Nickel Smelting and Refining

INDUSTRY PROFILE

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Canada

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INDUSTRY PROFILE

1990–1991

NICKEL SMELTING AND REFINING

FOREWORD

In a rapidly changing global trade environment, the international competitiveness of Canadian industry is the key to growth and prosperity. Promoting improved performance by Canadian firms in the global marketplace is a central element of the mandates of Industry, Science and Technology Canada and International Trade Canada. This Industry Profile is one of a series of papers in which Industry, Science and Technology Canada assesses, in a summary form, the current competitiveness of Canada's industrial sectors, taking into account technological, human resource and other critical factors. Industry, Science and Technology Canada and International Trade Canada assess the most recent changes in access to markets, including the implications of the Canada-U.S. Free Trade Agreement. Industry participants were consulted in the preparation of the profiles.

Ensuring that Canada remains prosperous over the next decade and into the next century is a challenge that affects us all. These profiles are intended to be informative and to serve as a basis for discussion of industrial prospects, strategic directions and the need for new approaches. This 1990–1991 series represents an updating and revision of the series published in 1988–1989. The Government will continue to update the series on a regular basis.

Michael H. Wilson
Minister of Industry, Science and Technology
and Minister for International Trade

Introduction

Nickel is one of a group of non-ferrous metals that are smelted and refined in Canada.[1] In addition to *Nickel Smelting and Refining*, industry profiles have been prepared covering

- *Aluminum Smelting*
- *Copper Smelting and Refining*
- *Lead and Zinc Smelting and Refining*

Structure and Performance

Structure

Nickel smelting transforms nickel concentrates into crude metal, while the refining operation upgrades the metal to 99.95 percent purity.

Nickel is used principally in metal alloys, imparting corrosion resistance, strength, toughness and other improved physical properties. About 64 percent of nickel consumption is used in the production of stainless steel, up from 45 percent a decade ago. Other alloyed steel and iron and steel castings account for 5 percent each of total consumption. Another 12 percent goes into the nickel-based and copper-based alloys used in chemical, petrochemical, power, nuclear and aircraft industries. Other important markets for nickel are in plating, mainly as a base for chrome plating, and in the production of rechargeable batteries, catalysts, ceramics and pigments. Broadly defined, about 55 percent of total nickel demand is from industrial markets, and the balance is from consumer markets.

Nickel is principally recovered from two types of ore — sulphide and laterite. Sulphide ores are the source of about

[1] See *Standard Industrial Classification, 1980*, Statistics Canada Catalogue No. 12-501, industry group 295. Data on each industry are not collected separately and should be considered only as indicators of trends.

Canadian Annual Processing Capacity

(tonnes of contained nickel per year)

	Smelter	Refinery
Inco		
Port Colborne	–	30 000
Sudbury	127 000[a]	56 700
Thompson	81 600	50 000
Falconbridge		
Sudbury	45 000	–
Sherritt Gordon		
Fort Saskatchewan	–	25 000

[a]Reduced from 154 200 tonnes per year because of a 1980 government regulation on sulphur dioxide emissions. Due to current nickel market conditions, effective capacity is closer to 110 000 tonnes per year.

Sources: ISTC and Energy, Mines and Resources Canada.

60 percent of the world's refined nickel production. Sulphide ores have historically been recovered by labour-intensive underground methods, while laterite ores are mined in large-scale, open-cut operations. However, a high degree of mechanization and improved techniques in recent years have reduced sulphide mining costs. Lower cost at other processing stages and greater recovery of other metals such as copper, cobalt and precious metals that are found in the same ore provide an additional reason for lower sulphide nickel production costs relative to those from laterite ore, even though some lateritic deposits do contain significant amounts of cobalt.

Primary nickel products are classified by the industry into two classes. Class I products are essentially pure, with a nickel content of more than 99 percent. They are sold as cathodes, pellets, shot, powder and briquettes. In Canada, these products are made from the processing of sulphide ores. Class II products consist mainly of ferronickel and nickel oxide. Ferronickel, with 20 to 50 percent nickel content, is produced mainly from lateritic ores found in tropical countries. Nickel oxide, with about 76 percent nickel content, is produced from both sulphide and lateritic ores. Of world refined production, approximately 55 percent is in Class I, and the remainder is in Class II.

