402 765	413 700	816 465
	Contractors	1 022 446	–	1 022 446	1 003 074	9 000	1 012 074	1 182 148	123 330	1 305 478
	Total	1 312 956	325 543	1 638 499	1 275 190	398 064	1 673 254	1 584 913	537 030	2 121 943
Nonmetal mines										
Gypsum	Own equipment	–	–	–	–	–	–	–	–	–
	Contractors	–	2 438	2 438	4 145	3 444	7 589	–	1 778	1 778
	Total	–	2 438	2 438	4 145	3 444	7 589	–	1 778	1 778
Other nonmetal mines	Own equipment	–	–	–	–	–	–	–	–	–
	Contractors	2 154	–	2 154	2 300	–	2 300	7 064	–	7 064
	Total	2 154	–	2 154	2 300	–	2 300	7 064	–	7 064
Asbestos	Own equipment	–	–	–	–	–	–	–	–	–
	Contractors	1 864	–	1 864	2 289	–	2 289	9 508	–	9 508
	Total	1 864	–	1 864	2 289	–	2 289	9 508	–	9 508
Potash	Own equipment	18 100	–	18 100	–	–	–	10 674	–	10 674
	Contractors	3 437	–	3 437	–	–	–	1 065	–	1 065
	Total	21 537	–	21 537	–	–	–	11 739	–	11 739
Total nonmetal mining	Own equipment	18 100	–	18 100	–	–	–	10 674	–	10 674
	Contractors	7 455	2 438	9 893	8 734	3 444	12 178	17 637	1 778	19 415
	Total	25 555	2 438	27 993	8 734	3 444	12 178	28 311	1 778	30 089
Total mining industry	Own equipment	308 610	325 543	634 153	272 116	389 064	661 180	413 439	413 700	827 139
	Contractors	1 029 901	2 438	1 032 339	1 011 808	12 444	1 024 252	1 199 785	125 108	1 324 893
	Total	1 338 511	327 981	1 666 492	1 283 924	401 508	1 685 432	1 613 224	538 808	2 152 032

Sources: Energy, Mines and Resources Canada; Statistics Canada, Catalogue Nos. 26-223 and 26-224.
– Nil.
Note: Totals may not add due to rounding.

TABLE 65. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1959-89

	Metals	Industrial[1]	Coal	Total
		(million tonnes)		
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	. .	162.1
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	274.9	162.6	. .	437.4
1974	278.7	178.8	. .	457.5
1975	264.2	158.7	. .	422.9
1976	296.5	167.1	. .	463.6
1977	299.5	205.2	33.8	538.5
1978	248.1	205.5	36.3	489.9
1979	274.8	200.1	39.8	514.6
1980	290.1	193.5	43.9	527.5
1981	301.5	172.5	48.2	522.2
1982	238.4	121.2	53.0	412.5
1983	219.0	137.0	54.8	410.8
1984	246.4	167.8	71.2	485.4
1985	245.0	171.9	76.7	493.6
1986	256.0	194.2	72.7	522.9
1987	266.2	213.1	77.5	556.8
1988	282.1	223.1[r]	89.3	594.5[r]
1989	283.8	223.1	87.7	594.6

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. From 1979 onwards, coverage includes miscellaneous nonmetal mines previously excluded.
[r] Revised; . . Not available.
Note: Totals may not add due to rounding.

TABLE 66. CANADA, TOTAL DIAMOND DRILLING, METAL DEPOSITS, 1959-89

	Gold Deposits	Copper-Zinc and Nickel-Copper Deposits	Silver-Lead-Zinc Deposits	Other Metal-Bearing Deposits[1]	Total Metal Deposits
			(metres)		
1959	558 160	1 110 664	282 088	383 471	2 334 383
1960	628 016	1 267 792	226 027	315 067	2 436 902
1961	595 180	1 128 091	255 101	221 079	2 199 451
1962	902 288	1 025 048	350 180	358 679	2 636 195
1963	529 958	977 257	288 204	148 703	1 944 122
1964	458 933	709 588	401 099	104 738	1 674 358
1965	440 020	779 536	331 294	275 917	1 826 767
1966	442 447	729 148	292 223	164 253	1 628 071
1967	391 347	947 955	230 182	120 350	1 689 834
1968	375 263	935 716	198 038	56 780	1 565 797
1969	274 410	923 452	197 670	109 592	1 505 124
1970	214 717	1 132 915	375 019	99 373	1 822 024
1971	193 291	1 089 103	308 798	83 851	1 675 043
1972	229 771	967 640	240 195	50 225	1 487 831
1973	243 708	713 134	185 946	57 730	1 200 518
1974	250 248	798 564	197 322	83 484	1 329 618
1975	216 158	532 991	184 203	97 971	1 031 323
1976	156 030	507 620	166 366	97 735	927 751
1977	175 643	515 780	213 279	124 329	1 029 031
1978	209 335	346 722	490 489	135 197	1 181 743
1979	198 955	437 562	131 032	150 018	917 567
1980	187 635	566 610	259 877	173 945	1 188 067
1981	306 197	675 712	478 754	170 369	1 631 032
1982	288 421	386 940	424 218	164 742	1 264 321
1983	352 218	512 745	269 659	97 661	1 232 283
1984	406 060	830 536	273 238	281 661	1 791 495
1985	429 565	475 582	152 692	286 764	1 344 603
1986	774 896	434 325	163 756	278 642	1 651 619
1987	650 688	503 509	125 291	359 011	1 638 499
1988	736 370	370 282	133 138	433 464	1 673 254
1989	964 922	551 506	99 153	506 362	2 121 943

Sources: Energy, Mines and Resources Canada; Statistics Canada, Catalogue No. 26-223.
[1] Includes iron, titanium, uranium, molybdenum and other metal deposits.

