Nickel

Bill McCutcheon

The author is with the Minerals and Metals Sector, Natural Resources Canada.
Telephone: (613) 992-5480
E-mail: bmccutch@nrcan.gc.ca

(Note: Because of the importance of cobalt in lateritic projects, this review on nickel includes some information about cobalt production associated with nickel production. However, this information on cobalt is not intended to be a comprehensive review of that commodity.)

The trend of declining nickel prices seen since March 1997, which continued throughout 1998, reaching a low of US$3715/t on December 15, 1998, was reversed dramatically during 1999. Prices climbed almost steadily during 1999 to finish the year at US$8450/t, while inventories on the London Metal Exchange (LME) declined by 18 700 t to just over 43 000 t by year-end. Nickel demand totaled 1.08 Mt and primary nickel production totaled 1.027 Mt in 1999. This represented an increase of 70 800 t in demand over 1998 and a decline in production of 7400 t relative to 1998. When comparing 1998 to 1997, demand in 1998 declined by 11 000 t whereas production increased by 22 000 t.

CANADIAN DEVELOPMENTS

Canadian mine production of nickel (i.e., nickel contained in concentrates produced) is estimated at 188 000 t in 1999 (shown as 177 200 t in Table 1),[1] down 10% from a revised figure of 208 200 t in 1998. Although the Raglan mine completed its first year of commercial production, a labour dispute at Inco Limited's operations in Manitoba resulted in lost production during the year. Primary nickel output in Canada was 124 000 t in 1999, down 15% from the 146 700 t produced in 1998.

In 2000, Canadian nickel output is expected to recover; production of nickel in concentrate is expected to increase to approximately 205 000 t and primary nickel production is expected to increase to 205 000 t. But, because both nickel producers and the unions representing the workers in Sudbury must renegotiate labour agreements in mid-2000, the possibility exists that Canadian production could be lower than forecast for 2000.

Falconbridge Limited operated four nickel-copper-cobalt mines near Sudbury, Ontario, and one in northern Quebec. The concentrate from the mines in the Sudbury area and from the Raglan mine in northern Quebec was smelted in the company's smelter near Sudbury. During 1999, Falconbridge reorganized its Sudbury operations into separate smelting and mining divisions to increase competitiveness. The matte containing 50% nickel from the smelter was shipped to Falconbridge's Nikkelverk refinery in Norway where nickel, copper, cobalt and precious metals were recovered. The company also has a subsidiary in the Dominican Republic called Falconbridge Dominicana, C. por A. (Falcondo) that produces ferronickel. Falconbridge is also considering nickel laterite projects in New Caledonia and the Ivory Coast. In addition to its nickel-copper and ferronickel operations, the company has copper and zinc facilities, including mines, mills, smelters and refineries, in Ontario and Chile. Noranda Inc. owned 49.9% of Falconbridge at year-end. Falconbridge's web site[2] is located at http://www.falconbridge.com.

At the start of 1999, Falconbridge had originally planned to produce 85 000 t of refined nickel and 28 000 t of nickel in ferronickel in 1999. However,

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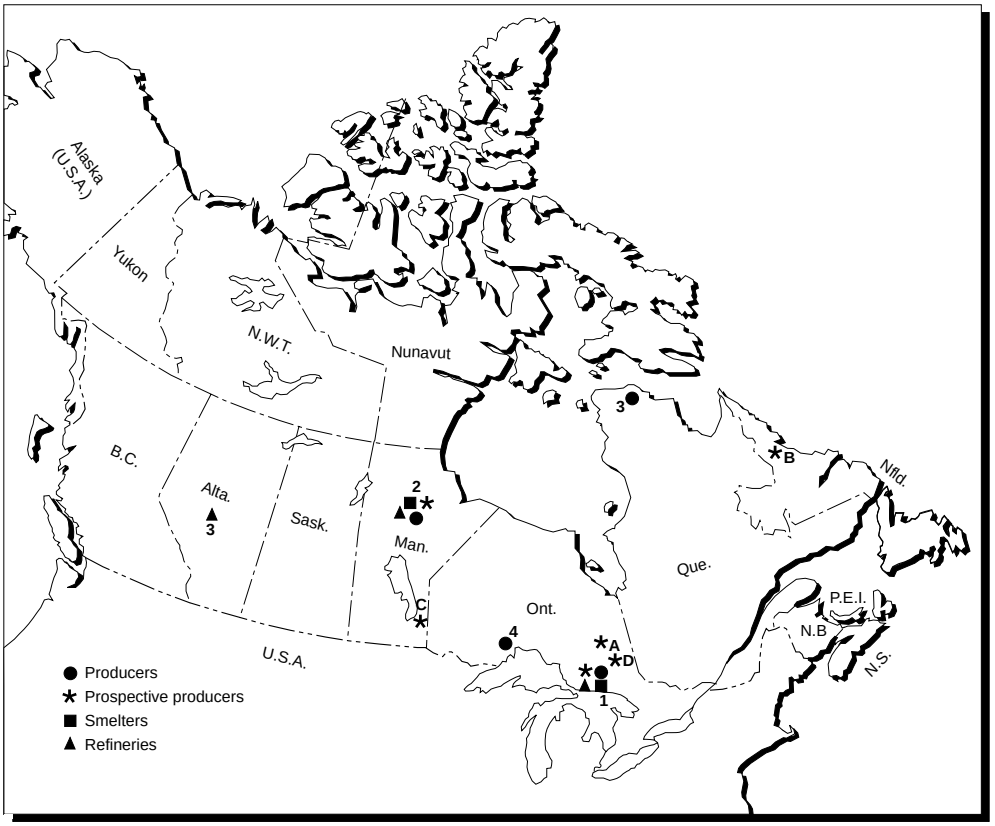
[1] The preliminary estimates of production are shown in Tables 1 and 2. However, more current information for the total production only (mine and refined) was available at the time of writing. These updated data are used throughout this review, except in Tables 1 and 2, which use the earlier preliminary estimates. For current monthly production data, refer to the Natural Resources Canada (NRCan) web site at http://www.nrcan.gc.ca/mms/efab/data/default.html, which offers downloads in pdf, Lotus or Excel formats. Similarly, preliminary production data by province for 1999 are available at http://www.nrcan.gc.ca/mms/efab/mmsd/production/production.htm.

[2] The exact internet address (URL) does not include those periods, brackets, etc., that form part of the sentence's punctuation.

Figure 1
Nickel in Canada, 1999



Numbers refer to locations on map above

PRODUCERS

1. Falconbridge Limited (Fraser, Lindsley, Onaping-Craig, Lockerby)
1. Inco Limited (Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood, Little Stobie, McCreedy East, Levack/McCreedy West, Garson, Stobie)
2. Inco Limited (Thompson, Birchtree)
3. Falconbridge Limited (Raglan)
4. North American Palladium Ltd. (Lac des Îles)

SMELTERS

1. Falconbridge Limited (Falconbridge)
1. Inco Limited (Copper Cliff)
2. Inco Limited (Thompson)

REFINERIES

1. Inco Limited (Sudbury)
2. Inco Limited (Thompson)
3. Sherritt International Corporation (Fort Saskatchewan)

PROSPECTIVE PRODUCERS

A. Outokumpu Mines Ltd. (Moncalm Township)
B. Inco Limited (Voisey's Bay mine site)
C. Canmine Resources Corporation (Maskwa)
D. Canmine Resources Corporation (Cobalt, Ontario)

the company experienced technical problems at its smelter near Sudbury, which then created a feed shortage at the company's refinery in Norway. The feed shortage at Falconbridge's Nikkelverk refinery was compounded by a decline in custom feed during 1999. At Falconbridge's ferronickel operation, electrical problems resulted in lost production during the year. In total, Falconbridge's nickel production was 74 137 t of refined nickel and 24 500 t of nickel in ferronickel. This combined nickel output of 98 600 t of contained nickel in 1999 was 3300 t higher than the 1998 total but was 14 400 t less than the original company target for 1999.

Falconbridge reorganized its Sudbury operations into a mining/milling business unit and a smelting business unit to assist the company in attaining its goal of cutting operating costs to US$1.30/lb by 2000. For the 1999 fiscal year, Falconbridge changed its definition of cash costs – marketing and sales were included in cash cost calculations while corporate expenses and exploration expenses were not. Using the new definition, Falconbridge's cash cost of production was US$1.59/lb in 1999.

While Falconbridge's four mines in Sudbury (Fraser, Lindsley, Onaping-Craig and Lockerby) produced nearly the same tonnage (2.75 Mt) as in 1998 (2.77 Mt), the output of contained nickel declined 7% to 35 700 t because lower-grade ore was mined (1.57% nickel in 1999 compared to 1.67% nickel in 1998). Although four mines supply ore to a single concentrator, the Onaping-Craig mine is the source of over half the nickel in ore produced by Falconbridge's mines in the Sudbury area. The Onaping Depth Project exploration program continued throughout 1999; Falconbridge expects to complete the project by mid-2000. As of the end of 1999, exploration at the Onaping Depth Project had shown an undiluted mineral resource totaling 20.7 Mt grading 2.57% nickel and 1.22% copper. Once the exploration is completed, a feasibility study will be done. Falconbridge's ore inventory in the Sudbury area at the end of 1999 was: total proven plus probable reserves, 19.5 Mt grading 1.53% nickel and 1.35% copper; possible ore reserves, 3.8 Mt grading 0.99% nickel and 1.31% copper; and measured and indicated, 21.3 Mt grading 2.48% nickel and 1.18% copper. In 2000, Falconbridge expects to increase production in Sudbury to 37 000 t, up from the 35 700 t produced in 1999. However, the planned production could be affected by labour negotiations in 2000. The labour agreement between Falconbridge and the Sudbury Mine, Mill & Smelter Worders' Union Local 598/CAW-Canada, which represents the 1200 workers at Falconbridge's Sudbury operations, expires on August 1, 2000. The CAW has a web site at http://www.caw.ca. Local 598's web site can be found at http://www.minemill598.com.

The year 1999 was the first complete year of normal production at Falconbridge's Raglan mine, which ramped up to design capacity in the third quarter of 1998. The $500 million mine was designed with a production capacity of 21 000 t/y of nickel plus contained copper, cobalt and precious metals. In 1999, Raglan produced 19 524 t of nickel contained in concentrate, up 19% from the 16 365 t produced in 1998. This increased nickel production from Raglan more than compensated for the lower nickel content in the Sudbury ores. Falconbridge and the Syndicat des Métallos Local 9449 (United Steelworkers of America-Canada) were in the process of negotiating their first collective agreement at Raglan at the end of 1999. The web site for the United Steelworkers of America-Canada can be found at http://www.uswa.ca.

During 2000, Falconbridge intends to debottleneck the Raglan concentrator to raise throughput. To do this, the company plans to spend $25 million to increase mine development and mill performance from 0.8 to 1 Mt/y, thereby increasing capacity to about 26 500 t/y of nickel in concentrate by the end of 2000. Capacity expansion beyond this level will likely depend upon Falconbridge's success in increasing ore reserves in the Raglan area. In its 1999 annual report, Falconbridge reported the discovery of 0.3 Mt of ore grading 3.34% nickel in a new, previously unexplored contact zone. Raglan's proven plus probable reserves totaled 19.7 Mt grading 2.82% nickel and 0.77% copper at the end of 1999, an increase of 0.3 Mt over 1998. The long-term goal is to find sufficient ore reserves to support an annual output of 30 000 t of contained nickel. Falconbridge plans to produce 23 000 t of nickel and 5000 t of copper from Raglan in 2000.

Falconbridge's smelter in Falconbridge, located northeast of Sudbury, experienced operating problems during the year, as did the acid plant. Scheduled smelter shut-downs took place in April, September and late December. The smelter could not keep up to the mine output so concentrate stocks at the smelter increased while refinery production was limited by the smelter's lower output. The smelter has a capacity to produce 130 000 t/y of nickel-copper matte for shipment to Nikkelverk. In 1998, about 6000 t of nickel output was derived from custom feed and recycling. Falconbridge captures over 90% of the sulphur in the ore and converts it to sulphuric acid.

Falconbridge's mines in the Sudbury area and its Raglan mine in northern Quebec also contain copper and cobalt. Details on copper production can be found in the Copper chapter of the *Canadian Minerals Yearbook*. In 1999, Falconbridge produced 900 t of cobalt in concentrate from its Sudbury operations and an additional 240 t from its Raglan mine. This material is sent to Sudbury for smelting. In addition to the 1140 t from mine production, Falconbridge also took in 1400 t of cobalt in the form of custom feed

during 1999. The custom material can include feed from both primary and recycled sources. The recovered cobalt is contained in the nickel-copper matte that is sent to the Nikkelverk refinery. The refinery takes custom feed as well as the cobalt contained in the matte from Sudbury; total refinery output in 1999 was about 4000 t of cobalt. Falconbridge intends to produce 4100 t of cobalt from all sources at its Nikkelverk operation during 2000.

Inco Limited operates nickel mines, mills, smelters and refineries in Sudbury, Ontario, and in Thompson, Manitoba, as well as a copper smelter and refinery in Sudbury. It produces refined nickel and nickel oxide sinter in Canada and refined nickel and nickel foam at Clydach in the United Kingdom. Inco recycles nickel-cadmium (Ni-Cd) rechargeable batteries at its subsidiary, The International Metals Reclamation Company, Inc. (INMETCO) based in the United States. It also owns 59% of a large nickel laterite operation in Indonesia, PT International Nickel Indonesia Tbk (PT Inco), which produces nickel in matte. Inco's other interests in Asia include: a 67% interest in Inco TNC Limited (formerly Tokyo Nickel Company, Ltd.) in Japan; a 49.9% interest in Taiwan Nickel Refining Corporation; a 25% interest in Korea Nickel Corporation in South Korea; and a 65% interest in the joint-venture company Jinco Nonferrous Metals Co., Ltd. in China, of which the Jinchuan Nonferrous Metals Corporation owns the remaining 35%. Inco also has a project in New Caledonia, run by Goro Nickel S.A., in which it has an 85% ownership. Inco's nickel powders and foams command a significant premium over the LME price for cut nickel cathode. Co-products and by-products sold by Inco include: copper, cobalt, gold, silver, platinum group metals, selenium and tellurium, sulphuric acid, and liquid sulphur dioxide. Inco has a web site at http://www.inco.com that also provides information about Voisey's Bay Nickel Company Limited (VBNC).

Inco produced 171 253 t of nickel in 1999 from its operations in Canada and Indonesia, down 7.5% from the 191 603 t produced in 1998 and less than the original 1999 target of 185 000 t that was forecast in February 1999. Of this amount, 75 million lb, or 34 000 t, came from Manitoba while 99 800 t came from Ontario. (Note that the preliminary estimate for Canadian mine production in Table 1 shows only 30 773 t of nickel produced in Manitoba in 1999; this estimate will be updated in the third quarter of 2000.) Inco's nickel production in Canada was affected by a three-month strike in Manitoba, an extended summer shut-down at the company's mines in Canada, and continued lower-than-average rainfall in Indonesia (which again restricted production at PT Inco). Inco began restructuring its business practices in 1997. Since then the company has reduced its cash operating costs by 26% from US$1.71/lb in 1997 to US$126/lb in 1999. Inco has also reduced its work force in Ontario by over 1900 since late 1997 in order to help reduce costs; many of the reductions were through early retirement. In Manitoba, over 400 jobs have been made redundant since 1997.

Inco put its first nickel foam line into production at Clydach in September 1999. The second INCOFOAM^{TM} line is due to be ready for production in 2000. Inco's foam and its nickel powder are used to make Ni-Cd batteries and nickel metal hydride batteries used in tools, computers, cameras, etc., and for electric and hybrid automobiles. Inco plans to increase sales of its specialty products from US$200 million in 1999 to US$400 million by 2004. In addition to selling the nickel that it produces, Inco purchases nickel produced by others for resale to customers. Inco's total deliveries of nickel to customers in 1999 were 258 088 t, up 2% from the 252 925 t delivered in 1998. In 1999, Inco's deliveries of by-product copper were 119 754 t. Additional details about Inco's copper production can be found in the Copper chapter of the *Canadian Minerals Yearbook*.

In 1999, Inco delivered 1568 t of by-product cobalt metal and oxides, down from the 2004 t delivered in 1998. Inco does not report its cobalt production, only its cobalt sales, nor does Inco report the breakdown of cobalt recovered from primary, custom or secondary sources. During 1999, cobalt production from the company's Ontario mines declined due to an extended summer shut-down and to a one-time drawdown of in-process cobalt inventories in 1998. Inco produces cobalt oxide at its Clydach and Manitoba operations and cobalt metal at its Port Colborne, Ontario, operation. Information collected by the Cobalt Development Institute (CDI), based in the United Kingdom, shows cobalt production reported for 1999 from many producers including Inco (refer to Table 12). According to CDI figures, Inco produced 1420 t of cobalt in 1999.

Special Metals Corporation purchased Inco Alloys International, Inc. (IAI) for US$365 million in October 1998. In December 1999, Special Metals filed a lawsuit against Inco in the United States alleging that Inco had not fully informed Special Metals about the condition of IAI. The lawsuit reportedly sought US$460 million in damages.

In May, Inco completed an issue of 15 million new common shares to raise US$273 million. As well as using the new capital to pay down floating debts, Inco used the money to complete the expansion of Inco's Indonesian subsidiary, a pilot program at the Goro deposit in New Caledonia, and mine development in the Ontario Division.