The Canadian nickel smelting and refining industry consists of three companies that smelt and/or refine nickel (see table above). Two of these also have mining and milling operations. Inco, the largest producer in the Western world, is fully integrated in its Canadian operations, processing its ores from 13 mines in Ontario and Manitoba through three smelter-refinery facilities at Port Colborne and Sudbury in Ontario, and Thompson in Manitoba. Falconbridge, the second largest nickel producer in Canada, smelts concentrates from six mines at Sudbury. Sherritt Gordon, which has no nickel mining operations, purchases nickel-bearing concentrates from domestic and foreign sources. Even so, it has experienced difficulties in procuring sufficient feedstock to maintain its operation at full capacity. It produces nickel powder and briquettes at its Fort Saskatchewan, Alberta, hydrometallurgical plant.

All three companies are Canadian-owned. Inco and Sherritt Gordon shares are owned by a broad spectrum of investors, while Falconbridge is owned jointly by Noranda and Trelleborg A.B. Sweden. Inco and Falconbridge have operations in some 20 countries. Total employment of Canadian nickel facilities, including the mining, milling, smelting and refining operations, was approximately 13 500 persons in 1990.

Canada provided an estimated 22 percent of 1990 world nickel mine production. Other important producers are the Commonwealth of Independent States (formerly the Soviet Union) with 26 percent, New Caledonia with 10 percent, Australia with about 8 percent, Indonesia with 6 percent and Cuba with just over 4 percent of world production. A total of 24 countries mine nickel in significant quantities.

In terms of delivery to the Western world's markets, Inco and Falconbridge hold about 33 and 12 percent, respectively. Other major suppliers are Australia's Western Mining Corp. at 10 percent, France's Société Métallurgique Le Nickel at 10 percent and Japanese producers at 10 percent. The remainder is shared among the Commonwealth of Independent States, Cuba and other producing nations.

The value of Canadian nickel production for 1990 was estimated at slightly over $2 billion, of which over $1.9 billion (estimated at 95 percent of shipments) was exported (Figure 1). Canadian nickel is exported as refined metal, nickel-copper matte and nickel oxide sinter. Of total exports, 56 percent is refined nickel, shipped primarily to the United States and the European Community (EC). Nickel-copper matte, a partially smelted material representing about 41 percent of exports, is shipped to Norway (Falconbridge) and the United Kingdom (Inco). Imports in 1990 amounted to $186 million, representing 65 percent of the Canadian market, 13 percent of which came from Norway and 14 percent from the United Kingdom.

Performance

The three major nickel-consuming geographic areas of Western Europe, Japan and the United States account for approximately 86 percent of the Western world's consumption. Between 1946 and 1973, nickel consumption in the non-Communist world grew at an annual rate of more than 6 percent. The growth rate declined after the oil shock in 1973, reflecting the decline in the overall performance of the world economy.