TABLE 67. CANADA, EXPLORATION DIAMOND DRILLING, METAL DEPOSITS, 1959-89

	Mining Companies with Own Personnel and Equipment	Diamond Drilling Contractors	Total
		(metres)	
1959	239 786	1 367 061	1 606 847
1960	268 381	1 409 416	1 677 797
1961	302 696	1 337 173	1 639 869
1962	167 214	1 748 023	1 915 237
1963	361 180	1 169 292	1 530 472
1964	143 013	1 072 985	1 215 998
1965	209 002	1 176 996	1 385 998
1966	163 379	1 044 860	1 208 239
1967	93 164	1 123 137	1 216 301
1968	159 341	990 690	1 150 031
1969	135 311	1 072 328	1 207 639
1970	62 147	1 228 061	1 290 208
1971	86 838	1 053 330	1 140 168
1972	251 651	839 753	1 091 404
1973	321 333	742 899	1 064 232
1974	357 823	892 557	1 250 380
1975	346 770	618 161	964 931
1976	335 919	532 036	867 955
1977	327 241	638 327	965 568
1978	237 250	534 557	771 807
1979	311 221	571 721	882 942
1980	347 829	747 566	1 095 395
1981	460 687	917 566	1 378 253
1982	289 901	713 413	1 003 314
1983	324 383	707 343	1 031 726
1984	357 680	936 459	1 294 139
1985	382 490	725 310	1 107 800
1986	347 154	915 809	1 262 963
1987	290 510	1 022 446	1 312 956
1988	272 116	1 003 074	1 275 190
1989	402 765	1 182 148	1 584 913

Sources: Energy, Mines and Resources Canada; Statistics Canada, Catalogue No. 26-223.

TABLE 68. CANADA, DIAMOND DRILLING, OTHER THAN FOR EXPLORATION, METAL DEPOSITS, 1959-89

	Mining Companies with Own Personnel and Equipment	Diamond Drilling Contractors	Total
		(metres)	
1959	488 783	238 753	727 536
1960	450 246	308 860	759 106
1961	384 432	175 149	559 581
1962	528 700	192 259	720 959
1963	388 228	25 422	413 650
1964	385 765	72 594	458 359
1965	393 947	46 822	440 769
1966	227 968	191 863	419 831
1967	186 463	287 071	473 534
1968	122 851	292 914	415 765
1969	87 552	209 933	297 485
1970	290 363	241 453	531 816
1971	295 966	238 910	534 876
1972	304 523	91 903	396 426
1973	77 162	59 124	136 286
1974	54 353	24 885	79 238
1975	31 917	34 475	66 392
1976	31 413	28 383	59 796
1977	24 303	39 160	63 463
1978	351 344	58 592	409 936
1979	4 090	30 535	34 625
1980	20 545	72 127	92 672
1981	200 898	51 881	252 779
1982	188 674	72 333	261 007
1983	81 138	119 419	200 557
1984	492 939	4 417	497 356
1985	230 501	6 302	236 803
1986	378 823	9 833	388 656
1987	325 543	–	325 543
1988	389 064	9 000	398 064
1989	413 700	123 330	537 030

Sources: Energy, Mines and Resources Canada; Statistics Canada, Catalogue No. 26-223.
– Nil.
Note: Non-producing companies excluded since 1964.

TABLE 69. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1987-89

	1987	1988	1989
		(kilotonnes)	
Metallic minerals			
Iron ores and concentrates	36 093	39 835	41 594
Nickel-copper ores and concentrates	3 797	3 742	2 961
Alumina and bauxite	3 363	3 224	3 841
Zinc ores and concentrates	1 380	1 554	1 231
Copper ores and concentrates	1 356	1 185	955
Lead ores and concentrates	514	590	465
Metallic ores and concentrates, n.e.s.	4	63	80
Nickel ores and concentrates	–	–	–
Total metallic minerals	46 509	50 193	51 127
Nonmetallic minerals			
Potash (KCl)	11 577	12 337	10 559
Sulphur, n.e.s.	5 731	6 559	4 227
Gypsum	5 636	5 418	5 621
Limestone, n.e.s.	3 301	3 008	2 939
Phosphate rock	1 162	1 236	1 275
Clay	750	1 025	786
Sulphur, liquid	970	1 002	1 016
Sand, industrial	948	985	854
Salt, rock	687	688	828
Sodium carbonate	663	659	631
Limestone, industrial	386	396	368
Nepheline syenite	252	302	321
Sodium sulphate	319	297	291
Nonmetallic minerals, n.e.s.	142	170	270
Salt, n.e.s.	146	161	137
Limestone, agricultural	93	122	55
Stone, n.e.s.	196	107	94
Silica	21	23	19
Abrasives, natural	21	21	27
Sand, n.e.s.	47	17	4
Barite	12	9	11
Asbestos	11	5	3
Peat and other mosses	2	1	2
Total nonmetallic minerals	33 072	34 550	30 338
Mineral fuels			
Coal, bituminous	39 051	47 117	38 856
Coal, lignite	2 549	2 976	1 856
Natural gas and other crude bituminous substances	43	34	87
Coal, n.e.s.	949	24	2
Oil, crude	7	12	12
Total mineral fuels	42 599	50 163	40 813
Total crude minerals	122 180	134 906	122 278
Total revenue freight[1] moved by Canadian railways	261 406	269 354	247 041
Crude minerals as a percentage of total revenue freight	46.7	50.1	49.5

Source: Statistics Canada.
[1] Revenue freight refers to a local or interline shipment from which earnings accrue to a carrier.
n.e.s. Not elsewhere specified; – Nil.