At the beginning of 1999, Inco had 11 mines operating in the Sudbury, Ontario, area: Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood, Garson, Little Stobie, McCreedy East, Levack/McCreedy West, and Stobie. The

Levack/McCreedy West mine was closed in July and the Little Stobie mine was closed in August. Three mines are scheduled for closure in the next two years: Crean Hill, Frood and Coleman. The Garson mine continued operations because of cost-cutting measures taken in 1998. The Murray, Totten and Gertrude mines remained on a standby basis. Inco announced plans in 1998 to reduce finished nickel production from its Ontario operations from 100 000 t/y to 80 000 t/y of nickel over the next two to three years. At the Creighton mine, development work continued to access proved plus probable ore below the 7400-ft level (2255 m). The US$125 million project will first develop access to and then produce from an ore zone totaling 2.8 Mt grading 3.45% nickel and 2.97% copper to the 7400-ft level, and then from an ore zone totaling 3.1 Mt grading 3.62% nickel and 3.25% copper extending from the 7400-ft level to the 8180-ft (2495-m) level.

In October, Inco announced the discovery of a new orebody near the company's former Totten mine, which closed in 1970. Inco expects to announce a tonnage and grade estimate in the first quarter of 2000 after more drilling is completed. The drilling program is part of Inco's US$6.4 million exploration program in Ontario during 2000. Inco's proved plus probable reserves in Ontario at year-end were 228 Mt grading 1.34% nickel and 1.23% copper. The measured plus indicated plus inferred resources totaled 54 Mt grading 1.62% nickel and 1.66% copper. No cobalt grades were released for Inco's Ontario reserves or resources.

In Manitoba, Inco and the United Steelworkers Local 6166 did not agree to a new contract before their labour contract ran out on September 15, 1999. With no agreement in place, Inco locked out the 1000 workers on September 15 and shut down the operation five days later. In late November, Inco declared force majeure on its nickel shipments from Thompson. Because most of Inco Manitoba's production is in the form of nickel rounds for plating, the shut-down resulted in increased prices for plating-grade nickel. On December 9, an agreement was reached between the union and the company. This resulted in wage increases of 5% to $24.48/h and pension improvements of 13% over the three-year contract. Workers received a $1000 signing bonus as well as a "success sharing" and savings fund plan in addition to a nickel price bonus. The Manitoba Division restarted operations in December and was operating at 80% of capacity by year-end. An estimated 12 000 t of production was lost during the work stoppage.

Inco operated the Thompson and Birchtree mines in Manitoba in 1999. In October, it was reported that Inco needed to invest $250 million to deepen the Birchtree mine over the next five years, thereby extending Thompson's life until 2016. Without the investment, it was reported that the operation could close down in approximately five years; the same source cited Inco's target for a return on investment at 20%. In early 2000, a US$48 million deepening program was announced. Inco's proved plus probable reserves in Manitoba were 45 Mt grading 2.28% nickel and 0.15% copper at year-end. The company's indicated resources totaled 58 Mt grading 0.79% nickel and 0.06% copper, comprising 50 Mt of open-pit resources grading 0.58% nickel and 0.05% copper plus 8 Mt of underground resources grading 1.97% nickel and 0.14% cobalt.

With the reductions in its mine output, Inco has spare smelting and refining capacity available in Canada. In November 1998, Inco entered into an agreement with Jubilee Gold Mines NL whereby Jubilee had the option to supply 10 000 t/y of nickel in concentrate or ore over three years. Jubilee announced its decision to proceed with development of its 420 000-t Cosmos orebody in Australia grading 7.52% nickel. The first delivery of the 20% nickel concentrate is scheduled for the second quarter of 2000. The original Cosmos orebody is expected to be mined out in three years.

Despite securing environmental approval to proceed with development of its important orebody at Voisey's Bay, Inco was unable to proceed with it in 1999. In March, the Federal Court of Canada ruled against an application initiated in 1998 by The Citizens Mining Council of Newfoundland and Labrador. The application had sought to require the environmental hearing of the VBNC mine/mill project in Labrador to include an evaluation of the nickel smelter and refinery, which had been announced for Argentia, in the assessment of the mine/mill. The environmental panel overseeing the coordinated federal/provincial environmental review of the mine, mill and related infrastructure planned for Voisey's Bay released its report on April 1. The report contained 107 recommendations. This report can be viewed on the Canadian Environmental Assessment Agency's web site at http://www.ceaa.gc.ca/panels2/voisey/index_e.htm. The panel concluded that the project could proceed if measures to mitigate environmental impacts and other measures were taken. The federal response to the panel's report addressed the panel's 107 recommendations. The federal government's response was released on August 3, the same day that the provincial government released its response to the panel's report. The federal response can be viewed on the Department of Fisheries and Oceans' web site at http://www.dfo-mpo.gc.ca/COMMUNIC/Reports/Voisey_e.htm. The response by the Government of Newfoundland and Labrador to the environmental panel's report can be found at http://www.gov.nf.ca/releases/1999/envlab/Vbay-sum.htm.

The Government of Canada concluded that the environmental effects of the mine/mill project will be

acceptable if measures to mitigate environmental impacts and other measures are taken. In September, the Innu Nation and the Labrador Inuit Association (LIA) applied to the Federal Court for a judicial review of the response of the federal government. The request was put into abeyance while the two governments and the two Aboriginal groups negotiated an environmental management agreement. Negotiations continued into 2000 despite the announced delay for the Voisey's Bay project; the abeyance was later extended until mid-2000.

In July 1999, the LIA voted to accept the land claims agreement in principle that had been initialed by negotiators for the Government of Newfoundland and Labrador, Canada, and the LIA (details of the negotiated agreement in principle can be found on the Internet at http://www.inac.gc.ca/nr/prs/m-a1999/1-99141.html). The vote meant that negotiation of the final land claims agreement could proceed. As of the end of 1999, the Innu Nation and the federal government had not completed negotiation of an agreement in principle for land claims (details on "an agreement in principle on next steps to provide the Innu of Labrador with the tools necessary to address the issues confronting their communities" are also available on the Internet at http://www.inac.gc.ca/nr/prs/s-d1999/1-99167.html). VBNC and the two Aboriginal groups continued negotiations for separate Impact and Benefit Agreements, but these were not completed by year-end due to the impasse between the Province and the company.

In November it was revealed that Inco and the Government of Newfoundland and Labrador had resumed confidential discussions concerning the future development of Voisey's Bay. Inco stated its wish to reach agreement with the Province by the end of 1999 so that construction could begin in mid-2000, once ice conditions permit the transport of equipment and supplies to the mine/mill site. On January 11, 2000, Inco announced that it had not been able to reach agreement with the Province to proceed with a project consisting of a 6000-t/d mine and mill at a cost of US$500 million, an underground exploration project at a cost of US$95 million, and a research and development program in Newfoundland, including a pilot plant, expected to cost US$125 million. The research and development program was designed to complete the evaluation of Inco's new, proprietary hydrometallurgical process for nickel sulphide concentrates.

The Province and Inco were unable to agree upon processing alternatives if the new process were proven to be economically or technically unfeasible. The Province sought an absolute guarantee that processing of nickel concentrates to refined nickel would occur within the province. Inco was not prepared to give such a guarantee. Inco then stated that there would be no construction at the Voisey's Bay site in 2000 and declined to predict when negotiations with the Province would restart. Inco said in early 2000 that it expected to continue hydrometallurgical research and development work and to continue a previously announced exploration program in Labrador and at the Voisey's Bay site.

At year-end, proved reserves at the site totaled 32 Mt grading 2.83% nickel and 1.68% copper. In addition, there were 91 Mt of indicated resources grading 1.25% nickel and 0.59% copper, plus 14 Mt of inferred resources grading 1.00% nickel and 0.70% copper. Of the resources noted, 95 Mt grading 1.24% nickel and 0.59% copper would be mineable by underground mining methods while 10 Mt grading 0.92% nickel and 0.72% copper would be mineable by open pit. No cobalt grades were released for the Voisey's Bay deposit.

Inco forecast in February 2000 that total corporate production for that year would be 465 million lb of finished nickel, or 211 000 t,[3] from its operations in Canada and Indonesia, an increase of 34 000 t, or 19%, over 1999 production. Details of the 2000 production forecast by geographic area were: PT Inco, 135 million lb or 61 000 t; Manitoba, 105 million lb or 48 000 t; and Ontario, 225 million lb or 102 000 t. These forecasts represent an increase over 1999 production of 41%, 40% and 2% for PT Inco, Inco Manitoba, and Inco Ontario, respectively.

Sherritt International Corporation and General Nickel Company S.A. of Cuba each have a 50% interest in a joint-venture operation called Metals Enterprise. Metals Enterprise operates a lateritic nickel-cobalt mine at Moa, Cuba. This process transforms oxides of nickel and cobalt into nickel-cobalt sulphides by leaching with sulphuric acid. The sulphides are shipped to Nova Scotia and then railed to Metals Enterprise's hydrometallurgical nickel-cobalt refinery at Fort Saskatchewan, Alberta. The imports to Alberta from Cuba in 1999 were reported under the tariff classification of 2620.90 (ashes and residues). Previously, the imports to Alberta from Cuba were reported under tariff classification 7501.20 (nickel oxide sinters and other intermediate products of nickel metallurgy).

The official capacity of the refinery at Fort Saskatchewan is 27 000 t/y of nickel in briquettes, but 1999 production reached 28 643 t, a record output for the plant, reflecting ongoing debottlenecking there (production in 1998 was 27 434 t). The refinery also takes materials from other sources for refining.

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[3] The original forecasts were released in February 2000 in millions of pounds of nickel. These data were converted to tonnes of nickel and rounded to the nearest 1000 t.

Cobalt output in the form of briquettes and powder increased to 2770 t in 1999, up 5% from the 2645 t produced in 1998. In the fourth quarter of 1999, Fort Saskatchewan established a new quarterly production record for cobalt of 735 t. Sherritt markets the entire cobalt output from the Fort Saskatchewan plant on behalf of the International Cobalt Company Inc. (ICCI), based in the Bahamas.

Sherritt purchased 9%, or 12.8 million, of the outstanding shares of Anaconda Nickel Limited on May 14, 1999. Sherritt described its purchase as a reflection of the company's long-term, positive outlook for the projects that Anaconda had under way. Sherritt does not have a web site, but its financial statements and press releases can be found at http://www.sedar.com/search/search_form_pc.htm.[4]

North American Palladium Ltd. (NAPL) has operated the Lac des Îles open-pit palladium mine near Thunder Bay, Ontario, since 1993. The 2400-t/d operation produces a bulk concentrate containing palladium and by-product platinum, gold, copper, nickel and cobalt. In 1999, the concentrate was sent to Sudbury for smelting and refining. The mine produced 301 t of by-product nickel in 1999 from 894 000 t of ore. Since 1994, the mine has produced about 2200 t of nickel in addition to the 12.2 t of palladium, 0.83 t of platinum, 0.77 t of gold and over 2800 t of copper recovered from the 4.4 Mt milled during the six-year period. During 1999, over 50 000 m of drilling was completed in NAPL's exploration program that began in 1998.

A detailed feasibility study of a proposed US$126.5 million expansion indicated that it was feasible and economically viable to expand production to 15 000 t/d. This would increase by-product nickel production to over 860 t/y (and palladium production to an estimated 7.75 t/y). Construction is forecast to begin in the summer of 2000 and commissioning of the new mill is planned to start in the spring of 2001. The operation is scheduled to work at full capacity for the 2002 calendar year. North American Palladium Ltd. has a site on the Internet at http://www.napalladium.ca.

Canmine Resources Corporation has a number of nickel-cobalt assets in Canada. The principal ones are the Werner Lake cobalt property and a cobalt-nickel refinery in Ontario, and the Maskwa nickel-copper-cobalt property and the BINCO exploration property in Manitoba. At its Maskwa property, which is the former Dumbarton mine site operated by Maskwa Nickel Chrome Mines Ltd., Canmine obtained 21-year renewable surface and mineral right leases. These leases will give Canmine the long-term security necessary for a major investment.

The Maskwa property is located in Nopiming Provincial Park. The park is designated as a multi-use park, which includes mining and mineral processing. Canmine has increased the indicated reserves at Maskwa from 0.7 Mt in 1996 to 2.9 Mt grading 1.27% nickel, 0.21% coppper, 0.04% cobalt, 0.3 g/t platinum and 0.96 g/t palladium. In 1999, the Manitoba government began a mapping program and a geochemical program to obtain more information on the possibility of further ore reserves at depth. Canmine must submit an Environmental Impact Statement to the Manitoba government and obtain provincial approval for the project before it can proceed with development of the mine. Canmine plans to invest about $30 million to develop an underground mine at the property. It also intends to examine alternative methods of processing the ore by either producing separate nickel and copper concentrates or using hydrometallurgical processing to obtain nickel metal. Depending upon the processing route taken and the throughput, the capital cost to develop Maskwa is expected to vary between $20 million and $60 million.

In July, Canmine announced an agreement to acquire the closed Cobatec hydrometallurgical plant from the first mortgage holders of the bankrupt Cobatec Inc. The purchase price of $6.1 million was paid out: $1.5 million in cash, $1.6 million in common shares or securities convertible into common shares of Canmine, and $3 million in the form of 8% Canmine preference shares. Canmine plans to process material from its Werner Lake operation to produce cobalt carbonate for Sheppard Chemical Company in the United States. The former Cobatec plant previously operated recovering both nickel and cobalt. The plant could be used to handle some material from the future Maskwa mine depending upon market conditions and the company's plans.

Canmine's Werner Lake cobalt project is located 80 km north of Kenora, Ontario. Canmine began exploration in 1995 and, by 1997, had established that a significant deposit was present. In 1997/98, the company obtained environmental permits to take bulk samples from the property and conduct test milling at its nearby Maskwa property in Manitoba. The undiluted reserve-resource estimate for the Werner Lake orebody of 1.1 Mt grading 0.31% cobalt, 0.29% copper and 3.4 g/t gold was used as the basis of a feasibility study during 1999. Some of the discovered material contains cobalt grades that are much higher than the average grade of the orebody. Canmine expects to be able to start production at a rate of about 300 t/d within three to four months of arranging financing and to produce at the rate of 270-275 t/y of cobalt in cobalt carbonate at the former Cobatec plant. Canmine was also considering obtaining additional feed for its refinery from the Temagami area in Ontario where an exploration program is under way, or from processing custom feed from other producers.

[4] At the site, it is necessary to type in the company name (Sherritt International Corporation).

Canmine also continued exploration of its BINCO project in Manitoba. The 120 000-ha BINCO claim, extending 200 km northeast of Thompson, was acquired by Canmine in 1996/97 following the release of new aeromagnetic maps by the Geological Survey of Canada. Canmine drilled at Osik Lake, Manitoba, in 1998 and conducted a high-definition airborne geophysical survey in late 1999. Canmine has a site on the Internet at http://www.canmine.com.

In 1998, Gossan Resources Limited announced plans to convert a former silicon metal facility into an operation that produces a chrome-nickel master alloy for the stainless steel industry. After considering both this and a project to produce ferronickel from laterite ores, Gossan decided to convert the former Dow Corning Corp. plant at East Selkirk, Manitoba, into a ferrosilicon operation. By year-end, Gossan had received a completed business plan recommending a $12 million conversion to a plant that produces ferrosilicon for the steel industry and silica fume for the Portland cement industry. Gossan has a site on the Internet at http://www.gossan.ca.

This chapter does not include a review of the many nickel exploration projects in Canada. However, several of the exploration properties, along with the company name and web site address, are listed in Table 9.

WORLD DEVELOPMENTS

Russia

The major nickel producer in Russia, and the largest in the world, is Rossiskoe Aktionernoe Obshestvo Norilsky Nikel, or **RAO Norilsk Nickel** (RAO Norilsk). This holding company has four operating subsidiaries, the largest and most important of which is the **A.P. Zavenyagin Norilsk Mining & Metallurgical Combine** (Norilsk Combine) located in the Taymyr region in the northern part of the Krasnoyarsk territory of Siberia. RAO Norilsk's other two producing subsidiaries are the **Severonickel Combine** located in the Murmansk region of Russia and the **Pechenganickel Mining & Metallurgical Combine** (Pechenganickel Combine) located in the Pechenga region of Russia. RAO Norilsk exports its nickel entirely through its subsidiary Norimet under long-term contracts. Norimet finances the metal from the point of export through foreign bank loans. The other Russian producers are Ufaleynikel Joint Stock Co., the Yuzhralnikel Kombinat Joint Stock Co., and the Rezh Nickel Plant.

Russian nickel exports to destinations outside the C.I.S. were 212 500 t, down 5000 t, or 2.3%, from 1998. The Russian government imposed a 10% export duty on nonferrous scrap in mid-January. A 5% tax on primary nickel was also imposed in January; this duty did not include ore, alloys or ferronickel. The tax on scrap (including nickel and cobalt) was increased to 20% in May, resulting in increased availability of secondary feed to Russian producers. The 5% tax on exports of primary nickel was extended indefinitely from July 12. The export duty on nickel waste and scrap was extended indefinitely by a decree on October 28 at a rate of 30% (with a minimum value of 720 euros/t). The 5% export duty on stainless steel was also extended indefinitely by the same decree. In early December, the duties on exports of nickel and copper were doubled to 10%.

As was the case for all nickel producers, rising nickel prices strengthened RAO Norilsk's financial position in 1999. In addition to this, RAO Norilsk's finances were further enhanced by the strong prices for palladium and the other platinum group metals. By the third quarter, the company had paid all current taxes and was continuing to pay off past debts under a restructuring program.

RAO Norilsk adopted a more international approach to business during the year by opening a sales office in Pennsylvania, visiting Cuba for preliminary discussions about the possible development of a Cuban nickel laterite property, and visiting Australia for talks with Anaconda Nickel Limited. RAO Norilsk retained KPMG to bring RAO Norilsk's financial reporting procedures and statements into line with international standards; KPMG will audit RAO Norilsk's 1999 fiscal year. In June, RAO Norilsk displayed its nickel products at the Metal Powder Industries Federation conference in Vancouver. Its refinery in the Severonickel Combine is the only facility outside of Inco's refineries (at Sudbury and Clydach) that produces nickel powders using the carbonyl process.