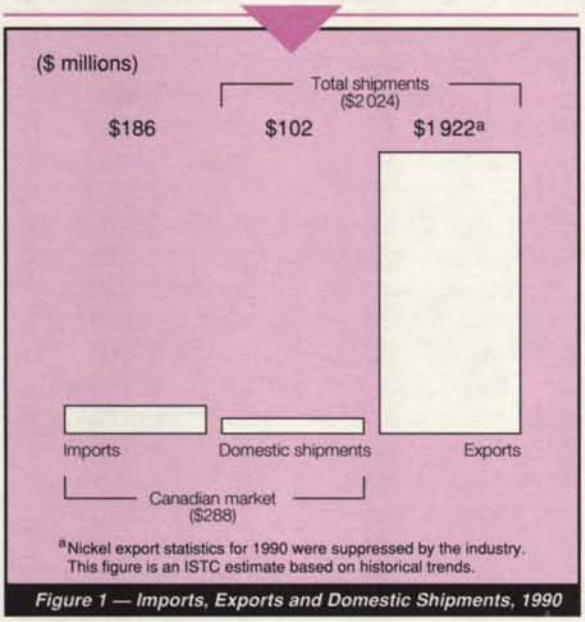

Figure 1 — Imports, Exports and Domestic Shipments, 1990

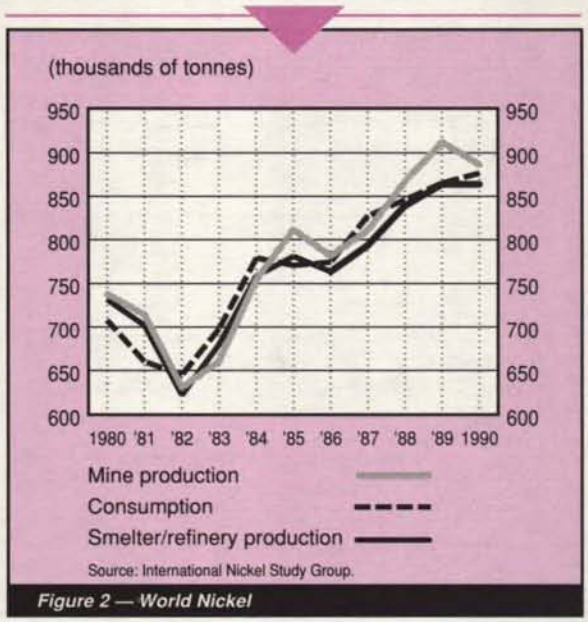

Figure 2 — World Nickel

Nickel demand picked up in 1976 to peak in 1979, when total non-Communist world consumption was 584 000 tonnes. Consumption then fell off again, but recovered to 582 000 tonnes by 1984 (see data for world consumption in Figure 2). Since then, the Western world's nickel consumption has risen sharply because of greater demand for stainless steel. Preliminary data for 1991 indicate that Western world consumption has decreased to 650 000 tonnes, compared with 670 500 tonnes in 1990.

Canada has been the dominant world nickel producer since the turn of the century. In the 1950s, Canada accounted for more than 95 percent of the output of the Western world's nickel mines. This situation changed in the 1960s and 1970s with the entry into the world nickel market of the newly industrialized countries (NICs) in Southeast Asia and Latin America, whose production capacity came under direct or indirect state control. Together with the former centrally planned economies, these countries presumably account for 40 percent of world production capacity. Their operations are not yet responsive to the usual price-cost relationships because the primary goals of their government owners are to gain foreign currency. As a consequence, Canada's role has changed from dominant supplier and price setter to swing supplier, because it is forced to cut back production from time to time in order to stabilize prices. Recently, Canadian companies have become more aggressive marketers to recapture market share.

The value of Canadian exports of primary nickel fell by about 32 percent during the 1981–1982 recession from $1.1 billion in 1980 to less than $750 million by 1983. Both Inco and Falconbridge suffered large losses as a result of depressed metal prices and high debt-servicing charges, which adversely affected the profitability of both companies.

Falconbridge returned to profitability in early 1984 while Inco, after sustaining losses for 13 consecutive quarters, took until the fourth quarter of 1984 to do so. Recovery was slow, as nickel prices remained depressed until the second half of 1987. However, between mid-1987 and mid-1988, nickel prices increased by 118 percent. These high prices persisted until the second quarter of 1989, contributing to record high profits in 1988 and 1989. Canadian exports rose from $1.2 billion in 1987 to an estimated $2.6 billion and $2.9 billion in 1988 and 1989, respectively, before falling in 1990 to $1.9 billion.

The economic downturn in the early 1980s had an impact on employment, as is shown in Figure 3. Falconbridge's work force was reduced by 38 percent, and Inco's by 41 percent. While production cutbacks accounted for some of the layoffs, the major reductions were caused by improvements in productivity and the rationalization of the companies' operations. The most noticeable cause for improved productivity has been brought about by the increase in the amount of ore being mined by bulk-mining methods, a procedure unique to Canadian operations. Because mining accounts for about 50 percent of current operating costs, the increased mining efficiency has resulted in higher Canadian productivity.