TABLE 70. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1987-89

	1987	1988	1989
		(kilotonnes)	
Metallic minerals			
Ferrous mineral products			
Iron and steel scrap	1 982	2 068	2 254
Sheets and strips, steel	1 140	1 191	1 196
Ingots, blooms, billets, slabs of iron and steel	659	674	818
Bars and rods, steel	648	593	654
Structural shapes and sheet piling, iron and steel	451	476	453
Plates, steel	311	311	260
Pipes and tubes, iron and steel	177	275	459
Rails and railway track material	70	91	191
Castings and forgings, iron and steel	67	83	62
Pig iron	68	36	55
Ferroalloys	37	27	20
Other primary iron and steel	23	9	10
Wire, iron or steel	5	4	4
Total ferrous mineral products	5 639	5 838	6 436
Nonferrous mineral products			
Aluminum and aluminum alloy fabricated material, n.e.s.	888	760	822
Zinc and alloys	433	517	492
Copper and alloys, n.e.s.	408	391	373
Aluminum paste, powder, pigs, ingots, shot	315	352	191
Other nonferrous base metals and alloys	123	167	150
Lead and alloys	116	163	134
Nonferrous metal scrap	104	94	107
Slag, dross, etc.	60	49	99
Copper matte and precipitates	1	–	22
Total nonferrous mineral products	2 449	2 493	2 390
Total metallic mineral products	8 088	8 332	8 826
Nonmetallic mineral products			
Fertilizers and fertilizer materials, n.e.s.	2 470	2 424	2 283
Portland cement, standard	1 873	1 813	1 716
Sulphuric acid	1 471	1 806	1 767
Gypsum basic products, n.e.s.	426	282	248
Cement and concrete basic products, n.e.s.	208	223	187
Nonmetallic mineral basic products, n.e.s.	210	210	178
Lime, hydrated and quick	177	185	168
Natural stone basic products, chiefly structural	185	166	152
Dolomite and magnesite, calcined	48	50	51
Glass basic products	43	45	36
Bricks and tiles, clay	104	30	50
Fire brick and similar shapes	23	24	21
Asbestos and asbestos–cement basic products	17	22	20
Plaster	6	9	9
Refractories, n.e.s.	9	6	3
Total nonmetallic mineral products	7 268	7 295	6 889
Mineral fuel products			
Refined and manufactured gases, fuel type	2 355	2 671	2 744
Diesel fuel	1 269	1 531	1 397
Gasoline	897	675	612
Fuel oil, n.e.s.	677	654	802
Coke, n.e.s.	633	623	459
Other petroleum and coal products	606	517	509
Petroleum coke	341	341	340
Lubricating oils and greases	308	304	331
Asphalts and road oils	284	248	211
Total mineral fuel products	7 371	7 566	7 405
Total fabricated mineral products	22 727	23 193	23 120
Total revenue freight[1] moved by Canadian railways	261 406	269 354	247 041
Fabricated mineral products as a percentage of total revenue freight	8.7	8.6	9.4

Source: Statistics Canada.
[1] Revenue freight refers to a local or interline shipment from which earnings accrue to a carrier.
n.e.s. Not elsewhere specified; – Nil.

TABLE 71. CANADA, CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1960-89

	Total Revenue Freight[1]	Total Crude Minerals	Total Fabricated Mineral Products	Total Crude and Fabricated Minerals	Crude and Fabricated Minerals as Percent of Revenue Freight
	(million tonnes)				
1960	142.8	57.1	14.5	71.6	50.1
1961	138.9	54.1	13.6	67.7	48.7
1962	146.0	60.3	13.8	74.1	50.8
1963	154.6	62.9	15.5	78.4	50.6
1964	180.0	74.6	15.9	90.5	50.3
1965	186.2	80.9	17.3	98.2	52.7
1966	194.5	80.6	17.8	94.8	50.6
1967	190.0	81.2	17.7	98.9	52.1
1968	195.4	86.7	18.8	105.5	54.0
1969	189.0	81.9	27.6	109.5	57.9
1970	211.6	97.5	28.4	125.9	59.5
1971	214.5	95.6	27.4	123.0	57.3
1972	215.8	89.4	27.6	117.0	54.2
1973	241.2	113.1	29.1	142.2	59.0
1974	246.3	115.3	30.9	146.2	59.4
1975	226.0	110.6	26.6	137.2	60.7
1976	238.5	116.6	25.5	142.1	59.6
1977	247.2	121.1	25.7	146.8	59.4
1978	238.8	107.7	26.2	133.9	56.1
1979	257.9	127.2	26.6	153.8	59.6
1980	254.4	124.8	24.6	149.4	58.7
1981	246.6	120.7	26.4	147.1	59.7
1982	212.5	95.7	21.0	116.7	54.9
1983	222.8	95.3	22.7	118.0	53.0
1984	254.6	121.1	25.1	146.2	57.4
1985	250.6	125.2	24.3	149.5	59.7
1986	249.8	121.2	23.0	144.2	57.7
1987	261.4	122.2	22.7	144.9	55.4
1988	269.4	134.9	23.2	158.1	58.7
1989	247.0	122.3	23.1	145.4	58.9

Source: Statistics Canada.
[1] Revenue freight refers to a local or interline shipment from which earnings accrue to a carrier.

TABLE 72. CANADA, CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY,[1] 1988-90