On February 10, 1999, RAO Norilsk announced anticipated production cuts due to the installation of new equipment in the second quarter. The capital expenditures were part of the planned US$200 million program to purchase new mining and processing equipment during the year. (This followed modernization expenditures totaling over US$300 million in 1997 and 1998.) The capital improvement programs for 1999 included ongoing mine development to prepare new work areas underground, increasing concentrating efficiencies and concentrate grade, the construction of new flash smelting capacity for nickel concentrates at the Nadezhdinsky Works in the Norilsk Combine, and increased nickel refining capacity and increased production of cobalt salts at the Severonickel Combine. There were no plans to close any of the Combines, but unprofitable production units at each of them were to be closed. The

Severonickel and Pechenganickel Combines are to be kept in production until 2005; thereafter, the continued operation of these Combines is expected to depend upon their profitability.

RAO Norilsk produced an estimated 217 600 t of nickel, 391 600 t of copper and 4600 t of cobalt in 1998. In February 1999, RAO Norilsk announced that the installation of new equipment and technology at the Severonickel and Norilsk Combines beginning in the second quarter would result in production interruptions. The company estimated that nickel production would be reduced by 10% at the Severonickel Combine and by 5-6% at the Norilsk Combine. Estimates in the press put the production loss at about 15 000 t of nickel, but some analysts discounted any anticipated reduction. The company reported 1999 interim results on December 30; these showed that the company's nickel production had increased by 1.8% over 1998 production and that its copper production had increased by 2.5%. This indicates that RAO Norilsk's nickel production was an estimated 221 600 t and its copper production was over 400 000 t.

During 1999, RAO Norilsk continued to reduce staff levels to less than 99 000 by the third quarter. This was accomplished by retraining and transferring staff from redundant activities. By the third quarter of 1999, labour productivity across the Combines had quadrupled compared to one year earlier.

In December, the Norilsk Combine transferred all staff to the Norilskya Gornnaya Kompaniya, also known as The Norilsk Mining Company, a subsidiary that was set up in 1997. This transfer was one of the steps taken by RAO Norilsk to spin off fixed assets. The Norilsk Mining Company holds the licences to develop the orebodies in the area and to run the operation of the mines, plants, and the seaport at Dudinka. RAO Norilsk holds all shares in The Norilsk Mining Company.

RAO Norilsk reported that the most important event in 1999 for the company occurred in April when the board of directors approved its 10-year development plan. A total of US$3 billion-$5 billion in capital investment will be allocated to exploration and mining (42%), ore concentration (16%), metallurgical processing such as smelting and refining (17%), and infrastructure (25%). The details of this investment plan can be found on RAO Norilsk's web site at http://www.nornik.ru. The company stated that its goal for development and investment was to be focussed more on cutting production costs than on increasing output. The investments for modernization will allow RAO Norilsk to become more productive relative to its material and labour inputs and to provide a basis for expansion should market conditions warrant.

About 85% of the nickel reserves for RAO Norilsk are located in the Norilsk Combine, which is the source of about 90% of the ore mined by RAO Norilsk. Dumont Nickel Inc. showed an estimate for RAO Norilsk's reserves as: Pechenga, 36 Mt grading 1.0% nickel and 0.4% copper; and Norilsk, 555 Mt grading 2.7% nickel and 2.1% copper.

The town of Norilsk is isolated, located 2000 km north of Krasnoyarsk. Norilsk is not connected to the outside world by rail or road facilities. Freight is handled primarily through the port city of Dudinka on the Yenesi River. RAO Norilsk's agreement for provision of ice-breaking services with the Murmansk Sea Shipping Co. expires in July 2000. A new company was in the process of being formed in November, called RAO Servmorput, to be owned by the Russian government, RAO Norilsk, LUKoil and the financial institution Sberbank. RAO Norilsk also examined the possibility of shipping material using converted nuclear submarines. The cost of submarine conversion was estimated to be about 25% of the cost of a new ice breaker. The decision to consider the submarine option was prompted by Murmansk Sea Shipping's increased tariffs, which it needs to maintain its nuclear ice breakers. RAO Norilsk intends to decide by March 2000 whether to proceed further with the submarine option.

The Norilsk Mining and Metallurgical Combinat (Norilsk Combine) was founded in 1935 and first produced matte in 1939. There are three ore types at the Norilsk Combine: the "rich ore" or massive sulphide ore (which contains 48% of the nickel reserves), the impregnation ore, and the copper-bearing ore. These sulphide ores grade between 1.5% and 3.2% nickel and between 3% and 17% copper. The bulk of the mine production comes from two main orebodies, the Oktyabr ("October") deposit and the Talnakh deposit. These orebodies are mined by the Oktyabrisky, Komsolomolsky and Taimyrsky mines. Together these three mines produce about 85% of the total ore mined in the Combine. The rich ore reserves are relatively limited and work has begun on examining the consequences of shifting production progressively to the impregnation ore and the copper-bearing ore. These ores have a lower nonferrous grade than the rich ore does, but their precious metals grade is about equal to that of the rich ore.

The Oktyabr deposit is mined by the Oktyabrisky and Taimyrsky mines. Of these, Oktyabrisky is the more important as it provides about 40% of the total ore mined in the Combine and over half of the total nickel and other metals mined. The Taimyrsky mine is the source of an additional 25% of the ore mined in the Combine. Some Taimyrsky mine ore is so rich that it goes directly into the smelter with no need for concentration. As a result of the 1999 investment program, development work to develop new mining areas in both of these mines to sustain continued production began.

The Komsolomolsky mine is the principal mine operating in the Talnakh orebody. While Komsolomolsky is the source of only about 20% of the ore mined, it will play an important role in future production when the Skalisty mine is fully operational. The new Skalisty mine produced limited amounts of ore at the end of 1999; it is expected to ramp up production in 2000. Because of its high grades (even by the standards of the Norilsk Combine), Skalisty is crucial to maintaining or increasing nickel output from the Norilsk Combine in the next decade. A completely new mine called the Gluboky mine has been planned for the deeper sections of the Talnakh orebody. It is expected to come on stream around 2005.

The ore from the mines in the Norilsk Combine is processed at the Norilsk concentrating mill and at the Talnakh concentrating mill. The Talnakh mill concentrates primarily rich ore to produce nickel and pyrrhotite concentrates. While its nameplate capacity is 9 Mt/y, it worked at a rate of only 3.5 Mt/y in early 1999. During 1999, progress was made in raising the grade of the concentrate produced from the Talnakh mill. The Norilsk mill handles the copper-bearing ores, the impregnation ores, and about 4 Mt/y of the rich ore. Separate nickel concentrate, copper concentrate and pyrrhotite concentrate are produced by the Combine's mills. The concentrates produced are relatively low grade compared to nickel sulphide concentrates produced at operations in Canada and Australia. Increasing the concentrate grade is a priority for the Norilsk Combine and an important goal of the 10-year development plan. The investment plan will direct all of the rich ore to the Talnakh mill and, at the same time, increase its effective operating capacity from 4 Mt/y first to 7 Mt/y and then to its nameplate capacity of 9.5-10 Mt/y. The second expansion from 7 Mt/y would accommodate production from the new 2-Mt/y Skalisty mine. Large-scale flotation units, automation, new crushing equipment, and a large ball mill are some of the ways being examined to expand the throughput at the Talnakh mill. At the same time, studies are under way to process more disseminated ore at the Norilsk mill as up to 4 Mt/y of rich ore will be diverted from the Norilsk mill to the Talnakh mill.

The Nadezhdinsky Works and the older Nikel Works process mainly the nickel concentrates while the Medny Works recovers copper using Vanyukov and reverberatory furnaces and electrolytic refining. The Nadezhdinsky Works includes a flash smelter and a hydrometallurgical section to process pyrrhotite concentrates. Management is considering closing the hydrometallurgical section that uses pyrrhotite feed and replacing it with a new nickel-refining section. Nadezhdinsky also handles precious metal and platinum group metal recoveries. The company describes Nadezhdinsky Works as the most highly modernized of its metallurgical operations.

The Pechenganickel Combine is located in the northern Kola peninsula. The Zhdanovskoe deposit and the Zapolyarnoe deposits are the principal orebodies worked in Pechenganickel. The two open pits of the Tsentralny mine on the Zhdanovskoe orebody account for 85% of the ore produced in the Kola peninsula. The present ore reserves will be exhausted by 2006, although a plan to extend the mine life to 2012/2015 is under consideration if the operations are cost-efficient. The Sverny and Kotselvaara mines exploit the Zapolyarnoe deposit while the Kaula-Kotselvaara mine operates on the Smiletka deposit. Ore is milled in Concentrating Mill No. 1 with a rated capacity of 7.5 Mt/y. In addition, a roasting facility processes nickel-copper concentrates. At the town of Nikel, a smelter produces matte in an electric furnace. Ore from the Norilsk Combine is being sent to the Pechenganickel Combine for concentration; management now believes that these shipments should cease within six to eight years (i.e., by 2005/07).

At Monchegorsk in the Severonickel Combine, processing facilities include a copper refinery, two nickel electrolysis shops, a carbonyl nickel facility, and cobalt chemical production facilities. The investment plans for the Severonickel Combine include optimization of the carbonyl nickel powder production, increased copper output, and increased recycling. The recycling of nickel was made easier by the export tax on nickel scrap, which diverted material to Severonickel and other nickel production facilities.

Increased nickel and precious metals prices provide RAO Norilsk with the opportunity to refurbish and modernize its facilities in order to compete more efficiently when future metal prices decline. As long as the state and sub-national governments allow RAO Norilsk to retain the increased revenues from the intermittent periods of high metal prices, RAO Norilsk should be able to successfully complete its modernization program and become a long-term competitive producer.

There are three other separate, significant nickel producers in Russia: **Ufaleynikel Joint Stock Co.**, the **Yuzhralnikel Kombinat Joint Stock Co.**, and the **Rezh Nickel Plant**. Ufaleynikel produced 5000 t of nickel in 1998. It was unable to obtain anticipated quantities of cobalt concentrates from the Norilsk Combine, and was therefore forced to reduce its cobalt production in February but was able to maintain nickel production. Its nickel feed consists of ore from the Sverdlovsk region, converter matte from the Rezh plant, and nickel scrap. Ufaleynikel stated its intention to raise nickel production to about 8500 t for 1999. In May, Rezh and Ufaleynikel formed the Uralnickel joint venture to manage the Serovskoye mine in the Sverdlovsk region. Although Ufaleynikel has mined the orebody under licence since privatization, the plant is in a different administrative region

than the mine. Under the agreement, Rezh, which is in the Sverdlovsk region where the Serovskoye mine is located, will receive sufficient ore from the mine to start up its third furnace.

By September, after obtaining more secure supplies of nickel feed (see above), the Rezh nickel plant reached an operating rate of about 7800 t/y of nickel in matte, compared to 6000 t produced in 1998. A secure ore supply from the Seovskoye pit will allow Rezh to restart production at its third furnace and boost production to 9000 t/y by early 2000. The Seovskoye pit produces 1.4 Mt/y of ore grading 1.2-1.3% nickel and has ore resources of about 140 Mt. Rezh produces metallurgical nickel powders and high-purity metal. While it has the capacity to produce nickel chemicals, the company intends to defer the decision on whether to proceed until after the presidential election in 2000. Rezh also intends to defer production of nickel chemicals until after the election. As was the case with the Severonickel Combine, Rezh was assisted by the export tax on nickel scrap, enabling it to obtain more domestic scrap in 1999. Rezh produces N3 nickel granules from matte; 40% of these go to meet domestic demand and the remaining 60% is exported, primarily by Glencore International AG.

Yuzhralnikel restructured itself into three operations: Yuzhpolymetall, Yuzhuralnikel, and the Nosta Works. The Nosta Works is leased to Norsk-Khalilovo Integrated Iron & Steel Works for the production of ferronickel matte used to make alloy steel at Norsk-Khalilovo. In April, Yuzhpolymetall reactivated its nickel hydrate production facilities.

Australia

While delays in start-up caused financial problems for three nickel-cobalt laterite producers in Australia (the Murrin Murrin, Cawse and Bulong projects), these delays contributed to higher nickel prices that benefited all nickel producers. Australian nickel production in 1999 was 108 100 t of nickel in concentrates, down from 143 500 t in 1998, and 77 900 t of refined nickel, down from the 79 600 t produced in 1998. The major reason for the drop in Australian production was the closures at WMC Limited.

Anaconda Nickel Limited officially opened its Murrin Murrin operation in late July. While the project did not attain the planned operating rate set out in the company's earlier schedule, it did achieve three major milestones: first, it was certified as mechanically completed, two weeks ahead of what would have been a technical default on US$300 million in bonds due in 2014, issued by Glencore Nickel Pty. Ltd.; second, Murrin Murrin began production in May; and third, it received a vote of confidence and funding when Sherritt International Corporation and later Anglo American plc purchased stock in Anaconda Nickel. Sherritt announced its purchase of A$45 million of shares (12.9 million shares) in May. Anglo purchased 77.3 million shares for over US$243 million through its Australian subsidiary, Anglo American Investments (Australia) Limited. By early January 2000, the three leading shareholders in Anaconda Nickel were Anglo American with 23%, Glencore International with 19.35% and ANZ Nominees with 11.55%.

Anaconda started up its refinery at Murrin Murrin in late January. After two years of construction and commissioning, the plant began production of nickel-cobalt sulphide in May, producing the first nickel briquettes during the same month. The first cobalt briquettes were produced on July 9. Mechanical completion of the refinery was achieved in June. In mid-December, Anaconda won a court case giving it access to A$45 million in guarantees from Fluor Daniel Pty Ltd. on the basis of failure "to rectify initial design deficiencies" in the A$1.2 billion plant. Anaconda also stated its intention to proceed with claims for A$300 million against Fluor Daniel through arbitration.

On June 30, Anaconda received the necessary environmental approvals to begin construction of its Stage II portion of the Murrin Murrin operation. The Stage II expansion would increase total production capacity at Murrin Murrin to 115 000 t/y of nickel and 9000 t/y of cobalt. Engineering work began in 1999 on the expansion and, at year-end, the company expected to issue the first construction tenders during the first quarter of 2000. Anaconda announced that it expects to operate Stage I at its rated capacity of 45 000 t/y of nickel and 3000 t/y of cobalt by mid-2001. Throughout 1999, Anaconda continued exploration work at its Marshall Pool, Lawlers, Tottenham, Weld Range and Siberia properties. As of year-end, total reserves at Murrin Murrin, including Murrin Murrin East, Murrin Murrin South and Abendego, totaled 330 Mt grading 1.00% nickel and 0.063% cobalt at a 0.8% nickel cutoff grade. At the Mount Margaret project, the nickel-cobalt resources totaled 376 Mt grading 0.71% nickel and 0.044% cobalt at year-end. Metallurgical testwork for the Mount Margaret project was undertaken by Dynatec Corporation at Fort Saskatchewan, Canada. Dynatec has been involved in the design of many acid pressure leach facilities for nickel-cobalt laterites. Dynatec has a site on the Internet at http://www.dynatec.ca.

Throughout 1999, Anaconda continued to seek new opportunities in Australia and Papua New Guinea (PNG). Through its subsidiary, Murrin Murrin Investments Pty. Ltd., Anaconda completed the acquisition of Abednego Nickel Limited in February, adding over 22 Mt of reserves. Anaconda also conducted exploration drilling at the Three Rivers project in Queensland and field geology work at the

Marlborough project, also in Queensland, as well as at the WoWo Gap project in PNG. The three aforementioned properties are part of a joint venture, established in 1998, with Cobra Resources NL in which Anaconda can earn up to a 70% interest.

Anaconda forged new alliances with the other two nickel laterite producers, Preston Resources NL and Centaur Mining & Exploration Limited, who also were ramping up production. Anaconda agreed to fund feasibility studies and to provide financing, if found feasible, to fund expansions at the Bulong and Cawse sites. In an agreement with Resolute Limited, the largest shareholder in financially troubled Preston Resources NL, which operates the Bulong project, Anaconda agreed to fund the study of an expansion from 9000 t/y to 40 000 t/y of nickel. The decision on the expansion is expected at the end of the third quarter of 2000. The agreement for Cawse announced in November with Centaur Mining & Exploration Limited would allow Anaconda to earn a 60% share if Cawse could be expanded to 50 000 t/y. If Cawse were to be expanded to only 40 000 t/y of nickel, then Anaconda would have only a 50% share. A prefeasibility study of the possible expansion at Cawse is expected in mid-2000; if favourable, this would be followed by a bankable feasibility study to be completed in mid-2001. Anaconda has a site on the Internet at http://www.anaconda.com.au.

Preston Resources NL's A$250 million Bulong operation was the second, after Cawse, of the three Australian laterite projects to reach commercial production. However, it was the first to produce cobalt metal on site from laterite (Cawse produces only cobalt sulphide). The delays in reaching projected operating rates caused serious financial difficulties not only to Preston, but also to Resolute Limited, a major shareholder in Preston. On October 24, Preston requested that trading in its shares be halted pending finalization and announcement of a recapitalization plan. On October 28, Preston and Anaconda announced their strategic alliance to study the feasibility of expanding Bulong to at least 40 000 t/y. As well as funding the feasibility study of an expansion, Anaconda would be responsible for marketing the additional production from an expanded operation. Anaconda also obtained the option to purchase all of Resolute's shares in Preston, exercisable until January 2001. The Bulong operation reached an annualized operating rate of 5100 t/y of nickel during November, compared to its design capacity of 9000 t/y. In November, Preston forecast that the plant would not reach design capacity until June 2000. Bulong produced a total of 2480 t of nickel and 79 t of cobalt metal in 1999.