Foreign operations representing about 80 percent of the highest-cost producers were forced to close, thus increasing Canada's cost competitiveness. Nickel capacity was reduced in operations in Australia, the United States and the Philippines by

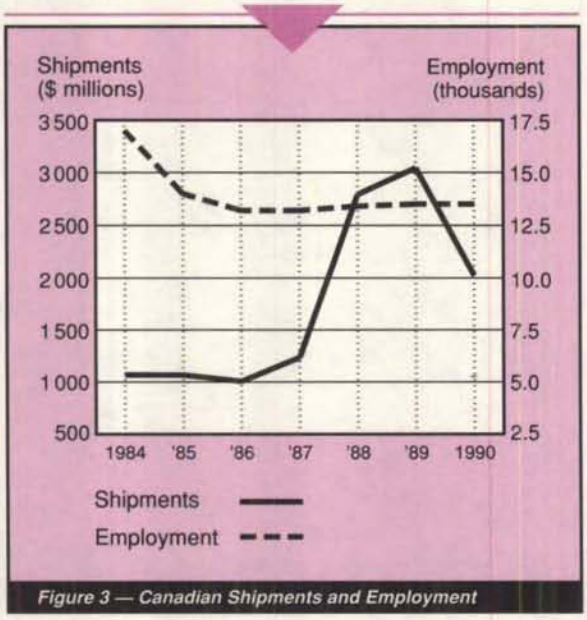

Figure 3 — Canadian Shipments and Employment

about 46 000 tonnes. An additional 100 000 tonnes of production was curtailed in operations in Canada, Australia, France and Japan. This restructuring dramatically lowered the annual nickel production capacity of Western world countries from 750 000 tonnes to 610 000 tonnes over the decade.

Some of the capacity that was lost through restructuring has since been reactivated. However, producers are taking a more cautious approach towards investing in expansion and new facilities. Either this added pressure or the need to create a better balance between supply and demand should strengthen nickel prices over the long run. In Canada, production is expected to increase marginally over the coming years, but smelter production will be constrained by the imposition of more stringent provincially regulated sulphur dioxide (SO_2) emission controls. Falconbridge is also concerned about the cost and reliability of power, having experienced several outages during the winter of 1989–1990 imposed by Ontario Hydro.

Strengths and Weaknesses

Structural Factors

A major competitive advantage enjoyed by Canadian nickel producers is the lower cost of smelting nickel from sulphide ore, the type usually found in Canada, rather than laterite ore, which is most often found in tropical countries. The difference in production cost is due in part to the amount of energy required to smelt nickel, constituting about 15 percent of the production cost of sulphide nickel, compared with 60 percent for laterite nickel. Hence, based on oil prices at U.S.$20 a barrel, total laterite production costs could be 1.2 to 1.5 times higher than those for sulphide ore. Another advantage enjoyed by Canadian producers is the presence of other metals that can be extracted from the nickel ore and sold; these include copper, cobalt, platinum-group metals and other precious metals.

Labour costs are a substantial and growing portion of Canadian operating costs, currently estimated at about 40 percent, although they are down from 50 percent a few years ago. While Canadian wage rates are significantly higher than those in laterite-producing countries, a well-trained work force, improved underground mining methods and modern processing facilities help the Canadian industry to improve productivity and to maintain lower unit operating cost. Canadian nickel producers have little problem obtaining qualified personnel for smelting operations. However, continuing efforts are being made to attract engineers and workers to the mining operations, which have become highly sophisticated. Potential employees are being offered training programs that involve classroom and work-site learning situations, while engineering students are being offered new mining courses and summer employment.

Canadian environmental regulations, on the other hand, represent a cost some foreign producers do not face. As a result of the federal-provincial acid rain agreements to reduce SO_2 emissions by 50 percent by 1994, the Ontario government has issued new control orders to Inco and Falconbridge. Under the new regulations, the two companies are obliged to cut SO_2 emissions at their Sudbury smelters to a combined total of 365 000 tonnes per year by 1994 from the 1980 permissible level of 882 000 tonnes. Essentially, this will require the companies to recapture all but 10 percent of the sulphur in the ore. To accomplish this goal, Inco and Falconbridge have announced major capital outlays to implement new technologies, amounting to $520 million and $35 million, respectively.