	Montreal-Lake Ontario Section			Welland Canal Section		
	1988	1989	1990	1988	1989	1990
	(tonnes)					
Crude minerals						
Iron ore	10 810 682	11 185 264	11 527 835	7 083 883	7 293 840	7 483 022
Coal	712 945	776 999	489 355	7 029 061	6 321 198	6 265 959
Salt	1 027 602	1 377 273	1 183 829	1 672 709	2 176 005	1 513 195
Stone, ground or crushed	432 370	448 117	715 500	992 668	1 187 148	1 766 491
Other crude minerals	1 000 802	965 083	1 019 901	601 526	920 752	543 373
Sand and gravel	–	–	–	226 492	241 749	214 373
Clay and bentonite	240 823	215 214	229 581	240 823	215 214	229 581
Aluminum ores and concentrates	230 356	236 629	178 327	218 960	203 711	178 327
Potash	294 948	291 373	252 467	372 971	105 371	343 978
Stone, rough	41	530	117	15 021	113	15 086
Phosphate rock	2 833	6 120	–	–	–	–
Total crude minerals	14 753 402	15 502 602	15 596 912	18 454 114	18 665 101	18 553 385
Fabricated mineral products						
Iron and steel, manufactured	2 724 806	3 353 717	3 106 287	2 327 939	2 782 889	2 493 714
Coke	1 466 718	1 272 068	946 154	1 638 341	1 412 270	1 037 047
Fuel oil	879 438	529 627	890 612	669 756	637 605	938 742
Cement	32 101	27 463	28 431	488 672	367 748	407 310
Scrap iron and steel	369 397	320 630	233 668	364 658	313 738	369 092
Iron and steel, bars, rods, slabs	1 581 257	825 931	498 284	697 850	304 885	268 199
Gasoline	248 120	485 319	481 265	126 537	275 681	223 997
Other petroleum products	141 952	124 006	53 127	141 004	155 894	39 556
Pig iron	93 248	70 938	67 942	82 921	65 164	66 500
Tar, pitch and creosote	27 104	29 432	23 770	62 830	32 035	42 849
Lubricating oils and greases	28 128	42 923	35 852	18 544	22 531	28 476
Iron and steel, nails, wire	10 670	6 468	2 904	8 396	4 995	2 284
Total fabricated minerals	7 603 029	7 088 522	6 368 296	6 627 448	6 375 435	5 917 766
Total crude and fabricated minerals	22 356 431	22 591 124	21 965 208	25 081 562	25 040 536	24 471 151
Total, all products[2]	40 557 669	37 070 370	36 655 939	43 536 317	39 909 450	39 397 900
Crude and fabricated minerals as a percentage of all products	55.1	60.9	59.9	57.6	62.7	62.1

Source: St. Lawrence Seaway Traffic Report.
[1] Total cargo transported regardless of travel direction. [2] Includes crude minerals and fabricated mineral products along with all other cargo transported.
– Nil.

TABLE 73. CANADA, CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY,[1] 1960-90

	Montreal–Lake Ontario Section				Welland Canal Section			
	Total All Products[2]	Total Crude Minerals	Total Fabricated Mineral Products	Crude and Fabricated Minerals as Percent of All Products	Total All Products[2]	Total Crude Minerals	Total Fabricated Mineral Products	Crude and Fabricated Minerals as Percent of All Products
	(kilotonnes)				(kilotonnes)			
1960	18 460	5 760	2 904	46.9	26 563	12 679	2 606	57.5
1961	21 212	6 706	2 358	42.7	28 490	12 599	2 378	52.6
1962	23 271	7 531	2 522	43.2	32 215	15 625	2 342	55.8
1963	28 198	9 507	2 804	43.7	37 490	18 094	2 524	55.0
1964	35 701	13 127	3 558	46.7	46 644	23 489	3 095	57.0
1965	39 352	13 788	6 024	50.3	48 477	23 555	4 933	58.8
1966	44 538	16 376	6 340	51.0	53 648	25 712	5 329	57.9
1967	39 918	17 800	6 430	60.7	47 945	26 010	5 459	65.6
1968	43 496	19 312	8 425	63.8	52 712	29 075	7 587	69.6
1969	37 256	12 682	8 263	56.2	48 601	25 090	6 715	65.4
1970	46 445	15 554	8 932	52.7	57 121	27 233	7 156	60.2
1971	48 069	14 204	9 263	48.8	57 205	23 903	7 914	55.6
1972	48 607	13 425	9 837	47.9	58 146	24 808	7 701	55.9
1973	52 285	17 111	9 639	51.2	60 958	26 907	7 718	56.8
1974	40 049	16 137	7 018	57.8	47 500	23 952	5 437	61.9
1975	43 554	15 698	6 071	50.0	53 387	26 100	5 129	58.5
1976	49 348	20 884	7 181	56.9	58 368	29 914	6 323	62.1
1977	57 456	23 008	9 918	57.3	65 079	30 459	8 933	60.5
1978	51 658	15 057	8 558	45.7	59 576	22 700	7 759	51.1
1979	50 187	16 408	8 104	48.8	60 023	24 851	7 940	54.6
1980	42 142	12 248	6 009	43.3	54 074	20 487	5 405	47.9
1981	45 876	15 453	5 711	46.1	53 389	22 132	5 529	51.8
1982	38 841	9 146	4 997	36.4	44 474	15 057	4 333	43.6
1983	45 061	12 443	5 422	39.6	50 145	17 412	5 618	45.9
1984	47 505	14 009	6 980	44.2	53 917	20 312	7 052	50.8
1985	37 322	11 689	6 152	47.8	41 852	16 203	6 127	53.4
1986	37 582	11 387	6 429	47.4	41 613	15 774	6 020	52.4
1987	39 969	12 565	5 893	46.2	42 725	15 687	5 403	49.4
1988	40 558	14 753	7 603	55.1	43 536	18 454	6 627	57.6
1989	37 070	15 503	7 089	60.9	39 909	18 665	6 375	62.7
1990	36 656	15 597	6 368	59.9	39 398	18 553	5 918	62.1

Source: St. Lawrence Seaway Traffic Report.
[1] Total cargo transported regardless of travel direction. [2] Includes crude minerals and fabricated mineral products along with all other cargo transported.