Preston also owns the Marlborough project, near Rockhampton in Queensland, controlled through a wholly owned subsidiary, Marlborough Nickel Pty Ltd. The global resource at Marlborough is 210 Mt grading 1.02% nickel and 0.06% cobalt contained in 10 orebodies. In the September 1999 quarter, Preston reported proved ore reserves of 16.3 Mt grading 0.89% nickel and 0.05% cobalt, and probable reserves of 56 Mt grading 0.79% nickel and 0.06% cobalt. Preston's feasibility study of the project indicated that an acid pressure leach and electrowinning operation to produce 25 000 t/y of nickel and 2000 t/y of cobalt could be built for A$688 million. Preston later determined that the ore grade could be upgraded by about 30%; the upgraded feed to the autoclave should allow the project to produce at a peak rate of 27 000 t/y of nickel and 2700 t/y of cobalt, assuming 2 Mt/y of ore feed at a beneficiated grade of 1.5% nickel and 0.15% cobalt.

Preston's Malborough project was designated a Major Project Facilitation (MPF) by the Australian government. This designation allows more timely and efficient approvals for proposed development. While Preston had hoped to have the plant on stream by 2002, the financial problems caused by the delays at Bulong led Preston to state that the financing of Marlborough would not be forthcoming until the economics of the Bulong project had been demonstrated and until Bulong had reached its design capacity. Preston estimated that these events would not occur until at least June 2000. Preston has a site on the Internet at http://www.prestonres.com.au.

Centaur Mining & Exploration Limited was the first to commission the new generation of nickel-cobalt laterite plants in Australia with the official opening on May 14, 1999. The A$340 million project shipped its first commercial nickel cathodes on February 25, 1999. The first shipment of cobalt sulphide occurred in January 1999; production of cobalt sulphide began in late December 1998. The project has 50 Mt of mineable reserves within a resource of 193 Mt grading 0.7% nickel and 0.04% cobalt, although initial feed to the plant is planned to be 2% nickel and 0.49% cobalt. Centaur expected to take two years to ramp up to its capacity of 10 000 t/y of nickel and 1500 t/y of cobalt in cobalt sulphides, although Centaur stated its desire to achieve this rate by mid-2000.

Despite becoming cash flow positive in September, Centaur experienced difficulties with cash flow and Standard and Poor's lowered the credit rating of Centaur in March and again in April. Centaur raised A$27 million by selling a power station and raised a further A$36.7 million by selling SX-EW equipment, which Cawse then leased back for a minimum of 15 years. Following an agreement with Heron Resources NL in August, Centaur announced its intention to complete a prefeasibility study by mid-2000 of an expansion of Cawse to 45 000 t/y of nickel cathode and 3000 t/y of cobalt in salts. Assuming a favourable result, Centaur intended to follow this up with a bankable feasibility study by mid-2001. A

strategic alliance between Heron and Centaur increased the ore reserves accessible to Cawse; in return, Heron secured the right to supply a minimum of 20% of the ore feed to Cawse II or a total of 24-48 Mt from the Goongarie, Kalpini and Ghost Rocks orebodies over 30 years starting in early 2003. In addition, Heron received the right to supply high-grade ore to Cawse I under a tolling agreement. The agreement will earn A$2 million annually from March 2000. Heron also received A$3 million as a result of the alliance, which it will use for further exploration of the three deposits.

In November, Centaur and Anaconda formed a strategic alliance to advance the Stage II expansion of the Cawse operations to a minimum of 40 000 t/y of nickel and 3000 t/y of cobalt (see above). If the prefeasibility study, due in mid-2000, is favourable, it would be followed by a full feasibility study to be completed in mid-2001. If the expansion were to proceed, Centaur and Anaconda would take equal shares of the expanded output up to a total (Stage I + Stage II) production of 40 000 t/y. If the total capacity were to be greater than 40 000 t/y, Anaconda would then receive an additional 1% share of the expanded output for each additional 1000 t/y of nickel production beyond 40 000 t/y to a maximum of 60% of the expanded operation. Centaur has the option of requiring Anaconda to fund all or part of Centaur's required equity component, which would dilute Centaur's interest accordingly. Centaur has a site on the Internet at http://www.cme.com.au.

Following an upgrading of ore reserves, **Black Range Minerals NL** began a bankable feasibility study of its Syerston lateritic nickel-cobalt property located in New South Wales, 400 km west of Sydney. The A$10 million for the study was provided by CIBC Capital Partners of the Canadian Imperial Bank of Commerce. The bankable feasibility study is to be completed by April 2000. Earlier, a prefeasibility study by Fluor Daniel Pty Ltd., completed in September 1998, had shown that a project would be viable with a throughput of 1.5 Mt/y of ore producing 15 500 t/y of nickel and 2900 t/y of cobalt at a cost of A$493 million. In mid-year, Black Range reported the global resource at 100 Mt grading 0.66% nickel and 0.11% cobalt. In the September quarter report, Black Range reported that pilot work had indicated that 2 Mt/y could be handled by a single autoclave; Black Range therefore increased the design throughput to 2 Mt/y. The design feed for the first five years was estimated at 1.08% nickel and 0.27% cobalt. At a feed rate of 2 Mt/y, the plant would produce 20 000 t/y of nickel metal and 5000 t/y of cobalt metal. The refinery may be designed to vary the cobalt metal production by up to 2000 t/y based upon market conditions. Assuming a favourable bankable feasibility study, Black Range intends to begin construction in the third quarter of 2000 in order to commence commissioning in the fourth quarter of 2001. Black Range has a site on the Internet at http://www.blackrange.com.

Jubilee Gold Mines NL decided to proceed with the development of its Cosmos deposit. Following completion of project financing, Jubilee announced the formal go-ahead for the Cosmos Nickel Project on October 4. The deposit is small and high grade with 420 000 t grading 7.52% nickel. Nickel production is expected to begin in the second quarter of 2000. The output of 10 000 t/y of nickel contained in concentrates will be sold to Inco Limited over the three-year life of the orebody. Jubilee has a site on the Internet at http://www.jubileegold.com.au.

In September, **Comet Resources NL** decided to increase the scale of the proposed development at its 80%-owned Ravensthorpe lateritic nickel-cobalt project from 22 000 t/y of nickel and 1400 t/y of cobalt to 35 000 t/y of nickel and 1900 t/y of cobalt. Comet achieved this by planning to add a second autoclave to the plant design. The second autoclave made the project more competitive by increasing output by 40% and by increasing capital costs by only 20% to A$870 million. The mineable reserves at Ravensthorpe are 52 Mt of ore grading 0.92% nickel and 0.04% cobalt within a resource of 150 Mt grading 0.9% nickel and 0.04% cobalt. The study has shown that the mine output can be upgraded by 221% for nickel and 195% for cobalt. Comet has a site on the Internet at http://www.cometres.com.au.

In November, Billiton plc's subsidiary, **QNI Ltd.**, entered into a joint-venture agreement with Comet. The joint venture married two assets: Comet's Ravensthorpe orebody and QNI's Yabulu refinery. This marriage reduces the technical risk for the project by utilizing an existing refinery with an operational history. Plans call for a "front-end" acid pressure leach plant to be built at Comet's Ravensthorpe deposit in Western Australia. The plant would produce a nickel and cobalt concentrate for shipment to QNI's Yabulu refinery in Queensland.

The first stage of the Comet-QNI agreement was an A$10 million, four-month feasibility study to be financed by QNI. The results are due in the first quarter of 2000; if encouraging, QNI would be able to acquire 40% of the Ravensthorpe nickel project from Comet for A$36 million. Construction might begin in the first half of 2001 with the start of commissioning and ramp-up occurring in the first quarter of 2003. About two years will be needed to complete the ramp-up to normal production. An important advantage of the Ravensthorpe ore is that it can be upgraded to 2% nickel for at least the first 10 years. QNI agreed to a take-or-pay agreement that will reduce the risks for the Ravensthorpe portion of the joint venture. QNI would undertake and fund the expansion of the Yabulu refinery to 65 000 t/y of nickel and 3000 t/y of cobalt to handle the additional 35 000 t/y of nickel

and 1300 t/y of cobalt production expected from Ravensthorpe. The total project costs are estimated at about US$630 million. The Yabulu refinery currently imports the majority of its ore from New Caledonia, about one third from Indonesia, and a small percentage from the Philippines. The price of the imported ore is related to the LME nickel price, so a lower-cost ore supply and greater throughput would enhance the competitive position of Yabulu by decreasing operating costs. Yabulu produced 25 400 t of refined nickel and 1500 t of cobalt in 1999 at a cost of US$2.55/lb. Information on QNI can be found on Billiton's web site at http://www.billiton.com.

Outokumpu Oyj operates nickel mines in Australia to supply its smelter in Finland. In July, the company announced an A$134 million expenditure to develop the Cygnet deposit at its Black Swan nickel mine near Kalgoorlie, Western Australia. Outokumpu had purchased the remaining 50% interest in the Silver Swan mine in November 1998 and renamed it Black Swan. As of July, the Black Swan mine was producing 13 000 t/y of nickel in concentrates. Black Swan's ore deposits are called the Silver and White Swan orebodies; at year-end these two orebodies contained 0.2 Mt grading 9.7% nickel of proved reserves, 0.1 Mt grading 8.4% nickel of probable reserves, and 0.1 Mt grading 10% nickel of inferred resources. The Black Swan area has an additional 30 Mt grading 0.8% of inferred resources. The Cygnet orebody is a lower-grade disseminated deposit consisting of 0.2 Mt grading 2.2% nickel of proved reserves, 0.5 Mt grading 2.4% nickel of probable reserves, and 2.4 Mt grading 1% nickel of indicated reserves. Once Cygnet begins operation in February 2000, the combined Black Swan/Cygnet operations will produce 450 000 t/y of ore grading 4.5% nickel. This will yield 18 000 t/y of nickel in concentrates. To achieve the increased concentrate production, Outokumpu will relocate the concentrator from its Forrestania mine, which closed at the end of August. Forrestania produced about 55 000 t of nickel contained in 3.8 Mt of ore mined over a period of seven years; rehabilitation and final closure of Forrestania is expected to take two to three years. Information about Outokumpu's Australian operations can be found on the Internet at http://www.outokumpu.com.

WMC Limited operates underground and open-pit mines in Australia. Its mines produce more concentrates than the company's Kalgoorlie smelter can process; excess concentrates are exported to Outokumpu's smelter at Harjavalta in Finland. WMC's Kwinana refinery at Freemantle does not have the capacity to handle the entire output from the Kalgoorlie smelter so surplus matte is exported to Sumitomo Metal Mining Co. Ltd. in Japan. WMC produces nickel powder and briquettes at Kwinana. The cobalt by-product from WMC is toll-refined by Falconbridge's Nikkelverk refinery in Norway.

WMC does not release its cobalt production data but, according to the *Metal Bulletin*, its capacity is said to be about 1000 t/y of cobalt in sulphides.

WMC made major production reductions during 1999, both voluntary and involuntary. The company produced 31 500 fewer tonnes of nickel in concentrates than in 1998, and sales of nickel in matte declined by 19 500 t compared to 1998. The reductions began with a furnace leak on January 3 that shut down the Kalgoorlie nickel smelter for two months. WMC estimated the lost nickel production at 15 000 t. It re-opened the Kalgoorlie smelter ahead of schedule, on March 4, producing the first metal on March 6. While the smelter was shut, WMC suspended milling operations at its Leinster and Kambalda operations. Shortly after the smelter was producing again, WMC announced that two underground mines (the Long/Victor and Mariners) at Kambalda would be put into a care-and-maintenance status. These mines joined the idled Otter/Juan mine, whose closure had been announced in September 1998. The closure of these two mines reduced nickel production by a further 10 000 t/y.

During the third quarter, the Converter Fume Capture Project at the Kambalda smelter was commissioned. Hoods over the converters to capture additional sulphur dioxide emissions were installed and the captured emissions were routed to the acid plant. WMC's production in 1999 and comparative figures for 1998 were: nickel in concentrate, 88 275 t (119 731 t); nickel in matte, 79 668 t (100 071 t); and nickel metal, 53 009 t (53 695 t). WMC may increase its nickel and cobalt production during 2000 due to the higher prices of nickel, but no re-openings were announced in the first quarter of the year. WMC has a site on the Internet at http://www.wmc.com.au.

Encouraged by the success of its internet sales site for cobalt metal established in August at http://wmc-cobalt.com, WMC began selling nickel metal through its site at http://wmc-nickel.com in September. This site enables WMC to participate in spot and near-term sales, as well as in longer-term contract sales. The reference price for all transactions is the official LME Settlement Price for the pricing period.

Cuba

Cuba's 1999 nickel production was below target, due partly to unusual amounts of rainfall late in the year. **Cubaniquel** produces Class II nickel oxide sinter from the Ernesto Che Guevara Mining and Metallurgical Combine's Punto Gorda mine and the René Ramos Latour Mining and Metallurgical Combine's Nicaro mine. The reported capacities of the smelters at these Combines are 30 000 t/y of nickel plus cobalt at the Punta Gorda smelter, and 22 000 t/y of nickel plus cobalt at the Nicaro smelter. In December,

Cubaniquel forecast that production from these plants would be between 41 000 and 42 000 t for 1999, down from earlier estimates of 45 000 t. The national production (Cubaniquel's production plus output from Metals Enterprise's joint-venture operation) amounted to an estimated 67 000 t of contained nickel in 1999. The output from Nicaro and Punto Gorda was expected to remain unchanged in 2000.

Sherritt International Corporation and **General Nickel Company S.A.** of Cuba each have a 50% interest in a joint-venture operation called Metals Enterprise. The Metals Enterprise operates a lateritic nickel-cobalt mine at Moa, Cuba, that produces mixed nickel and cobalt sulphides from its lateritic orebody. Production in 1999 was 27 020 t of contained nickel plus cobalt, virtually the same as the 27 066 t produced in 1998. During the fourth quarter of 1999, the Moa operation produced 7045 t of nickel and cobalt contained in mixed sulphides, a record for the plant.

Three major developments occurred with respect to new production capacity in Cuba during the year. Officials from RAO Norilsk visited Cuba during the year to discuss potential investments there, possibly concerning the partially completed Las Camariocas plant. However, talks broke off and no agreement was reached. Also during the year, WMC closed its Pinares laterite exploration project in Cuba. QNI continued its work on the San Felipe project. QNI has a 75% interest in this nickel-cobalt project. A government organization, Geominera, has the remaining 25% share. The San Felipe deposit exceeds 200 Mt grading 1.3% nickel.

New Caledonia

Inco Limited officially commissioned a 12-t/d pilot plant at its Goro project in southern New Caledonia on October 22. The pilot plant will test Inco's proprietary process for treating lateritic nickel-cobalt ore. The new process runs at a higher temperature than do the acid leaching operations built recently in Australia. The higher temperature promotes faster reactions. This reduces the autoclave capacity needed per tonne of ore treated. The process is designed to produce a nickel oxide that will be exported to Asian refineries. The cobalt in the laterite will be recovered as a cobalt carbonate precipitate. A decision on whether Inco will proceed with a commercial plant is expected in late 2000. Plans in 1999 called for a US$1.3 billion operation producing 54 000 t/y of nickel as nickel oxide plus 5400 t/y of recovered cobalt. The plant could be built in one or two stages; if construction were to start in 2001, commissioning could take place in 2004. At year-end, the total of measured plus indicated plus inferred resources at Goro was 219 Mt grading 1.57% nickel and 0.18% cobalt. Within the resources are 47 Mt of proved plus probable reserves grading 1.59% nickel and 0.17% cobalt, delineated for initial mining. These 47 Mt of reserves consist of 35 Mt of proved material grading 1.46% nickel and 0.18% cobalt plus 12 Mt of probable reserves grading 1.95% nickel and 0.12% cobalt. **Goro Nickel S.A.** is owned 85% by Inco and 15% by the Bureau de Recherches Géologiques et Minières de France.

Falconbridge holds a 49% interest in a joint venture with **La Société Minière du Sud Pacifique S.A.** (SMSP) to examine the feasibility of exploiting the Koniambo deposit in the Northern Province of New Caledonia. As of the end of 1998, an inferred resource of saprolitic laterite totaling 132.4 Mt grading 2.46% nickel and 0.06% cobalt had been identified. Falconbridge planned to spend US$15 million-$25 million annually during the period 1999-2001/02 to complete the evaluation of the reserves (including investigation of the additional limonitic resources), to assess the technical aspects of the planned operation, and to conduct environmental baseline studies for an environmental review. Falconbridge expects to begin the prefeasibility study of the Koniambo project in the third quarter of 2000 and to start the feasibility study by the end of 2003. The project's goal is the construction of a ferronickel plant capable of producing 54 000 t/y of nickel in ferronickel.

Through Eramet Nickel, The Eramet Group of France has a 60% interest in **Le Nickel-SLN**. Le Nickel-SLN operates nickel mines and a nickel-processing plant near Nouméa, the capital of New Caledonia. It also operates four mining centres on the island located between 120 and 400 km from the company's Doniambo ferronickel smelter. The four centres that feed Doniambo are Kouaoua, Nepoui-Kopeto, Tiebaghi and Thio. Thio also sent laterite ore to smelters in Japan as well. Le Nickel-SLN's Doniambo plant has a capacity of 60 000 t/y of nickel in ferronickel, making it the world's largest ferronickel plant. Doniambo's nickel output is 80% in the form of granulated ferronickel and 20% as nickel in matte. In 1999 the plant produced 56 642 t of nickel, up slightly from the 56 502 t produced in 1998. Eramet has a web site on the Internet at http://www.eramet.fr.