Trade-Related Factors

In almost all industrial countries, imports of nickel ores and concentrates are admitted duty-free. Refined nickel enters the EC and the United States duty-free; however, Japan still levies a duty of 81 yen per kilogram.[2] As far as non-tariff barriers are concerned, no significant measures prevent the entry of refined nickel into major importing markets.

The EC has been and is expected to remain an important export market for Canadian production. Most of these exports

[2]As of February 1992, one yen equalled C$0.009266.

enter the European market as a nickel-copper matte, which is refined in the United Kingdom by Inco and in Norway by Falconbridge.

Under the Canada-U.S. Free Trade Agreement (FTA), implemented on 1 January 1989, most remaining tariffs will be eliminated in 10 annual, equal steps. In the case of primary nickel, trade between Canada and the United States is already duty-free. Some tariffs do apply on fabricated products containing nickel and its derivatives, and these will be gradually eliminated under the agreement.

Technological Factors

Inco has traditionally been the world leader in the development of both new production processes and new applications for nickel. In recent years, however, the company has been concentrating its research and development (R&D) efforts on new technologies in mining, milling and smelting. It has undertaken a major expansion of its R&D facilities at Sheridan Park, Ontario, and an extensive development program on value-added products, including new nickel powders and advanced materials, such as nickel-coated fibres and particles. Sherritt Gordon has been the world leader in developing hydrometallurgical and powder metallurgy processes. Falconbridge has focused its R&D on improving productivity and on reducing SO_2 emissions in smelting operations.

The technological challenge faced by Inco and Falconbridge is the development of affordable processes to permit the reduction of SO_2 emissions to the levels stipulated in the new Ontario environmental protection regulations. To meet this challenge, R&D pursued vigorously by both companies has resulted in successful technological developments. Research aimed at further reductions in emissions continues unabated.

A dramatic improvement in Canadian cost competitiveness over the past few years has resulted principally from the implementation of new mining equipment techniques and from automation of operations. The modernization of the smelters, including the installation of larger flotation cells, semi-autogenous milling processes and continuous casting capability, is currently under way. In addition, further automation of refinery operations is planned. These planned capital improvements in all production stages will raise productivity and lower operating costs.

Other Factors

Under the *Ontario Mining Act*, the provincial government has the legislative power to require companies to increase further processing of ores in Canada. It has, however, allowed a number of specific exemptions to reflect special circumstances. For instance, Falconbridge has been permitted to export nickel-copper matte to its refinery in Norway, because of its long-standing involvement in that country. Similarly, Inco has been given an exemption, which has been extended to December 1995, to ship nickel oxide sinter and nickel sulphide to its refinery in Clydach, Wales. It is also permitted to ship nickel sulphide under long-term contracts to two Japanese refineries, one Taiwanese refinery and one Korean refinery in which it has equity interests. This has allowed Inco to develop a significant market share in Asia.

Evolving Environment

The demand for nickel in the Western world is expected to grow at 1.5 to 2.5 percent per year to the end of this century, starting in 1992. A maturing of the nickel market and the moderate-growth forecast for the Western economy support this slow-growth outlook. Increased stainless steel scrap supplies should also affect the demand for primary nickel. There are few substitutes for nickel today; however, rapid developments in ceramics and plastics could affect nickel markets over the longer term. The key to the future of the industry, therefore, depends on the continual development of new applications, and hence new markets, for new nickel alloys. For this reason, Western world producers have established the Nickel Development Institute, headquartered in Canada, which will ensure a continuation of the market development and applications research carried on by Inco for decades. As well, some companies continue to develop proprietary products.