TABLE 75. CANADA, FABRICATED MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1990

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
	(tonnes)							
Metallic mineral products								
Iron, steel and alloys	43 098	126 588	58 435	228 121	35 231	134 200	58 691	228 121
Aluminum and aluminum products	5 261	–	–	5 261	–	5 261	–	5 261
Total metallic mineral products	48 359	126 588	58 435	233 382	35 231	139 461	58 691	233 382
Nonmetallic mineral products								
Cement and related products	50 965	586 289	110 027	747 367	61 163	576 176	110 027	747 367
Other fabricated nonmetallic minerals, n.e.s.	44 293	529 243	443 468	1 017 005	149 834	423 703	443 468	1 017 005
Total nonmetallic mineral products	95 258	1 115 532	553 495	1 764 372	210 997	999 879	553 495	1 764 372
Mineral fuel products								
Gasoline	2 956 777	461 683	577 959	3 996 420	2 970 962	447 510	577 948	3 996 420
Fuel oil	4 705 087	1 039 167	951 534	6 695 788	4 969 214	778 850	947 724	6 695 788
Petroleum coke	106 821	129 834	–	290 654	248 762	41 892	–	290 654
Other fabricated mineral fuels, n.e.s.	2 483 763	373 512	258 550	3 115 825	2 364 942	492 333	258 550	3 115 825
Total mineral fuel products	10 306 448	2 004 196	1 788 043	14 098 687	10 553 880	1 760 585	1 784 222	14 098 687
Total fabricated mineral products	10 450 065	3 246 316	2 399 973	16 096 441	10 800 108	2 899 925	2 396 408	16 096 441
Total all commodities[1]	22 033 178	20 072 974	18 254 259	60 360 410	25 121 445	16 986 026	18 252 938	60 360 410
Fabricated minerals as a percentage of all commodities	47.4	16.2	13.1	26.7	43.0	17.1	13.1	26.7

Source: Statistics Canada.
1 Includes metallic mineral products, nonmetallic mineral products and mineral fuel products, along with all other cargo loaded and unloaded in coastwise shipping.
– Nil; n.e.s. Not elsewhere specified.
Notes: Totals may not add due to rounding.
In 1990 the Transportation Division of Statistics Canada implemented a new commodity coding system which is not in complete accordance with the previous method of reporting. Therefore, tables 74 through 79 have been reformatted to reflect the 1990 coding system.

TABLE 76. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN COASTWISE SHIPPING, 1960-90

	Total All Commodities[1]	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
		(kilotonnes)		
1960	37 058	8 786	8 229	45.9
1961	41 861	9 527	8 857	43.9
1962	39 763	8 361	9 768	45.6
1963	40 328	7 998	9 942	44.5
1964	47 171	8 522	11 194	41.8
1965	48 200	9 183	11 766	43.5
1966	55 122	10 155	12 653	41.4
1967	49 799	11 509	12 207	47.6
1968	50 921	13 698	13 245	52.9
1969	51 890	12 746	14 181	51.9
1970	57 301	14 415	14 818	51.0
1971	55 128	14 783	15 374	54.7
1972	55 326	14 197	15 290	53.3
1973	55 314	16 573	15 615	58.2
1974	53 633	11 723	16 575	52.8
1975	54 373	15 687	17 510	61.1
1976	53 882	15 924	16 208	59.6
1977	58 309	18 131	17 435	61.0
1978	60 668	18 318	16 619	57.6
1979	79 950	22 130	17 486	49.6
1980	82 761	22 947	17 134	48.4
1981	71 271	17 849	16 669	48.4
1982	65 881	16 473	13 214	45.1
1983	67 598	21 248	12 025	49.2
1984	68 698	22 798	11 909	50.5
1985	61 717	19 867	10 291	48.9
1986	60 506	19 901	10 264	49.9
1987	67 572	20 969	11 118	47.5
1988	69 974	23 325	11 676	50.0
1989	61 122	22 963	11 825	56.9
1990	60 360	22 430	16 096	63.8

Source: Statistics Canada.
[1] Includes metallic mineral products, nonmetallic mineral products and mineral fuel products, along with all other cargo loaded and unloaded in coastwise shipping.
Note: In 1990 the Transportation Division of Statistics Canada implemented a new commodity coding system which is not in complete accordance with the previous method of reporting. Therefore, tables 74 through 79 have been reformatted to reflect the 1990 coding system.

TABLE 78. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE,[1] 1988-90

	1988		1989		1990	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
			(tonnes)			
Metallic minerals						
Iron, steel and alloys	1 005 743	3 333 003	1 898 150	1 982 130	2 494 124	1 769 750
Nonferrous metals, n.e.s.	696 619	326 824	762 061	204 929	428 680	332 546
Total metallic minerals	1 702 362	3 659 827	2 660 211	2 187 059	2 922 804	2 102 296
Nonmetallic minerals						
Cement and related products	1 579 898	778 713	1 494 839	625 672	1 695 880	1 028 456
Other nonmetallic minerals, n.e.s.	112 017	468 563	270 415	492 025	636 339	324 987
Total nonmetallic minerals	1 691 915	1 247 276	1 765 254	1 117 697	2 332 219	1 353 443
Mineral fuels						
Gasoline	2 329 522	905 923	1 944 466	1 348 571	2 596 345	841 980
Fuel oil	5 861 422	5 249 818	5 193 961	6 172 370	4 054 455	3 973 134
Coke, petroleum and coal products	642 127	2 434 471	2 060 017	2 364 253	232 225	1 067 483
Other mineral fuels, n.e.s.	. .	. .	. .	. .	2 350 898	2 569 567
Total mineral fuels	8 833 071	8 590 212	9 198 444	9 885 194	9 233 923	8 452 164
Total fabricated mineral products	12 227 348	13 497 315	13 623 909	13 189 950	14 488 946	11 907 903
Total all commodities[1]	171 064 410	78 911 838	156 568 302	79 670 214	159 039 270	73 296 005
Fabricated minerals as a percentage of all commodities	7.1	17.1	8.7	16.6	9.1	16.2

Source: Statistics Canada.
[1] Includes metallic products, nonmetallic minerals and mineral fuels, along with all other cargo loaded and unloaded at Canadian ports.
n.e.s. Not elsewhere specified; . . Not available.
Notes: Totals may not add due to rounding.
In 1990 the Transportation Division of Statistics Canada implemented a new commodity coding system which is not in complete accordance with the previous method of reporting. Therefore, tables 74 through 79 have been reformatted to reflect the 1990 coding system.