Argosy Minerals Inc. was formed in May 1999 by the merger of **Calliope Metals Corporation** and **Argosy Mining Corp.** The merger gave the new company access to two laterite nickel deposits, one in New Caledonia and one in Burundi. In New Caledonia, Argosy has an agreement with **Société des Mines de la Tontouta** (SMT) with respect to SMT's mining concessions at Nakety. Argosy has an exclusive licence from Dynatec for the use of Dynatec's acid pressure leach technology within a 40-km radius around the Nakety deposit. By the end of 2000, Argosy intends to complete a feasibility study of development of the mine and processing of the ore. If the results are favourable, Argosy will form a joint

venture with SMT to exploit the orebody and build the plant. The total measured and indicated ore reserves at Nakety are 34.6 Mt grading 1.53% nickel and 0.11% cobalt. About 40% of these reserves, or 13.5 Mt, are saprolite ore that grades 1.83% nickel and 0.06% cobalt. The remaining 21 Mt is limonite ore grading 1.33% nickel and 0.14% cobalt. In addition to these reserves, Argosy has inferred total reserves of 48.3 Mt grading 1.42% nickel and 0.12% cobalt. Various possibilities for the development of Nakety have been examined. One possible scenario is a US$615 million operation mining 4 Mt/y of ore to produce 34 500 t/y of nickel metal plus 2000 t/y of cobalt metal or salts and 112 800 t/y of ammonium sulphate. A second scenario is a US$300 million, Stage I "front end" plant processing 1.5 Mt/y ore to produce intermediates (sulphides or hydroxides or carbonates) containing about 20 000 t/y of nickel and 2300 t/y of cobalt. A staged development may be the most likely scenario with initial production of 2 Mt/y, followed by expansions to 4 Mt/y and perhaps to 8 Mt/y as finances and markets permit. Argosy plans to complete environmental and regulatory permitting in 2000, then to complete a final feasibility study and obtain financing in the second half of 2000, and finally to start construction in the first half of 2001. Argosy has a site on the Internet at http://www.argosy-mining.com.

Asia

Japan supports a nickel smelting and refining industry based on imported ore. Three ferronickel producers import garnierite ore (nickel silicates) from New Caledonia, the Philippines and Indonesia. Two companies process imported matte into refined nickel and nickel oxide sinter. Japan produced 134 000 t of primary nickel in 1999. Internet links to Japanese nickel and stainless steel companies can be found at http://www.gcis.com/japan.

The three ferronickel producers and their capacities are: **Pacific Metals Co., Ltd.**, with a capacity of 40 000 t/y of nickel contained in ferronickel, **Hyuga Smelting Co. Ltd.** (a subsidiary of **Sumitomo Metal Mining Co., Ltd.**), with a capacity of 18 000 t/y of nickel contained in ferronickel, and **Nippon Yakin Kogyo Co. Ltd.**, with a capacity of about 12 700 t/y of nickel contained in ferronickel. These ferronickel plants produce material grading about 20% nickel. Pacific Metals increased its production from 37 000 t in fiscal year 1998 to 42 000 t in fiscal year 1999 (ending in March 2000) as export markets in Taiwan and South Korea strengthened. Pacific Metals also announced in March that it would cease its stainless flat-rolled and stainless steel billet operation in order to concentrate on ferronickel production; the company had previously ceased producing stainless steel round bars and rods in September 1998.

In March, Inco announce the amalgamation of its Tokyo marketing operation with **Tokyo Nickel Company, Ltd.**, then owned 51% by Inco. The new company, **Inco TNC Limited,** is owned 67% by Inco, 12.8% by Sumitomo Metal Mining Co., Ltd., and 16% by other Japanese companies. Inco TNC imports nickel matte from the PT Inco operation in Indonesia and then converts it to nickel oxide sinter (78% nickel) and to utility nickel (96% nickel) for sale to the stainless steel industry. Inco TNC expanded its capacity in 1998 from 36 000 t/y to 60 000 t/y of nickel contained in either oxide sinter or in utility nickel.

Sumitomo Metal Mining Co., Ltd. imports nickel matte from Australia and Indonesia to produce refined nickel cathode and nickel chemicals in its plant at Niihama. Sumitomo can produce about 36 000 t/y of contained nickel, having increased its capacity from 24 000 t/y in 1998. Sumitomo announced a production cutback in mid-March due to low nickel prices. Production in 1999 was forecast at 29 300 t of nickel in cathodes and chemicals plus an additional 15 000 t of nickel in ferronickel at its Hyuga subsidiary. In November, Sumitomo announced plans to boost the production of nickel in metal and chemicals to 34 000 t in 2000 and to increase the production of nickel in ferronickel at Hyuga to 19 000 t from 17 000 t in 1999.

In South Korea, the **Korea Nickel Corporation** (KNC), owned 25% by Inco Limited, takes nickel oxide sinter feed and refines it to Class 2 melting-grade nickel used to make stainless steel. KNC increased its production capacity from 16 500 t/y to 32 000 t/y, officially commissioning its new plant at Onsan on August 17. To meet customer demand, KNC purchased refined nickel to supplement its production. Due to an expected shortage of nickel oxide feed from Inco, KNC lowered its production forecast for 2000 in November from 32 000 t to between 28 000 and 29 000 t. KNC produced an estimated 19 000 t of Class 2 nickel in 1999 from its old and new plants.

Inco owns 49.9% of the **Taiwan Nickel Refining Corporation**. The company converts nickel oxide sinter into Class 2 or utility nickel grading 97% nickel. The refinery has a capacity to produce 14 000 t/y of contained nickel. Taiwan Nickel obtains nickel oxide from Canada, Australia and Japan.

The majority of China's nickel is produced by the **Jinchuan Nonferrous Metals Corporation** in Gansu Province. Jinchuan's two underground mines produce between 2.5 and 3 Mt/y of ore averaging about 1.25% nickel and 0.89% copper. Jinchuan operates an electric furnace and flash furnaces, and produces nickel cathodes by electrolytic refining. In April, Jinchuan shut down one of its refineries due to low prices for nickel. The refinery was re-opened in

the summer. This shut-down cut production at Jinchuan by about 5000 t of refined nickel. In December, Jinchuan signed an agreement to transfer its 1.2 billion yuan debt to banks and asset management companies in return for an 18% equity share in Jinchuan. The company's production capacity was reported in the media as 34 000 t/y of refined nickel plus 500 t/y of cobalt; however, the International Nickel Study Group's publication, *World Directory of Nickel Production Facilities*, reported capacity as 40 000 t/y of refined nickel. The **Jilin Nickel Industry Co.**, in Jilin Province, mines nickel-copper ore and smelts the concentrates at its smelter. The smelter also takes material from the Tonghuan mine, located in the same province. Jilin's reported capacity is 5500 t/y of nickel in matte. The smelter was shut down in October 1998 due to low nickel prices; it was reportedly re-opened in March 1999. Jilin's matte is sent to the Chengdu operation in Sichuan Province for refining. Chengdu also takes matte from the small Huili mine and smelter located in Sichuan Province.

The Philippines has not processed nickel ore since the Nonoc plant shut down in 1986. Four mining operations mine and export ore, principally to Japan. The **Hinatuan Mining Corp.** operates two nickel laterite mines, both of which have ore grading about 2.3% nickel. **The Rio Tuba Nickel Mining Corp.**'s laterite mine has a capacity of about 0.5 Mt/y of ore. The smallest operation is owned by **Taganito Mining Corp.** with a capacity of about 100 000 t/y of ore.

Mindex ASA had identified a laterite resource of 49 Mt grading 0.94% nickel and 0.08% cobalt on Mindoro Island in the Philippines. The company needed $10 million for a full feasibility study that would take 18-24 months to complete. Mindex had planned to start construction in 2003 of a 40 000-t/y nickel plant that would also produce 3000 t/y of cobalt and 126 000 t/y of ammonium sulphate fertilizer. Capital costs were estimated at $650 million. A prefeasibility study of the deposit was completed in August 1998 by Kvaerner Metals; the estimated cash costs were US30¢/lb, assuming cobalt credits of US$4.10/lb. The company also considered an expansion to 80 000 t/y of output using Mindex's concession on Palawan Island for additional feed. **Crew Development Corporation**, based in Vancouver, acquired Mindex ASA of Norway when shareholders approved the plan in late December. In early 2000, Mindex was delisted on the Oslo stock exchange and Crew was listed. Crew has a site on the Internet at http://www.crewgroup.com.

Kvaerner Metals sold its 25-30% interest in **Philippine Nickel Corporation** (Philnico) to **Macquarie Bank** and **Pacific Energy Ltd**. Kvaerner had planned the rehabilitation of Nonoc, shut since 1986, using acid pressure leach technology. Previous plans had envisaged completion of the rehabilitation during 2001 at a production rate of 38 000 t/y of nickel at a cost estimated at US$650 million. Glencore International retained an offtake agreement for the entire output.

PT International Nickel Indonesia Tbk (PT Inco) completed its expansion by 50% to 68 000 t/y of nickel contained in nickel matte. Production was adversely affected by the continued low rainfall, which restricted hydro-electric production. The power bottleneck prevented full operation of all three electric furnaces at PT Inco. A rebuild of the thermal power plant, completed at the beginning of the second quarter, allowed PT Inco to increase its operating rate despite the continued below-average rainfall. PT Inco completed the expansion of its operation in the fourth quarter. The company expected that the ramp-up of production in 2000 would be constrained if low rainfall were to continue. PT Inco arranged to borrow up to US$200 million from Inco Limited to complete the expansion and to meet cash requirements. As of September 30, US$102 million of this facility had been drawn. Inco expected that the expansion will reduce operating costs by at least 10%. Production in 1999 was 45 400 t, up 28.6% from the 35 300 t produced in 1998.

PT Aneka Tambang (Persero) Tbk operates two lateritic nickel mines, one at Gebe Island and one at Pomalaa on Sulawesi Island. The company's two ferronickel smelters are also located on Sulawesi Island. In addition to its own operations, Aneka Tambang has interests in laterite projects in Indonesia. Aneka Tambang has a 10% interest in the Weda Bay nickel laterite project and a 25% interest in the Gag Island project with The Broken Hill Proprietary Company Limited (BHP). In August, Aneka Tambang and PT Inco entered into negotiations about a joint venture to explore within PT Inco's 66 000-ha concession.

Aneka Tambang mines more ore than it needs at its smelters, so it sells the surplus to Japanese smelters and to QNI's Yabulu plant. In mid-February, the company restarted its No. 1 ferronickel smelter. This smelter had been shut down for six months for modernization and relining. The modernization program increased its capacity to 11 500 t/y of nickel in ferronickel. Aneka Tambang produced 9140 t of nickel in ferronickel during 1999, up from 8451 t in 1998. In 1999, the production of laterite ore was virtually unchanged from 1998; the company's high-grade nickel laterite ore production was over 2.03 Mt (wet) while low-grade ore production was 1.14 Mt (wet).

Aneka Tambang was reorganized in mid-year in preparation for its partial privatization. The initial stage of privatization was in 1997 when the government sold off 35% of the company. However, the privatization was delayed until at least the first quarter of 2000. The program to expand nickel

production at Aneka Tambang to 24 000 t/y of nickel in ferronickel was delayed due to financing difficulties. Aneka Tambang has a site on the Internet at http://www.antam.co.id.

As noted above, Aneka Tambang also owns 10% of the Weda Bay project. The project is managed by **Weda Bay Minerals Inc.**, a Canadian company listed on the Toronto Stock Exchange in April. Indicated and inferred resources are estimated at 117 Mt (dry) grading 1.36% nickel and 0.12% cobalt. This includes an indicated resource of 60 Mt (dry) grading 1.51% nickel and 0.09% cobalt using a cutoff grade of 1% nickel and 0.1% cobalt. A cobalt-rich indicated resource of 10 Mt (dry) grading 0.81% nickel and 0.18% cobalt has also been identified. Metallurgical testing in 1997 showed that an acid pressure leach plant at Cape Ulie on Halmahera Island would be feasible. In 1998, testwork at Dynatec Corporation's facility in Fort Saskatchewan confirmed the suitability of the processing option. A project evaluation study reported favourable results for a US$890 million plant processing 4 Mt/y and yielding 60 000 t/y of nickel metal and 2660 t/y of cobalt. The 2-Mt/y option was also considered in 1999. It would produce 30 000 t/y of nickel and 1330 t/y of cobalt for a capital cost of only US$550 million. Weda Bay has a site on the Internet at http://wedabay.com.

Ownership of the Ramu project changed during 1999. First, Highlands Pacific Ltd. purchased an additional 10% of the project from a private company based in Papua New Guinea (PNG) called Eastern Pacific Mines. This transaction increased Highlands' share to 68.5% of Ramu. Shortly thereafter, Nord Pacific Limited sold its 35% interest to **Orogen Minerals Limited** (OML) for US$6.75 million. The Government of PNG has a 51% stake in OML. It also has the option to purchase an additional 25% share from the major shareholder and plans ultimately to give a 5% interest to local landholders. Before the project is developed, Highlands and Orogen are expected to sell half of their interests to an incoming third party, leaving Highlands and Orogen with a 22.5% share each.

The expected cost of the Ramu project is US$838 million. The orebody has been defined as having a resource of 143 Mt grading 1.01% nickel and 0.1% cobalt. The partners expect production to be 33 000 t/y of nickel plus 3200 t/y of cobalt metal produced by acid pressure leach and electrowinning. Costs have been estimated at US41¢/lb in the project feasibility study. The partners hope to obtain environmental permits early in 2000, secure financing in mid-2000, and see first commercial production in 2002. The current plans call for the mined ore to be shipped via a 130-km slurry pipeline to a refinery located at a deep-water port site at Basamuk. This location would also minimize the costs of obtaining sulphur from Canada to make sulphuric acid for the leaching process. Deep-water disposal of the tailings from the plant site at Basamuk is being considered. Highlands has a site on the Internet at http://www.highpacific.com.au.

Africa

In Botswana, **Bamangwato Concessions Limited** (BCL) operates three underground mines and a smelter. The BCL mines produce a nickel-copper concentrate; their capacity is approximately 19 500 t/y of nickel in concentrates. The smelter's capacity is 26 000 t/y of nickel in matte. BCL's smelter handles the company's own mine output as well as material from the Tati operation, also located in Botswana. In 1999, it also took 2500 t of nickel-copper concentrate diverted from WMC in January when WMC experienced an unexpected furnace shut-down. BCL sends most of its nickel-copper matte output to Falconbridge's refinery in Norway and sends a small share to the Empress refinery in Botswana. Information about BCL can be obtained on the Internet at http://www.mbendi.co.za/indy/ming/mingbo.htm.

Tati Nickel Mining Company (Pty) Ltd. in Botswana is owned 41.65% by LionOre Mining International Ltd., a Canadian company, and 43% by Anglo American plc. Tati's Selkirk and Phoenix mines produce nickel and copper that are smelted at BCL. The BCL smelter in Botswana experienced technical difficulties during the third quarter of 1999, restricting its feed intake. Tati completed a feasibility study to increase nickel production by 200% to about 12 500 t/y of nickel. The study included a possible expansion and construction of a concentrator. LionOre has an Internet site at http://www.lionore.com and Anglo American has a site at http://www.angloamerican.co.uk.

Argosy Mining Corp. acquired all the issued shares of Andover Resources NL in early 1999, thereby gaining control of the Musongati, Nyabikere and Wage nickel-cobalt laterite deposits in Burundi. The three orebodies, located 1100 km by rail from the port of Dar Es Salaam, contain inferred resources of 185 Mt grading 1.31% nickel and 0.08% cobalt using a cutoff grade of 0.8% nickel. Within the Musongati deposit, the inferred resource is 72 Mt grading 1.56% nickel, 0.12% cobalt and 0.30% copper. Argosy has a site on the Internet at http://www.argosy-mining.com.

Phelps Dodge Corporation continued the evaluation of its Ambatovy nickel-cobalt laterite deposits in Madagascar. The project was stalled during the year awaiting the resolution of permitting and regulatory issues. The estimated grade of the mineralized material is 210 Mt grading 1.1% nickel and 0.1% copper. Phelps Dodge holds a 100% interest in the property.

In South Africa, the Nkomati joint-venture mine owned 75% by **Anglovaal Mining Limited** and 25% by Anglo American is the only operation in South Africa that produces nickel as a principal product. In the financial year ending June 30, the Nkomati mine produced 3875 t of nickel in concentrate, or about one third more nickel in concentrate than planned. Nkomati's nickel is mostly recovered at the Bindura operation in Zimbabwe; some also goes to South Africa for recovery. A feasibility study to expand production at the nickel-cobalt-copper-platinum group metals mine from 16 000 t per month to 150 000 t per month was to have been completed before the end of 1999. The remaining nickel production in South Africa is a by-product of the platinum group metals operations. Anglovaal has a site on the Internet at http://www.avmin.co.za. **Impala Platinum Holdings Ltd.** has the capacity to produce 14 500 t/y of by-product refined nickel powder and briquettes at its platinum group metals refinery at Springs. **Rustenburg Platinum Holdings Ltd.** has two smelters and a refinery that have the capacity to produce 21 000 t/y of by-product nickel in cathode. **Western Platinum Limited**'s capacity is 3000 t/y of by-product nickel in nickel sulphate from its refining operations. **Northern Platinum Ltd.**'s capacity is 1900 t/y of by-product nickel contained in nickel-cobalt sulphate. South Africa produced an estimated 35 800 t of nickel in concentrates and an estimated 35 800 t of refined nickel in 1999.