Thirteen countries including Canada, which collectively account for about two-thirds of the world nickel trade, have formed the International Nickel Study Group (INSG). Several other countries, as well as the European Community, are expected to join the association, which is headquartered in The Hague, Netherlands. The INSG serves the industry by compiling and publishing statistical data on the international nickel trade and will provide an intergovernmental forum for discussion of issues of concern to nickel-producing and nickel-consuming countries.

Over the short term, nickel markets are expected to be in an oversupply position until at least the end of 1992, but there is a concern that production capacity may not keep pace with the longer-term growth in consumption. Reactivation of some idle capacity is being investigated, and overall capacity could increase if Cuba, New Caledonia, the Philippines, Brazil and the Commonwealth of Independent States follow through with announced expansion plans. However, given the high cost of establishing new facilities, the return on investment is not likely to be sufficient to pay for them, unless high nickel prices are sustained over the project's life. Also, the uncertainty over energy availability and costs further complicates investment

decisions; for instance, the Cuban situation is precarious because of its past dependency on the Commonwealth of Independent States for oil supplies. These factors suggest another nickel shortage may occur before the next round of capacity increases.

Economic reforms are expected to stimulate the Eastern bloc economies, and this should have a long-term positive impact on increased consumption of stainless steel and, in turn, on nickel demand. However, exports of primary nickel from the Commonwealth of Independent States are expected to remain at significant levels over the short- to medium-term, more specifically until profound economic reforms can stimulate internal consumption or until uneconomical or polluting production units are decommissioned.

The Canada-U.S. Free Trade Agreement has not had any impact on this industry, as the United States had no restrictions on imports of primary nickel.

The question of nickel's role as a carcinogen has received increased attention. In 1988, the International Agency for Research on Cancer (IARC) reclassified nickel and nickel compounds as probable carcinogens. A more recent epidemiology study sponsored by European, U.S. and Canadian groups has shown that there is no evidence that nickel metal is a carcinogen, but has concluded that exposure to high concentrations of certain nickel compounds, which occur in the production of nickel, can result in increased lung and nasal cancers. Further findings along these lines could have far-reaching long-term effects on the industry, including a demand for regulations, a potential increase in product liability cases and consumer resistance to products containing nickel.

Competitiveness Assessment

The restructuring and rationalization of the nickel industry has reduced worldwide capacity by about 18 percent, bringing Western supply and demand essentially into balance. Both Inco and Falconbridge have made extensive improvements to their mining and smelting operations that have resulted in raised productivity and lowered operating costs. As a result, they have regained their status as low-cost producers, while lowering their debt obligations. This places them in a strong position to remain competitive and to secure a steady share of the Western world nickel market, as long as they pay very close attention to the evolution of their respective cost structures.

The evolution of the economic reforms in the former Eastern bloc countries will nevertheless influence the price of nickel, at least until those economies are better integrated into the global economy. This should provide an additional incentive to Canadian nickel producers for maintaining competitive cost structures across their operations.

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PRINCIPAL STATISTICS[a]

	1984	1985	1986	1987	1988	1989	1990
Establishments	7	7	7	7	7	7	7
Employment[b]	17 000	14 000	13 200	13 200	13 400	13 500	13 500
Shipments (current $ millions)	1 069	1 067	1 007	1 233	2 790	3 042	2 024
(thousands of tonnes)	168	165	164	188	199	196	197
GDP[c] (constant 1986 $ millions)	2 608	2 845	1 954	2 297	2 417	2 382	2 336
Investment[d] (current $ millions)	1 049	1 321	964	1 453	1 558	2 139	3 124

[a]ISTC estimates unless otherwise indicated.

[b]Estimates combine mining, milling, smelting and refining employment.

[c]See *Gross Domestic Product by Industry*, Statistics Canada Catalogue No. 15-001, monthly. Data relate to total for industry group 295, non-ferrous metal smelting and refining industries, not specifically to nickel.

[d]See *Capital and Repair Expenditures, Manufacturing Subindustries, Intentions*, Statistics Canada Catalogue No. 61-214, annual. Data relate to total for industry group 295, and combine capital and repair expenditures.