TABLE 79. CANADA, CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS LOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1960-90

	Total All Commodities[1]	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
	(kilotonnes)			
1960	45 872	24 671	2 039	58.2
1961	48 771	23 241	2 133	52.0
1962	54 676	30 446	2 296	59.9
1963	62 031	32 214	2 503	56.0
1964	75 760	42 087	2 602	59.0
1965	74 521	41 338	2 746	59.2
1966	76 192	41 374	3 350	58.7
1967	72 598	42 704	3 701	63.9
1968	78 663	48 680	2 960	65.6
1969	70 432	42 442	3 456	65.2
1970	95 807	55 849	4 965	63.5
1971	95 887	53 245	5 022	60.8
1972	98 988	51 912	9 091	61.6
1973	112 434	64 195	10 103	66.1
1974	106 110	64 093	9 041	68.9
1975	102 444	61 970	7 495	67.8
1976	114 815	71 527	6 108	67.6
1977	119 770	70 257	5 979	63.7
1978	116 522	62 291	7 556	59.9
1979	134 639	79 685	8 901	65.8
1980	138 161	67 898	11 770	57.7
1981	145 445	83 007	9 022	63.3
1982	125 282	65 594	7 115	58.0
1983	129 490	67 152	6 197	56.6
1984	145 322	82 752	7 986	62.4
1985	143 421	83 878	10 814	66.0
1986	144 561	84 720	8 303	64.3
1987	158 994	86 085	10 488	60.7
1988	171 064	98 934	12 227	65.0
1989	156 568	90 807	13 624	66.7
1990p	159 039	88 504	11 349	62.8

Source: Statistics Canada.
[1] Includes metallic products, nonmetallic products and mineral fuel products, along with all other cargo loaded and unloaded at Canadian ports.
p Preliminary.
Note: In 1990 the Transportation Division of Statistics Canada implemented a new commodity coding system which is not in complete accordance with the previous method of reporting. Therefore, tables 74 through 79 have been reformatted to reflect the 1990 coding system.

TABLE 81. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] BY GEOGRAPHICAL REGION, 1989-91

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
						($ million)				
Atlantic Region	1989	235.1	135.0	370.1	23.0	250.2	273.2	258.1	385.2	643.3
	1990p	313.3	116.1	429.4	21.0	264.3	285.3	334.3	380.4	714.7
	1991i	925.4	176.8	1 102.2	24.3	289.3	313.6	949.7	466.1	1 415.8
Quebec	1989	365.2	151.9	517.1	27.4	233.2	260.6	392.6	385.1	777.7
	1990p	251.0	129.5	380.5	41.4	264.7	306.1	292.4	394.2	686.6
	1991i	266.4	114.8	381.2	38.4	268.6	307.0	304.8	383.4	688.2
Ontario	1989	524.1	236.6	760.7	65.8	429.7	495.5	589.9	666.3	1 256.2
	1990p	388.8	230.7	619.5	69.2	428.0	497.2	458.0	658.7	1 116.7
	1991i	315.9	202.8	518.7	55.0	404.0	459.0	370.9	606.8	977.7
Prairie Region	1989	3 897.1	412.5	4 309.6	227.5	1 078.5	1 306.0	4 124.6	1 491.0	5 615.6
	1990p	4 260.5	417.4	4 677.9	301.6	1 176.1	1 477.7	4 562.1	1 593.5	6 155.6
	1991i	5 037.4	539.1	5 576.5	319.8	1 136.3	1 456.1	5 357.2	1 675.4	7 032.6
British Columbia	1989	804.1	151.6	955.7	72.8	468.2	541.0	876.9	619.8	1 496.7
	1990p	776.9	122.3	899.2	67.4	449.1	516.5	844.3	571.4	1 415.7
	1991i	827.9	128.2	956.1	72.8	444.1	516.9	900.7	572.3	1 473.0
Yukon and Northwest Territories	1989	392.8	67.2	460.0	12.4	73.0	85.4	405.2	140.2	545.4
	1990p	213.9	41.7	255.6	5.3	52.1	57.4	219.2	93.8	313.0
	1991i	128.9	52.9	181.8	5.3	46.0	51.3	134.2	98.9	233.1
Total	1989	6 218.4	1 154.8	7 373.2	428.9	2 532.8	2 961.7	6 647.3	3 687.6	10 334.9
	1990p	6 204.4	1 057.7	7 262.1	505.9	2 634.3	3 140.2	6 710.3	3 692.0	10 402.3
	1991i	7 501.9	1 214.6	8 716.5	515.6	2 588.3	3 103.9	8 017.5	3 802.9	11 820.4

Source: Statistics Canada.
[1] Includes mines, quarries and oil wells.
p Preliminary; i Intentions.
Note: Totals may not add due to rounding.