In Tanzania, Anglo American continued its drilling program of the Kabanga project in accordance with its agreement with **Barrick Gold Corporation** (which acquired a share in Kabanga when it purchased Sutton Resources Ltd.). A prefeasibility study showed 21 Mt grading 2.2% nickel, within which a higher-grade section of 15 Mt grading 2.6% nickel, 0.3% copper and 0.2% cobalt was identified. A mining rate of 860 000 t/y is being considered; this would yield 17 000 t/y of nickel, 1600 t/y of copper and 1200 t/y of cobalt. Anglo American expects to complete the full feasibility study by September 2001. If the study is favourable, a start-up date in 2004 is envisaged. Anglo American can earn up to 60% of the project if it invests at least US$27 million. It may consider refining at Bindura Nickel in Zimbabwe as one option for processing material from Kabanga. Further information on Anglo American is available on the Internet at http://www.angloamerican.co.uk.

In Zimbabwe, **Bindura Nickel Corporation Ltd.**, a subsidiary of Anglo American plc, has a capacity to produce up to 14 000 t/y of refined nickel. Bindura also took concentrates from the Nkatomi mine in South Africa. The Madziwa mine is Bindura's smallest mine, producing at a rate of 1200 t/y of nickel in concentrate; a portion of Madziwa is scheduled to close in 2000. The Shangani mine, which produced 3100 t of nickel in 1998, is scheduled to close in 2008. The Trojan mine is Bindura's largest producer. In order to access deeper reserves, Trojan's shaft was deepened in 1997/98 at a cost of Z$27 million; the company may again deepen the shaft to extend the mine life to 2007. A decision about extending the shaft at the Trojan mine is required by 2003 if production is to continue past 2007. Bindura produced 8723 t of contained nickel in 1998/99, down 13% from one year earlier. In addition to this production in 1998/99, the company processed an additional 4150 t of nickel in imported concentrates. Bindura has not yet been able to identify another viable exploration target in Zimbabwe. Information about Bindura can be found on Anglo American's Internet site at http://www.angloamerican.co.uk.

The Empress nickel refinery in Zimbabwe is owned 56% by **Rio Tinto Mining (Zimbabwe) Ltd.** It processes nickel-copper matte from BCL in Botswana as well as imported nickel sulphate to produce refined nickel. Capacity at Empress is 8300 t/y of nickel cathode. Total production at Empress in 1999 was 7027 t of nickel in 1999, up 9.3% from the 6430 t produced in 1998. Information about Empress can be found on Rio Tinto plc's Internet site at http://www.riotinto.com.

Latin America

In Brazil, **Mineraçao Serra da Fortaleza Ltda.**, owned by Rio Tinto plc, operates the Fortaleza operation. This sulphide operation began in 1998. The open pit mined 550 000 t/y of ore from an orebody with reserves of 5.7 Mt grading 2.14% nickel. The capacity of the smelter is 10 000 t/y of nickel in matte, which is sent to Outokumpu's refinery in Finland under a long-term contract. Fortaleza produced 9445 t of nickel contained in matte in 1999, up 102% from the 1998 production of 4670 t. Elsewhere in Brazil, **Cia de Niquel Tocantins**, increased production to 16 300 t of nickel and 630 t of cobalt from its laterite mines in Niquelandia and its refinery in São Paulo, up from the 1998 level of 12 980 t of nickel and 364 t of cobalt. Tocantins increased its capacity to 17 500 t/y of nickel in late 1998 at a cost of US$130 million. **Codemin SA**, owned 90% by Anglo American, operates a lateritic nickel mine and ferronickel smelter in Niquelandia that has a capacity of 6500 t/y of nickel in ferronickel. Further information about Codemin can be found on Anglo American's Internet site at http://www.angloamerican.co.uk.

Billiton plc's nickel property in Colombia is called **Cerro Matoso S.A. (CMSA)**. It consists of a 77 000-ha concession containing open-pit nickel laterite operations and an existing 29 000-t/y ferronickel smelter. Mine reserves of the laterite deposit at year-end were 40 Mt grading 2.3% nickel, at a cutoff grade of 1.5% nickel, and are adequate for over 15 years of ore supply. The current feed grade averages about 2.82% nickel. At the end of 1999, the

operation was in the process of being expanded. Over half of the budget of US$353 million had been spent by year-end. The expansion involves the construction of a second production line with a planned capacity of 20 000 t/y of nickel in ferronickel. The second line will raise CMSA's capacity to 55 000 t/y of nickel in ferronickel. The project is due to be completed in April 2001. CMSA plans to take an additional 18 months to work up to design capacity. Debottlenecking has already reduced costs at CMSA from US$2.50/lb to US$1.50/lb since 1996; the expansion is expected to reduce costs further. Production in 1999 was estimated at 28 300 t of nickel contained in ferronickel. Further information about CMSA can be found on Billiton's Internet site at http://www.billiton.com.

Falconbridge Dominicana, C. por A. (Falcondo) re-opened its plant in the Dominican Republic at the end of January. The operation had been closed for three months due to weak markets and to repair the power plant and furnace corrosion problems. In the first quarter, Falcondo reduced its production target for 1999 from 28 000 t of nickel in ferronickel to 26 000 t. In the third quarter, Falcondo reduced its production target for 1999 to 25 000 t because of power supply interruptions. Production for 1999 was 24 454 t, down 3% from 1998's production. Because of the higher oil prices and lower production, cash operating costs increased to US$2.12/lb. The target for production in 2000 is 30 000 t of nickel in ferronickel. Falcondo's proven plus probable reserves in December 1999 were 53.6 Mt grading 1.21% nickel.

Falcondo received its ISO 14001 environmental certification during the year; it is the first ferronickel plant to be so certified. At year-end, Falcondo had not completed negotiation of a new labour contract with its 1000 workers at the mine and ferronickel smelter. Although the labour contract expired in October, work continued past the contract expiration date while negotiations continued, as has been the practice in the past. A new contract was signed in early 2000 that will run until December 1, 2002. The increase in oil prices in late 1999 will cause operating costs at Falcondo to rise; in early February 2000, the operating costs had risen to US$2.50/lb. Information on Falcondo can be found on Falconbridge's Internet site at http://www.falconbridge.com.

Anglo American owns 82.5% of the **Loma de Niquel** project in Venezuela. The open-pit mine and ferronickel smelter are expected to be in operation in the second or third quarter of 2000. The capacity of the operation will be 16 800 t/y of nickel in ferronickel. The laterite reserves at Loma de Niquel are 34 Mt grading 1.48% nickel. Anglo American has a site on the Internet at http://www.angloamerican.co.uk.

Europe

At the end of 1998, the **General Mining and Metallurgical Co. S.A.** (LARCO) in Greece announced a production cutback to 12 000 t/y of contained nickel in ferronickel. LARCO has a capacity of 18 000 t/y of nickel in ferronickel. In 1998, the Greek government had stated its intention to sell its interest in LARCO and had requested non-binding expressions of interest by February 26, 1999. In October, a Greek trading company held discussions with the Greek government and the other owners of LARCO about purchasing the company. As of year-end, no further details were available. LARCO is expected to boost its production in 2000 to take advantage of higher nickel prices.

Outokumpu Oyj operates a custom nickel smelter and refinery in Finland as well as mines in Australia and Finland. In 1999, Outokumpu's mines in Australia produced 23 100 t of nickel in concentrate, compared to 22 400 t in 1998. This concentrate was shipped to Harvjavalta as feed for Outokumpu's flash smelter. In addition, Outokumpu took nickel concentrates from the Mt. Keith mine in Australia, owned by WMC Limited, and about 3000 t/y of nickel in concentrate from the Nikkel og Olivin mine in Norway (owned 70% by Outokumpu). In 1999, Outokumpu produced 52 800 t of nickel metal, an increase of almost 10 000 t from the 43 400 t produced in 1998. Outokumpu also processed about 9000 t of nickel matte from Rio Tinto plc's 10 000-t/y Fortaleza operation in Brazil.

In mid-November, Outokumpu announced that its Hitura nickel mine in Finland would be re-opened. The mine had been closed in mid-1998 due to low prices. Hitura's capacity is 3500 t/y of nickel in concentrate; its reserves are adequate for five years of production. Hitura was the first mine to re-open in 1999 as a result of the higher nickel prices. For details about Outokumpu's mines in Australia, please refer to the section in this chapter on Australia. Outokumpu has a site on the Internet at http://www.outokumpu.com.

The Eramet Group of France received authorization at a July general meeting to purchase the Sima Group, a leading producer of nickel alloys, superalloys, and special steels. At the same time, Eramet Nickel sold 30% of its holdings in Le Nickel-SLN to be later transferred to a New Caledonian public company that was then in the process of being incorporated. This left Eramet Nickel with a 60% share in Le Nickel-SLN and a 100% interest in the Sandouville refinery near Le Havre, France. Sandouville is a hydrometallurgical facility with a capacity to produce 13 000 t/y of high-purity electrolytic nickel, 3000 t/y of nickel contained in nickel chloride, 300 t/y of cobalt as cobalt chloride, and 3100 t/y of iron as ferric chloride. The matte from Le Nickel-SLN's Doniambo

plant in New Caledonia is finely ground, then leached by a ferric chloride solution that converts the nickel, cobalt and iron into chlorides. Eramet has a site on the Internet at http://www.eramet.fr.

Falconbridge Nikkelverk A/S operates a refinery at Kristiansand, Norway, that was expanded in 1998 to a capacity of 85 000 t/y of nickel, 40 500 t/y of copper and 4500 t/y of cobalt. The refining process consists of grinding the matte into a very fine powder, putting it into a chlorine leach, and then recovering the nickel by electrowinning. As well as taking matte from Sudbury, Falconbridge takes nickel matte from BCL and other sources. Kristiansand's capacity could be increased to 100 000 t/y of nickel (plus 60 000 t/y of copper and 5000 t/y of cobalt) if market conditions warrant. During 1999, Nikkelverk's output was restricted due to a feed limitation caused by furnace problems at Falconbridge's Sudbury smelter. In 1999, refined output from Nikkelverk was 74 137 t, up 5% from 70 152 t in 1998, but this represented only 87% of capacity. During the year, the forecast output from Nikkelverk was lowered from 85 000 t to 79 000 t in the first quarter, and then to 75 000 t in the third quarter. Falconbridge forecast its production in 2000 from Nikkelverk as 80 000 t of nickel and 4000 t of cobalt.

Inco Limited's Clydach plant in Wales, United Kingdom, uses nickel oxide from Canada as feed for its carbonyl refinery. Clydach is the only significant producer of primary nickel in the United Kingdom, producing 38 400 t in 1999. Clydach also produces cobalt oxide.

In the former Yugoslav Republic of Macedonia, the Feni-Mak laterite mine and smelter was believed to have produced very little ferronickel during 1999. The effective capacity of the plant was reported in the media as 3000 t/y of nickel in ferronickel, down from 8000 t/y in the mid-1990s. At year-end, it was reported that talks were being held between the government and potential investors about a possible sale and reactivation of the plant.

The Feronikel Kosovo plant at Glogovac in Kosovo, Yugoslavia, takes feed from the open-pit laterite mine with reserves grading about 1% nickel. The plant capacity was reported at 7000 t/y of nickel in ferronickel but no production data were available for 1999 and the plant is thought to have been idle during the year.

CONSUMPTION

The stainless steel industry is the largest consumer of primary nickel, accounting for about two thirds of consumption. Other important consuming sectors include the nonferrous alloys, plating, low-alloy steel and foundry sectors (Figure 2). Stainless steel is "stainless" or corrosion-resistant when it contains a minimum of 10.5% chromium by weight. A thin film of chromium oxide adheres to the surface of stainless steel. When damaged, this film is self-healing if sufficient oxygen is present. The presence of nickel gives stainless steel superb resistance to corrosion, even in harsh operating environments. The common form of stainless steel that contains nickel is called "austenitic." Its weldability characteristics are very good, making it a good choice for construction. Austenitic stainless steel has exceptional resistance to extreme temperatures. In addition, austenitic stainless steel is very easily cleaned and therefore has excellent hygienic characteristics.

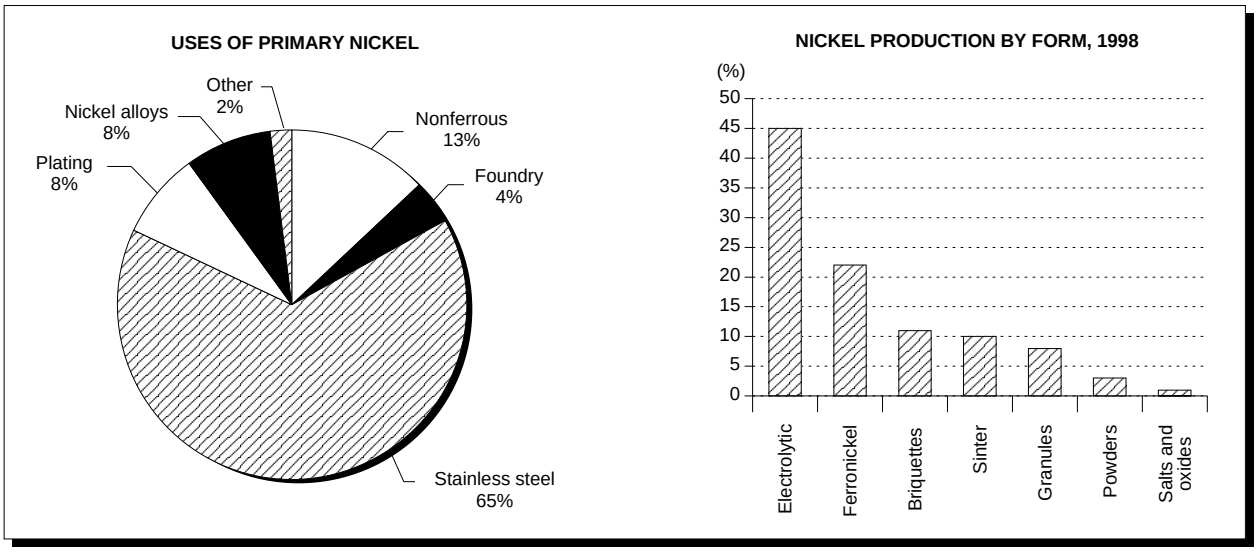
Stainless steel comes in a variety of grades and types. The most common grade is a 304 grade composed of 18-20% chromium and 8-10.5% nickel with most of the remainder being iron. While austenitic stainless steel contains nickel, ferritic stainless steel need not. A guide to these two types of stainless steel and others can be found at the Specialty Steel Industry of North America's Internet sites at http://www.ssina.com/stainless.html and http://www.ssina.com/student.html. General information on stainless steels can be found on Outokumpu's Internet site at http://www.outokumpu.com/steel/pprod4.htm. Additional information is available from the International Iron and Steel Association's Internet site at http://www.worldsteel.org/issf/issf_about/index.html. A list of stainless steel producers and organizations can be found at http://www.mlc.lib.mi.us/~stewarca/stainless.html.

Stainless steel and high-nickel alloys are used in many applications including gas turbines, petroleum refining, the chemical industry, the food industry, flue gas desulphurization plants, batteries (in both nickel-cadmium and nickel-metal hydride cells), liquified petroleum gas tank liners, cryogenic applications, electronics, surgical equipment, and household goods (such as cutlery, building facings and building trim). Various car manufacturers continued their work on the development of nickel-metal hydride batteries to power electric and hybrid cars.

Stainless steel production reached an estimated 17 Mt in 1999, up from 16.4 Mt in 1998. The production increase accelerated near year-end with fourth-quarter production up about 13% compared to the fourth quarter of 1998. Forecasts for production in 2000 were in the range of 18.25 Mt as double-digit increases occurred in early 2000.

Information about cobalt consumption can be obtained from Canmine' Internet site at http://www.canmine.com/me/index.html (click on "cobalt market"), and from the U.S. Geological Survey Internet site at http://minerals.usgs.gov/minerals/pubs/commodity/cobalt.

Figure 2
Nickel Uses and Production



Source: Outokumpu Oyj 1999.

Source: *Into the New Millennium*, RAO Norilsk Nickel.

HEALTH AND THE ENVIRONMENT

Nickel is a naturally occurring element that exists in soil and is believed to make up a large percentage of the earth's core. It is also considered to be an essential element for plants and most animals. Nickel has been proven to be an absolute growth requirement for certain types of bacteria and algae, and nickel deficiencies in animals have been linked to growth retardation. Besides being an essential element for plants and many animals, it is the view of many experts that nickel is likely an essential element for humans as well.

The average human body contains an estimated 7-10 milligrams of nickel, and nickel is present in human fetal tissue. Food is the major route for nickel intake by humans. The ingestion of nickel has not been shown to be either a cause of cancer in humans or a cause of nickel sensitivity. The principal health risks associated with oxidic, sulphidic and soluble nickel compounds include lung or nasal cancer and contact dermatitis.

Nickel dermatitis is caused through long-term direct or indirect contact of the skin with certain nickel-containing items that can dissolve in sweat and penetrate the skin. It is estimated that 10-20% of women and 1-2% of men are "sensitive" to nickel, with nickel dermatitis being one of the principal adverse health effects. However, many nickel alloys, including stainless steel, do not react with sweat and therefore do not cause a nickel allergy.

In the past, increased rates of lung and nasal cancers were experienced by personnel employed in certain dusty nickel-processing facilities where most of the workers involved were also exposed to other substances in the dust and where tobacco smoking was a compounding factor.