TRADE STATISTICS[a]

	1984	1985	1986	1987	1988	1989	1990
Exports ($ millions)	1 016	1 013	957	1 171	2 650[b]	2 890[b]	1 922[b]
Domestic shipments ($ millions)	53	54	50	62	140	152	102
Imports[c] ($ millions)	111	138	148	107	133	164	186
Canadian market ($ millions)	164	192	198	169	273	316	288
Exports (% of shipments)	95	95	95	95	95	95	95
Imports[c] (% of Canadian market)	68	72	75	63	49	52	65
Canadian share of international market (% of mine production)	23	22	22	24	24	22	22

[a]ISTC estimates. All amounts are in current dollars.

[b]Figure suppressed by the industry; ISTC estimates based on historical trends.

[c]Canadian producers do most of the importing. Data include ores, concentrates and intermediary nickel products to be processed in Canada, and may also include re-imports from Canada.

SOURCES OF IMPORTS[a] (% of total value)

	1984	1985	1986	1987	1988	1989	1990
United States	49	48	42	56	57	49	37
European Community	18	14	17	17	9.5	6	22.5
Japan	1	0.5	0.5	–	0.5	1	0.5
Other	32	37.5	40.5	27	33	44	40

[a]See *Imports by Commodity*, Statistics Canada Catalogue No. 65-007, monthly.

DESTINATIONS OF EXPORTS[a] (% of total value)

	1984	1985	1986	1987	1988	1989	1990
United States	37	37	38	39	19	19	53
European Community	28	32	34	32	35	24	17
Japan	1	1	1	2	2	2	2
Other	34	30	27	27	44	55	28

[a]See *Exports by Commodity*, Statistics Canada Catalogue No. 65-004, monthly.

PRODUCTION STATISTICS[a] (tonnes)

	1973	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Production, all forms[b]	274 527	184 802	160 247	88 581	125 022	173 725	169 971	163 639	188 366	198 744	195 554	196 605
Exports												
Mattes, ores and concentrates	100 385	42 647	53 841	27 037	40 087	59 409	63 305	57 780	56 560	67 888	61 682	68 082
Oxides	65 818	16 989	14 390	13 127	11 167	20 080	17 992	13 923	20 715	17 075[c]	21 917[c]	15 966[c]
Refined metal	132 949	88 125	79 935	62 314	66 949	153 935	81 601	86 007	96 121	103 843[c]	102 177[c]	102 726[c]
Total	299 152	147 761	148 166	102 478	118 203	233 424	162 898	157 710	173 396	188 806[d]	185 776[d]	186 774[d]
Imports	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22 546[d]	24 901[d]	29 166[d]
Consumption	11 862	10 000	8 600	6 600	8 000	13 400	9 300	11 200	10 200	11 400	13 800	12 500
Refinery production	N/A	134 400	110 400	72 800	93 000	120 800	117 200	124 200	131 300	135 200	129 100	126 800

[a]ISTC estimates based on data from the International Nickel Study Group and Energy, Mines and Resources Canada.

[b]Estimated production, all forms, for 1991 was 197 000 tonnes.

[c]ISTC estimates based on historical trends.

[d]Changes in data reporting took place due to the adoption of the Harmonized Commodity Description and Coding System (HS).

N/A: not available

REGIONAL DISTRIBUTION[a] (1990)

	Atlantic	Quebec	Ontario	Prairies	British Columbia
Employment (% of total)	–	–	86	14	–
Production (% of total volume)	–	–	65	35	–
(% of total value)	–	–	65	35	–

[a]ISTC estimates.

MAJOR FIRMS

Name	Ownership (principal shareholders)	Location of major plants
Falconbridge Limited	Noranda Inc. 50% Trelleborg A.B. Sweden 50% (21 September 1989)	Sudbury, Ontario (S)
Inco Limited	Widespread ownership: Canadian residents 67%	Sudbury, Ontario (S)(R) Thompson, Manitoba (S)(R) Port Colborne, Ontario (R)
Sherritt Gordon Limited	Widespread ownership: no major shareholder	Fort Saskatchewan, Alberta (HR)

(S) Smelter
(R) Refinery
(HR) Hydrometallurgical refinery

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