TABLE 82. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES,[2] 1989-91

	1989			1990p			1991i		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Mining industry									
Metal mines									
Copper-gold-silver	294.4	281.0	575.4	303.4	298.9	602.3	241.5	296.7	538.2
Gold	847.9	227.1	1 075.0	476.3	211.4	687.7	364.1	212.5	576.6
Iron	136.2	243.8	380.0	194.5	240.8	435.3	244.4	245.4	489.8
Silver-lead-zinc	165.1	133.1	298.2	145.4	87.6	233.0	166.6	108.9	275.5
Other metal mines	491.4	330.1	821.5	466.4	354.7	821.1	421.9	310.3	732.2
Total metal mines	1 935.0	1 215.1	3 150.1	1 586.0	1 193.4	2 779.4	1 438.5	1 173.8	2 612.3
Nonmetal mines									
Asbestos	77.4	38.4	115.8	56.7	55.9	112.6	26.1	50.9	77.0
Other nonmetal mines[3]	609.8	684.7	1 294.5	615.7	735.0	1 350.7	662.5	748.3	1 410.8
Total nonmetal mines	687.2	723.1	1 410.3	672.4	790.9	1 463.3	688.6	799.2	1 487.8
Mineral fuels									
Petroleum and gas[4]	4 751.0	1 023.5	5 774.5	5 003.7	1 155.9	6 159.6	6 589.4	1 130.9	7 720.3
Total mining industries	7 373.2	2 961.7	10 334.9	7 262.1	3 140.2	10 402.3	8 716.5	3 103.9	11 820.4
Mineral manufacturing									
Primary metal industries									
Aluminum rolling, casting and extruding	107.2	68.0	175.2	77.9	52.1	130.0	64.5	53.0	117.5
Copper and copper alloy, rolling, casting and extruding	6.1	7.7	13.8	2.8	6.8	9.6	7.0	6.9	13.9
Iron and steel mills	591.6	1 076.9	1 668.5	670.4	875.7	1 546.1	625.2	912.0	1 537.2
Iron foundries	59.7	74.1	133.8	37.1	54.2	91.3	25.0	50.3	75.3
Metal rolling, casting and extruding	26.4	17.8	44.2	23.3	22.1	45.4	21.2	22.8	44.0
Smelting and refining	1 503.6	585.3	2 088.9	2 167.0	606.0	2 773.0	2 171.2	640.3	2 811.5
Steel pipe and tube mills	46.5	77.9	124.4	50.9	82.1	133.0	56.4	87.2	143.6
Total primary metal industries	2 341.1	1 907.7	4 248.8	3 029.4	1 699.0	4 728.4	2 970.5	1 772.5	4 743.0
Nonmetallic mineral products									
Abrasives	4.5	14.8	19.3	9.4	14.6	24.0	7.5	12.9	20.4
Cement	159.7	111.8	271.5	138.6	121.4	260.0	122.0	120.2	242.2
Clay products	4.5	15.3	19.8	10.3	16.0	26.3	11.5	12.7	24.2
Concrete products	52.5	42.0	94.5	51.4	36.9	88.3	31.1	33.8	64.9
Glass and glass products	128.7	34.1	162.8	170.6	32.1	202.7	57.6	39.9	97.5
Lime	x	x	18.8	23.5	9.7	33.2	21.6	10.0	31.6
Ready-mix concrete	74.7	69.4	144.1	66.9	77.9	144.8	71.0	77.4	148.4
Stone products	x	x	7.6	0.1	0.0	0.1	0.1	0.0	0.1
Other nonmetallic mineral products	124.7	67.2	191.9	94.4	56.1	150.5	47.5	58.1	105.6
Total nonmetallic mineral products	568.1	362.2	930.3	565.2	364.7	929.9	369.9	365.0	734.9
Metal-fabricating industries									
Boiler and plate works	16.1	11.0	27.1	13.4	12.7	26.1	15.9	12.9	28.8
Fabricated structural metal	16.4	12.9	29.3	17.2	15.4	32.6	19.2	13.7	32.9
Hardware, tool and cutlery	72.4	28.7	101.1	38.1	33.0	71.1	40.5	27.1	67.6
Heating equipment	9.7	4.1	13.8	18.1	6.2	24.3	6.9	6.7	13.6
Machine ships	23.4	10.4	33.8	23.7	8.0	31.7	19.4	8.4	27.8
Metal stamping, pressing and coating	126.7	70.8	197.5	69.1	47.7	116.8	74.9	49.4	124.3
Miscellaneous metal fabricating	67.5	32.0	99.5	32.7	23.2	55.9	38.6	24.3	62.9
Ornamental and architectural metal	41.1	12.3	53.4	48.1	15.1	63.2	26.5	16.1	42.6
Wire and wire products	51.8	48.5	100.3	46.2	38.4	84.6	54.1	39.3	93.4
Total metal-fabricating industries	425.1	230.7	655.8	306.6	199.7	506.3	296.0	197.9	493.9

TABLE 84. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES,[1] 1985-91

	1985	1986	1987	1988	1989	1990p	1991i
				($ millions)			
Primary metal industries[2]							
Capital							
Construction	593.8	400.2	265.7	287.3	611.7	711.6	774.4
Machinery	1 019.0	1 333.6	1 223.2	1 242.8	1 729.4	2 317.8	2 196.1
Total	1 612.8	1 733.8	1 488.9	1 530.1	2 341.1	3 029.4	2 970.5
Repair							
Construction	125.2	126.9	119.0	134.0	186.4	265.1	273.2
Machinery	1 231.1	1 279.0	1 409.4	1 616.8	1 721.3	1 433.9	1 499.3
Total	1 356.3	1 405.9	1 528.4	1 750.8	1 907.7	1 699.0	1 772.5
Total capital and repair	2 969.1	3 139.7	3 017.3	3 280.9	4 248.8	4 728.4	4 743.0
Nonmetallic mineral products[3]							
Capital							
Construction	39.2	36.0	73.5	88.1	120.5	76.0	30.0
Machinery	193.2	295.1	282.6	352.5	447.6	489.2	339.9
Total	232.4	331.1	356.1	440.6	568.1	565.2	369.9
Repair							
Construction	21.2	24.7	23.3	24.0	23.1	15.8	15.8
Machinery	270.6	285.7	277.5	313.9	339.1	348.9	349.2
Total	291.8	310.4	300.8	337.9	362.2	364.7	365.0
Total capital and repair	524.2	641.5	656.9	778.5	930.3	929.9	734.9
Metal-fabricating industries							
Capital							
Construction	133.6	194.7	107.1	112.2	84.5	62.1	38.6
Machinery	438.7	525.4	356.3	355.2	340.6	244.5	257.4
Total	572.3	720.1	463.4	467.4	425.1	306.6	296.0
Repair							
Construction	23.7	22.7	24.2	27.8	29.6	23.0	21.9
Machinery	167.7	209.1	194.7	197.1	201.1	176.7	176.0
Total	191.4	231.8	218.9	224.9	230.7	199.7	197.9
Total capital and repair	763.7	951.9	682.3	692.3	655.8	506.3	493.9
Petroleum and coal products							
Capital							
Construction	248.3	272.3	464.9	437.9	626.0	870.3	938.2
Machinery	87.4	125.9	205.0	261.0	335.1	294.0	323.2
Total	335.7	398.2	669.9	698.9	961.1	1 164.3	1 261.4
Repair							
Construction	213.0	212.0	252.8	255.6	274.3	330.5	346.4
Machinery	74.9	91.9	112.8	115.7	129.7	133.8	138.2
Total	287.9	303.9	365.6	371.3	404.0	464.3	484.6
Total capital and repair	623.6	702.1	1 035.5	1 070.2	1 365.1	1 628.6	1 746.0
Total mineral manufacturing industries							
Capital							
Construction	1 014.9	903.2	911.2	925.5	1 442.7	1 720.0	1 781.2
Machinery	1 738.3	2 280.0	2 067.1	2 211.5	2 852.7	3 345.5	3 116.6
Total	2 753.2	3 183.2	2 978.3	3 137.0	4 295.4	5 065.5	4 897.8
Repair							
Construction	383.1	386.3	419.3	441.4	513.4	634.4	657.3
Machinery	1 744.3	1 865.7	1 994.4	2 243.5	2 391.2	2 093.3	2 162.7
Total	2 127.4	2 252.0	2 413.7	2 684.9	2 904.6	2 727.7	2 820.0
Total capital and repair	4 880.6	5 435.2	5 392.0	5 821.9	7 200.0	7 793.2	7 717.8