In 1999, two studies were released that address health issues and nickel. The first was the peer-reviewed "TERA Study" (prepared by Toxicology Excellence for Risk Assessment), dated March 1999, entitled *Toxicological Review of Soluble Nickel Salts*. This study was funded by Health Canada, the U.S. Environmental Protection Agency and the Metal Finishing Association of Southern California, Inc. It reviewed available data and is available on the Internet at http://www.tera.org/vera/nickel%20doc%20page.htm. The study reviewed the non-cancer effects of soluble nickel compounds (such as effects on the lungs and kidneys, and nickel sensitivity). Areas of uncertainty and deficiencies in existing studies were noted. The cancer effects of soluble nickel compounds were also reviewed with the conclusions that:

- "Human studies suggest a secondary role for soluble nickel in occupational carcinogenicity, whereas water-soluble nickel salts are not carcinogenic in experimental animals exposed by inhalation or oral routes;
- "Water-soluble salts of nickel are distinctly different from water-insoluble nickel compounds with respect to carcinogenic potential, as demonstrated by data from both the inhalation and perenteral routes;

- "Assays of the carcinogenic activity of water insoluble nickel compounds should not be used to predict the carcinogenic potential of water-soluble nickel salts."

The report then said that the carcinogenic potential of inhaled water-soluble nickel salts cannot be determined because of conflicting results. The report also said the carcinogenic potential of soluble nickel compounds by oral exposure cannot be determined because of inadequate data (TERA Study, paraphrased – refer to the report on the Internet for full conclusions).

The European Confederation of Iron and Steel Industries (EUROFER) commissioned a review of the health effects of stainless steel by The Institute of Occupational Health at The University of Birmingham. The report, entitled *Manufacture, Processing and Use of Stainless Steel: A Review of the Health Effects*, was dated January 1999. Its main conclusions included (pp. iii and iv of the the executive summary):

- "The suggestion that 'no acute toxicity would be anticipated';

- "Prolonged skin contact with most stainless steel grades is unlikely to elicit a skin response in nickel-sensitised individuals (it was noted that prolonged contact with, AISI 303, a resulfurised grade of stainless steel grade . . . may evoke skin reactions in nickel-sensitised subjects);

- "No evidence of specific reactions to stainless steel implants over and above non-specific responses that would be seen with any inert implanted material;

- "Results from a single intra-muscular carcinogenicity study provide no evidence for the carcinogenicity in animals of metallic stainless steel."

The report is available from EUROFER, Rue du Noyer 211, B-1000, Bruxelles, Belgium.

RECYCLING

Nickel is a metal that is intensively recycled. This recycling is driven by economic incentives, not government subsidies. The major competitor for primary nickel's biggest market, stainless steel-making, is nickel in scrap. On a worldwide basis, about 45% of the nickel needed by the austenitic stainless steel industry is obtained in the form of stainless steel scrap. Stainless steel scrap not only contains nickel, but also chrome and iron, which are needed to produce austenitic stainless steel.

Roughly 65% of the consumption of primary nickel is used for the production of austenitic stainless steels. As an approximate calculation, this would amount to 700 000 t of primary nickel of the 1 080 000 t consumed in 1999. At a ratio of 55:45 of primary to scrap nickel inputs, the implied consumption of scrap nickel by the austenitic stainless steel industry would have been in the order of about 570 000 t. At an average nickel content of 8%, this implies that over 7 Mt of austenitic stainless steel was recycled in 1999; the economics of the recycling of stainless steel are driven by the value of the contained nickel. (Billiton plc estimated 510 000 t.[5]) Billiton also estimated that an additional 170 000 t or so of nickel in alloys are recycled yearly. This implies a total nickel consumption (primary plus secondary) of approximately 1.6-1.7 Mt in 1999. More precise data on scrap usage in stainless steels are available from many sources, including The Eramet Group.

NICKEL ORGANIZATIONS

Fifteen nickel-producing and consuming nations are members of the International Nickel Study Group (INSG) based in The Hague. The Group publishes comprehensive monthly nickel statistics (refer to Table 11 for details). A new directory of nickel mines and plants, including two annual updates, is to be sold starting in mid-1999. The INSG has a site on the Internet at http://www.insg.org.

The Nickel Development Institute (NiDI), based in Toronto, is funded by most major nickel producers. NiDI provides technical information about nickel alloys to end users and promotes new uses for nickel from offices in Toronto, London, Beijing, Tokyo, India, Australia and South Korea. The organization has a quarterly publication about applications, entitled *Nickel*, with a circulation of 35 000 in over 90 countries. It also publishes *Communiqué*, which is about regulatory developments affecting nickel, twice a year. Both are available free upon request. NiDI has an Internet site at http://www.nidi.org.

The Nickel Producers Environmental Research Association (NiPERA) conducts and sponsors independent research into the health and environmental effects of nickel and nickel compounds. NiPERA has a site on the Internet at http://www.nipera.org.

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[5] Billiton plc, slide 157, Nickel Seminar, is available by going to http://www.billiton.com. Choose "Investor Relations" from the menu at the left, then go to "Our Presentations" and choose either a download of PowerPoint slides or complete a request for a CD-ROM.

PRICES AND STOCKS

Nickel prices strengthened throughout 1999, bouncing back from their progressive weakening during 1998. The LME cash settlement price averaged US$6026/t, up strongly from US$4618/t in 1998 but still below the 1997 average. Prices varied from US$3885/t (January) to US$8450/t on December 30. The daily settlement prices from the start of 1994 to the end of 1999 are shown in Figure 3. LME stocks declined from 65 988 t at the end of 1988 to 47 304 t at the end of 1999. The long-term relationship between prices and stocks is shown in Figure 4.

Table 7 shows the average yearly nickel prices over the period 1981-98. Table 8 shows the average monthly prices for the period 1994-98. Historical and current LME nickel prices can be found on the Internet at http://www.lme.co.uk and at http://metalprices.com.

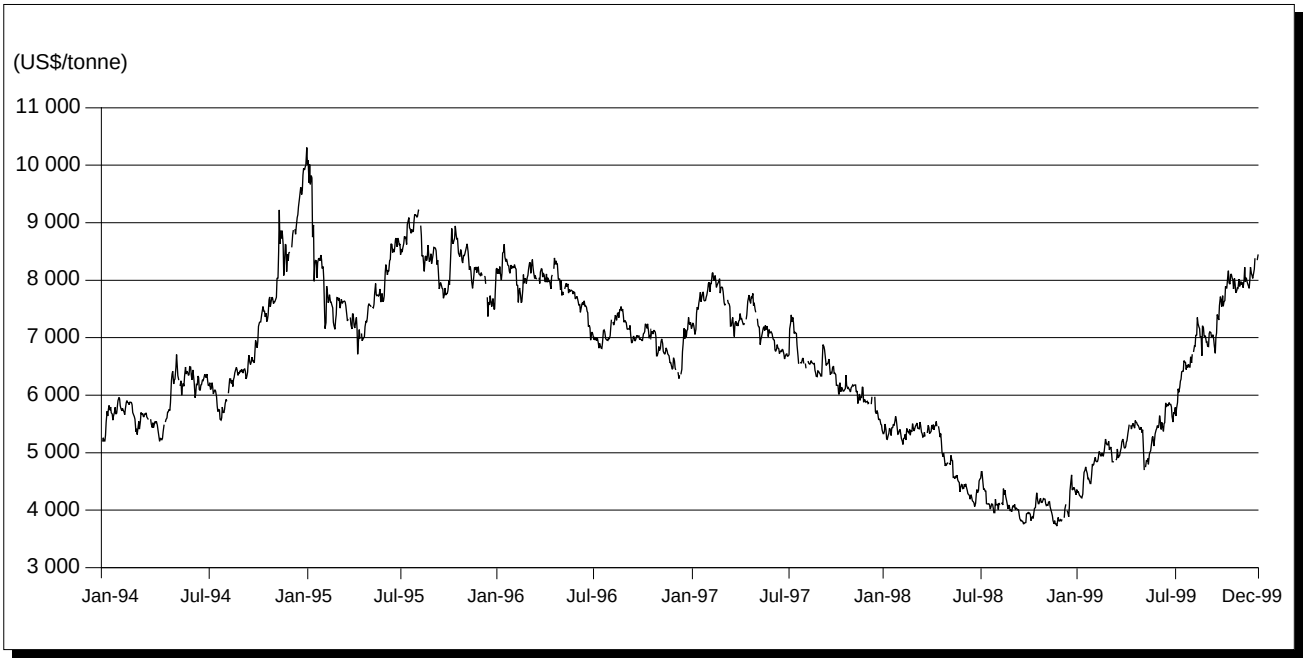
The LME decided to allow the delivery of approved full-plate cathode starting January 4, 2000, for payment of a standard discount of US$100/t. The discount reflects the approximate cost of cutting cathode into 10 cm x 10 cm or 2.5 cm x 2.5 cm sections, which up until 2000 were the form in which the nickel had to be delivered against the LME contracts. Various producers whose full-plate cathode has been approved for delivery at the standard discount, such as RAO Norilsk and Tocantins, indicated that they did not initially plan to deliver full-plate cathode for the standard discount. The forms of nickel that constitute good delivery are cut cathodes, pellets or briquettes. Acceptable brands and other details for trading on the LME are available at the LME web site noted above.

OUTLOOK

The demand for nickel is largely a function of the demand for austenitic stainless steel and high-nickel alloy steels. The major determinant for continued nickel and stainless steel demand is the continued growth in industrial production (see Figure 5). Infrastructure growth demands heavy use of stainless steel. The growth rate for austenitic (nickel-containing) stainless steel is expected to exceed that for ferritic (containing little or no nickel) stainless steel. Presently, about 74% of stainless steel output is austenitic. The demand for primary nickel is expected to continue to increase at over 3% per year on average, based upon continued U.S. and world economic growth.

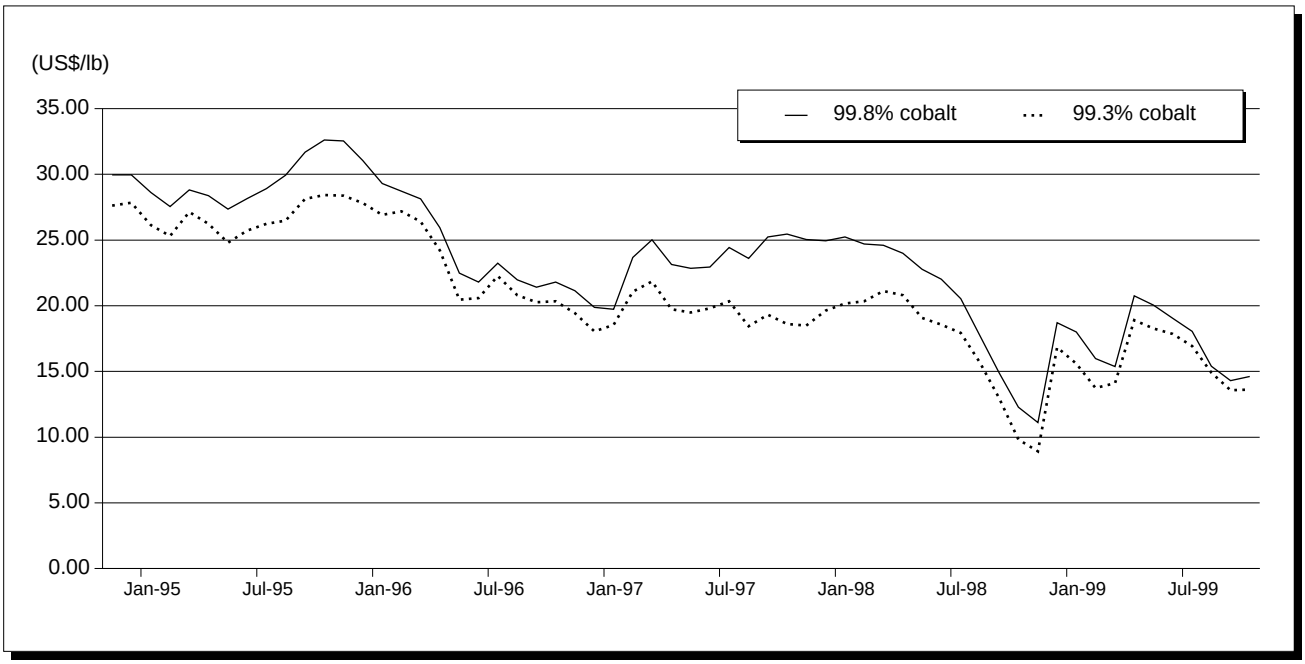
The aggregate non-stainless steel demand for nickel is expected to grow much more slowly than the demand for primary nickel in austenitic stainless steel. For example, nickel use in iron and steel castings for the automotive industry is expected to decline due to substitution by lower-cost alternatives.

Figure 3
London Metal Exchange Cash Settlement Nickel Price, 1994-99



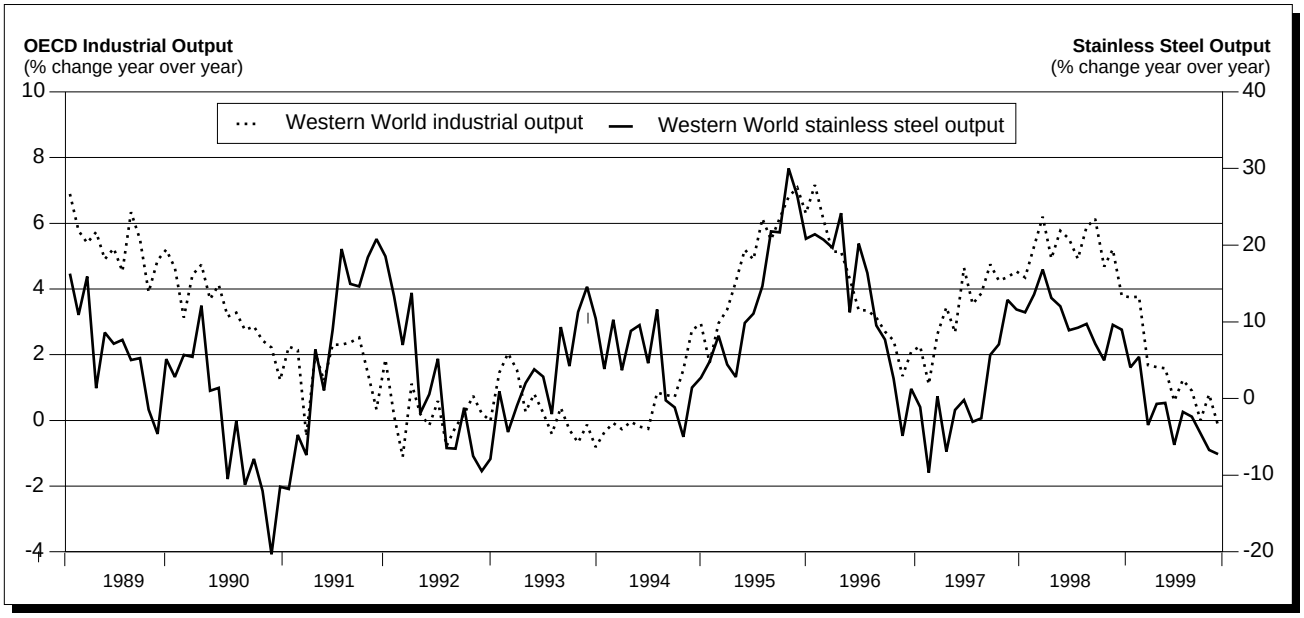
Sources: International Nickel Study Group; Reuters; World Bureau of Metals Statistics.

Figure 4
Cobalt Prices, Average of High and Low Prices, 1995-99



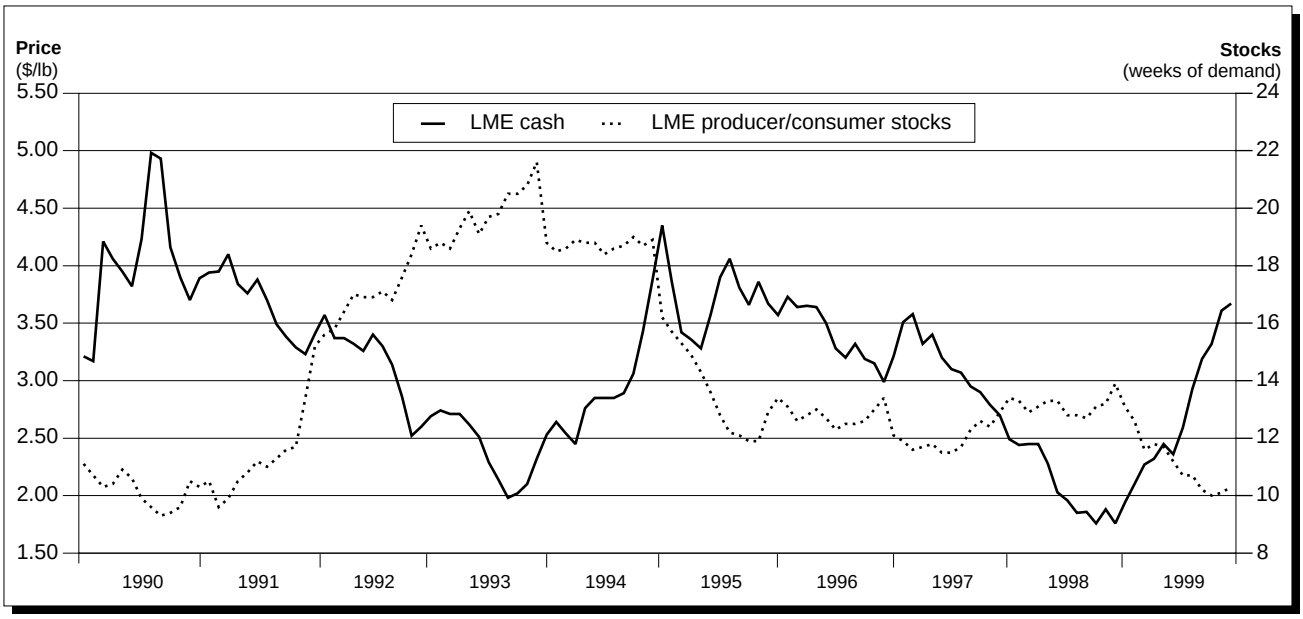
Source: Metal Bulletin monthly averages.