Source: Statistics Canada.
[1] All years have been revised to include the metal-fabricating industries. [2] Includes smelting and refining. [3] Includes cement, lime and clay products manufacturing.
p Preliminary; i Intentions.
Note: Totals may not add due to rounding.

TABLE 85. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES,[1] 1981-91

	Petroleum and Natural Gas Extraction	Transportation (Pipelines)	Marketing (Chiefly Outlets of Oil Companies)	Natural Gas Distribution	Petroleum and Coal Products Industries	Natural Gas Processing Plants	Oil and Gas Drilling Contractors	Total Capital Expenditures
				($ million)				
1981	6 444.9	1 745.7	264.1	408.7	844.9	311.6	274.9	10 294.8
1982	6 743.4	1 994.3	320.5	517.6	1 224.5	522.8	173.5	11 496.6
1983	6 563.5	660.5	374.5	516.8	840.8	195.8	155.4	9 307.3
1984	6 946.4	795.4	422.9	604.1	432.4	340.0	43.8	9 585.0
1985	8 187.6	664.2	356.8	603.5	335.7	337.7	80.1	10 565.6
1986	5 401.1	586.9	344.9	573.9	398.2	207.8	29.9	7 542.7
1987	4 414.6	503.0	412.4	571.8	669.9	174.1	13.1	6 758.9
1988	5 589.9	828.9	478.4	602.8	698.9	271.8	16.9	8 487.6
1989	4 309.7	1 520.7	501.7	570.4	961.4	427.4	14.0	8 305.3
1990[p]	4 635.2	1 852.8	407.7	631.8	1 164.3	356.6	11.7	9 060.1
1991[i]	6 033.3	2 454.4	620.5	717.9	1 261.4	543.7	12.5	11 643.7

Source: Statistics Canada.
[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities.
[p] Preliminary; [i] Intentions.
Note: Totals may not add due to rounding.

TABLE 87. CANADA, CAPITAL AND CURRENT INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING-RELATED INDUSTRIES, IN CURRENT DOLLARS, 1985-91

	1985	1986	1987	1988[r]	1989[r]	1990[p]	1991[f]
				($ million)			
Capital expenditures							
Mining industry	27	11	9[r]	8	13	21	33
Mines	4	8	4	3	11	17	29
Oil and gas wells	23	3	5[r]	5	2	4	4
Mineral manufacturing	82	30	32[r]	51	48	26	26
Ferrous primary metals	3	3	4	3	3	2	2
Nonferrous primary metals	5	7	15	15	11	11	9
Nonmetallic mineral products	6	3	2	2	2	1	1
Petroleum products	68	17	11[r]	31	32	12	14
Metal fabricating	2	4	4	4	3	3	2
Current expenditures							
Mining industry	92	79	84[r]	91	81	91	89
Mines	47	44	42[r]	44	38	49	50
Oil and gas wells	46	35	42[r]	47	43	42	39
Mineral manufacturing	260	249	227[r]	260	263	286	310
Ferrous primary metals	23	24	27	28	21	23	23
Nonferrous primary metals	87	81	96	115	125	121	126
Nonmetallic mineral products	13	13	13	18	18	19	19
Petroleum products	137	131	91[r]	99	99	123	142
Metal fabricating	28	30	31	35	36	32	39
Total expenditures							
Mining industry	119	90	93[r]	99	94	112	122
Mines	51	52	46[r]	47	49	66	79
Oil and gas wells	69	38	47[r]	52	45	46	43
Mineral manufacturing	342	279	259[r]	311	311	312	336
Ferrous primary metals	26	27	31[r]	31	24	25	25
Nonferrous primary metals	92	88	111	130	136	132	135
Nonmetallic mineral products	19	16	15	20	20	20	20
Petroleum products	205	148	102[r]	130	131	135	156
Metal fabricating	30	34	35	39	39	35	41

Source: Statistics Canada.
[p] Preliminary; [f] Forecast; [r] Revised.
Note: Capital expenditures are expenditures on construction, acquisition or preparation of land, buildings, machinery and equipment. All other expenditures are current expenditures. Totals may not add due to rounding.