Figure 5
Stainless Steel Output and Industrial Output, 1989-99



Source: Macquarie Equities Limited, January 26, 2000, used with permission.

Figure 6
Nickel Stocks and Prices, Monthly, 1990-99



Source: Macquarie Equities Limited, January 26, 2000, used with permission.

However, the automotive industry's demand for nickel may increase rapidly from a small base at present if nickel-metal hydride batteries become the battery of choice for electric and hybrid motor vehicles. Inco estimated that for every 1% of the world automobile production that is converted to hybrid vehicles (i.e., having both an electric motor and a gasoline motor), the demand for nickel would increase by 10 000 t/y. Inco also noted that some automotive executives have estimated that between 5% and 10% of all vehicles manufactured worldwide will be hybrid vehicles within a decade.

A number of new technologies appear to be vying against each other to become the lowest-cost technology to recover nickel and cobalt from lateritic ores. Australia is the main proving ground at present; its net evaporative climate may give Australia a distinct competitive advantage in managing the residues of hydrometallurgical processing. However, these plants experienced more difficulties than their owners had foreseen. The delay in ramping up production at these operations was a significant factor in the run-up of nickel prices in 1999. Except for Inco's new pilot plant at its Goro site, new nickel laterite developments appeared to be stalled at the study stage in 1999.

The new laterite technologies have the potential to have a greater relative impact on the cobalt market than on the nickel market. Because most laterite projects will depend more on the nickel revenues than the cobalt revenues, operators are not expected to make major changes such as closure or expansion (although some like the Syerston project are being designed to be able to vary the cobalt production rate relative to the nickel production rate). As much of the present cobalt production is the by-product of copper mining, deriving an increasing share of cobalt production from nickel operations will change the dynamics of cobalt price fluctuation. This dynamic will also be abetted by the more transparent markets courtesy of Internet sites such as, for example, WMC's cobalt site. As cobalt production is expected to increase significantly during the next five years, cobalt prices are expected to decrease substantially. Thus, once the lower prices have spawned new uses for cobalt and the substitution of cobalt into new markets, the cobalt price may regain its volatility, albeit at lower price ranges than in the past 10 years. Figure 4 shows the *Metal Bulletin* monthly average high and low prices. The superalloy/special metals and some chemical producers prefer the higher-grade cobalt to reduce the levels of impurities that might cause difficulties and increase operational costs.

Looking at the new nickel-cobalt laterite projects from the nickel aspect, with the associated revenues from cobalt recovery, these operations have the potential to lower the average operating costs for these lateritic nickel-cobalt producers and to reduce overall nickel production costs. This will put increased competitive pressures on the rest of the nickel industry. The success of new nickel laterite

technologies would also reduce cobalt prices to the US$5-$10/lb range (some guess an even lower price), especially if a number of cobalt deposits in the Congo also proceed. The acid pressure leach "revolution" epitomized by Murrin Murrin has proven, so far, to be more of a "stop and go" process due to continued operational and design problems.

Nickel prices are more volatile than those of other major nonferrous metals. Part of the reason for this is that the nickel industry is very small compared to the industries of other metals. If recycled nickel contained in stainless steel scrap is included, total nickel consumption was about 1.5 Mt in 1999, compared to 6 Mt of lead, over 8 Mt of zinc, over 17 Mt of copper and 30 Mt of aluminum.[6] Thus, the forecast for nickel is presented as a range rather than as discreet values by year.

In the 1998 edition of this review, an average nickel price of US$5510/t (US$2.50/lb) was forecast for 1999, based upon continued progress in resolving the financial problems in Asia, continued Chinese economic growth, and a moderately healthy resumption in growth of stainless steel production. In reality, the price averaged US$2.73/lb during 1999, or 9% greater than forecast. There are three main reasons for underestimating the nickel price for 1999. The first reason was the strong demand growth for nickel, which was up over 70 000 t, or 7%, compared to 1998. This increased demand was the product of strong demand for stainless steel during 1999. The second reason was the poor record of the new Australian producers at ramping up their production in 1999, which limited supply growth. These operations produced about 20 000 t less than anticipated in 1999. The third reason was the lowered production at major producers such as Inco, WMC and Falconbridge; together these three companies produced 60 000 t less than they had originally forecast for 1999.

The forecast for 2000 is that strong nickel prices should continue, assuming that the continued restocking and increased demand for stainless steel observed in late 1999 continue throughout 2000. A price of US$4.30/lb, or US$9500/t, is forecast for 2000 based upon declining nickel inventories and increasing demand but, if a strike were to occur in Sudbury at the Inco or Falconbridge operations, or at both these operations, then prices should rise much higher. Extended strike action could cause prices to reach higher levels.

The longer-term price for nickel is expected to range between US$4400 and $8800/t (US$2 and $4/lb).

This long-term range of average annual prices should gradually decline, by perhaps US$550-$880/t (US25¢-40¢/lb), if new lateritic production technologies operate at or near their predicted rates, recoveries and costs.

While average annual prices for any particular year are expected to fall within this projected price band, unforeseen events at production facilities could cause major supply interruptions and, consequently, substantially higher prices until supply/demand relationships are restored to more normal ranges. (The market situation in 2000 is an example of an unusual conjunction of low stocks, high demand growth, and threat of strikes.) Such events would include serious technical problems at leading producers (e.g., extended labour or transportation problems at the Norilsk Combine) or political problems (e.g., political problems associated with the future of New Caledonia). On the other hand, major new discoveries of high-grade orebodies should lead to a period of lower prices.

It is difficult to say if these prices should be quoted in constant dollars (i.e., inflation adjusted) or current dollars (i.e., dollars of the day). In the longer term, the decline in nickel prices in "real terms" "or constant dollars" is expected to continue because of increases in production efficiency, the application of new technologies and competitive pressures. There seems to be little reason for changes in prices for this specific industry to mirror the general inflation rate. In the medium term, inflation rates are not expected to be significant; therefore, the entry into production of large high-grade deposits or the changing patterns in demand are expected to have more of an effect on nickel prices than the rate of inflation is. In the short term, the size of the nickel inventory compared to demand and the activities of investment funds are expected to be the dominant factors.

Canada's mine production of nickel in concentrate in 2000 is forecast to recover from 180 000 t to about 205 000 t, unless the producers and unions are unable to reach an agreement and production interruptions occur. The major uncertainty for future nickel production in Canada remains the timing of development of the Voisey's Bay deposit.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 65. (2) Information in this review was current as of March 31, 2000. (3) Various Internet sites have been identified in this article. Please note that Natural Resources Canada has no control over the content of the web sites of other organizations, which may be modified, updated or deleted at any time. (4) This and other reviews, including previous editions, are available on the Internet at http://www.nrcan.gc.ca/mms/cmy/index_e.html.

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6 If the value of metal consumed is taken into consideration, then the major nonferrous metals for 1999, using average LME annual settlement prices, are: aluminum, US$36 billion; copper, US$27 billion; nickel, US$9 billion; zinc, nearly US$9 billion; and lead, US$3 billion.

NOTE TO READERS

The intent of this document is to provide general information and to elicit discussion. It is not intended as a reference, guide or suggestion to be used in trading, investment, or other commercial activities. The author and Natural Resources Canada make no warranty of any kind with respect to the content and accept no liability, either incidental, consequential, financial or otherwise, arising from the use of this document.

TARIFFS

Item No.	Description	Canada			United States	EU	Japan[1]	Brazil	India	Taiwan	Korea[2]
		MFN	GPT	USA	Canada	MFN	WTO	MFN	MFN	MFN	MFN
2604.00	Nickel ores and concentrates	Free	Free	Free	Free	Free	Free	5%	5%	Free	1%
2825.40	Nickel oxides and hydroxides	Free	Free	Free	Free	Free	4.8%	5-13%	3.5%	2.5%	8%
7202.60	Ferronickel	6.5%	Free	Free	Free	Free	3.3%	9%	25%	Free	3%
7501.10	Nickel mattes	Free	Free	Free	Free	Free	Free	9%	15%	Free	1%
7501.20	Nickel oxide sinters and other intermediate products of nickel metallurgy	Free	Free	Free	Free	Free	Free-44 yen/kg[3]	9%	15%	Free	1%
7502.10	Unwrought nickel, not alloyed	Free	Free	Free	Free	Free	44 yen/kg	9%	15%	1.25%	3%
7502.20	Unwrought nickel alloys	Free	Free	Free	Free	Free	Free-3%[4]	9%	15%	1.25%	3%
7503.00	Nickel waste and scrap	Free	Free	Free	Free	Free	Free	5%	15%	Free	1%
7504.00	Nickel powders and flakes	Free	Free	Free	Free	Free	Free-41 yen/kg-3%	9%	15%	Free	5%
7505.11	Bars, rods and profiles of nickel, not alloyed	Free	Free	Free	Free	Free	3%	15%	15%	2.5%	5%
7505.12	Bars, rods and profiles of nickel alloys	Free	Free	Free	Free	2.9%	3%	15%	15%	2.5%	5%
7505.21	Nickel wire, not alloyed	Free	Free	Free	Free	Free	3%	15%	15%	1.25%	5%
7505.22	Wire of nickel alloys	Free	Free	Free	Free	2.9%	3%	15%	15%	1.25%	5%
7506.00	Nickel plates, sheets, strip and foil	Free	Free	Free	Free	Free-3.3%	Free-3%	15%	15%	2.5%	5%
7507.00	Nickel tubes, pipes, and tube or pipe fittings	Free	Free	Free	Free	Free-2.5%	Free-3%	17%	15%	2.5%	8%
7508.00	Other articles of nickel	Free-3%	Free	Free	Free	Free	3%	19%	15%	1.25-5%	8%

Sources: Customs Tariff, effective January 2000, Canada Customs and Revenue Agency; Harmonized Tariff Schedule of the United States, 2000; Worldtariff Guidebook on Customs Tariff Schedules of Import Duties for European Union (39th Annual Edition: 1999); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of Brazil (6th Annual Edition: 1999); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of India (6th Annual Edition: 1999); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of Korea (6th Annual Edition: 1999); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of Taiwan (4th Annual Edition: 1999); Customs Tariff Schedules of Japan, 1999.

[1] WTO rate is shown; lower tariff rates may apply circumstantially. [2] South Korea. [3] Free except for nickel oxide sinters containing by weight not less than 88% nickel, for which the tariff rate is 44 yen/kg, and nickel oxide containing by weight not more than 1.5% copper, for which the tariff rate is 3%. [4] The tariff rate of 3% applies to nickel alloys other than those containing by weight less than 50% nickel and not less than 10% cobalt.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2605.00	Cobalt ores and concentrates	Free	Free	Free	Free
2822.00	Cobalt oxides and hydroxides, commercial cobalt oxides	Free	Free	Free	Free
2827.34	Cobalt chloride	4%	3%	Free	Free
2833.29.00.40	Cobalt sulphate	Free	Free	Free	Free
2836.99.10.30	Cobalt carbonates for use in the manufacture of animal or poultry feeds, glues or adhesives, optical fibres or optical fibre bundles or cables, typewriter or similar ribbons, polymers in primary forms or profile shapes or sheets of plastics; cobalt carbonates to be employed as drilling mud or additives in drilling for minerals, natural gas, oil or water	Free	Free	Free	Free
2836.99.90.20	Other cobalt carbonates	3.5%	3%	Free	Free
2915.23.10	Cobalt acetates for use as petroleum refining catalysts, or for use in the manufacture of animal or poultry feeds, glues or adhesives, optical fibres or optical fibre bundles or cables, typewriter or similar ribbons, polymers in primary forms or profile shapes or sheets of plastics	Free	Free	Free	Free
2915.23.90	Other cobalt acetates	8%	3%	Free	Free
8105.10	Cobalt mattes and other intermediate products of cobalt metallurgy; unwrought cobalt; waste and scrap; powders				
8105.10.10	Cobalt waste and scrap fit only for remelting and recovery of the metal content; powders; unwrought cobalt, not alloyed	Free	Free	Free	Free
8105.10.90	Other	3%	Free	Free	Free
8105.90.10	Cobalt bars and rods, not alloyed	3%	Free	Free	Free
8105.90.90	Cobalt and articles thereof, n.e.s.	3%	Free	Free	Free

Sources: Customs Tariff, effective January 2000, Canada Customs and Revenue Agency; Harmonized Tariff Schedule of the United States, 2000.
n.e.s. Not elsewhere specified.

TABLE 1. CANADA, NICKEL PRODUCTION AND TRADE, 1998 AND 1999

Item No.		1998		1999p	
		(tonnes)	($000)	(tonnes)	($000)
PRODUCTION[1]					
	All forms				
	Quebec	16 297	116 182	19 943	175 877
	Ontario	133 715	953 253	126 514	1 115 726
	Manitoba	47 935	341 732	30 773	271 383
	Total	197 947	1 411 167	177 229	1 562 986
	Refined	146 755	..	123 944	..
EXPORTS					
2604.00.40	Nickel ores and concentrates, nickel content				
	United States	–	3	–	–
	Total	–	3	–	–
2825.40	Nickel oxides and hydroxides				
	Hong Kong	210	2 389	479	5 999
	Singapore	–	–	95	1 043
	China	7	81	47	387
	United States	61	949	21	248
	Other countries	24	255	11	150
	Total	302	3 674	653	7 827
7202.60	Ferronickel	–	–	–	–
7501.10	Nickel mattes				
	Norway	50 520r	423 104r	51 799	434 836
	United Kingdom	41 994	357 154	39 467	268 339
	Other countries	–	–	247	1 636
	Total	92 514r	780 258r	91 513	704 811

TABLE 1 (cont'd)

Item No.		1998		1999p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)					
7501.20	Nickel oxide sinters and other intermediate products of nickel metallurgy				
	South Korea	9 454	87 133	5 764	43 869
	United States	2 670	15 276	4 189	30 044
	Taiwan	1 984	16 176	1 135	9 085
	Belgium	1 193	8 190	649	4 947
	Other countries	2	65	–	–
	Total	15 303	126 840	11 737	87 945
7502.10	Nickel unwrought, not alloyed				
	United States	52 694	413 045	45 306	362 442
	Italy	8 756	58 993	7 550	65 832
	Netherlands	7 560	51 254	6 345	58 306
	Belgium	9 365	69 642	7 354	54 467
	Hong Kong	3 227	24 018	3 400	28 579
	Taiwan	4 719	41 784	3 609	25 914
	South Korea	1 497r	11 248r	2 630	20 906
	Japan	3 042	23 654	2 684	19 235
	China	4 974	36 974	2 295	16 090
	Other countries	11 176	84 713	5 615	46 095
	Total	107 010r	815 325r	86 788	697 866
7502.20	Nickel unwrought, alloyed				
	United States	158	1 006	203	1 502
	Other countries	68	221	–	–
	Total	226	1 227	203	1 502
7503.00	Nickel waste and scrap				
	United States	2 147	5 425	3 010	9 329
	Japan	79	782	137	817
	Other countries	45r	112r	21	32
	Total	2 271r	6 319r	3 168	10 178
7504.00	Nickel powders and flakes				
	United States	6 004r	92 272r	5 744	85 129
	Japan	4 585r	40 053r	5 149	46 082
	China	738	11 076	843	13 494
	Belgium	675	6 109	601	5 902
	United Kingdom	204	5 714	168	4 032
	Netherlands	526	4 978	417	3 648
	Other countries	978r	11 258r	483	6 726
	Total	13 710r	171 460r	13 405	165 013
7505.11	Bars, rods and profiles of nickel, not alloyed	–	–	–	–
	Total	–	–	–	–
7505.12	Bars, rods and profiles of nickel alloy				
	United States	14	167	2	151
	Other countries	3	39	2	35
	Total	17	206	4	186
7505.21	Nickel wire, not alloyed				
	United States	1	25	11	294
	Spain	24	157	–	–
	Total	25	182	11	294
7505.22	Wire, nickel alloy				
	United States	97r	2 370r	13	303
	United Kingdom	2	83	4	138
	Brazil	1	24	–	–
	Total	100r	2 477r	17	441
7506.00[a]	Nickel plates, sheets, strip and foil				
	United States	6	161	20	185
	Libyan Arab Jamahiriya	2	18	10	100
	Poland	3	34	1	19
	Other countries	–	–	4	30
	Total	11	213	35	334
7507.00[b]	Nickel tubes, pipes, and tube or pipe fittings				
	United States	. .	2 619r	. .	2 923
	Germany	–	–	. .	136
	Brazil	. .	51	. .	77
	Other countries	. .	415	. .	150
	Total	. .	3 085r	. .	3 286
7508.00	Other articles of nickel				
	United States	. .	9 748r	. .	10 464
	Poland	–	–	. .	241
	United Kingdom	. .	17	. .	111
	Other countries	. .	158	. .	204
	Total	. .	9 923r	. .	11 020

TABLE 1 (cont'd)

Item No.		1998		1999p	
		(tonnes)	($000)	(tonnes)	($000)
IMPORTS[2]					
2604.00.00.20	Nickel ores and concentrates, nickel content				
	United States	1 135	6 842	929	5 834
	Finland	–	–	3	17
	Germany	–	–	2	15
	Other countries	3	21	–	–
	Total	1 138	6 863	934	5 866
2825.40	Nickel oxides and hydroxides				
	Finland	576	9 402	392	5 173
	Other countries	2 197	1 862	1 724	403
	Total	2 773	11 264	2 116	5 576
7202.60	Ferronickel				
	United States	5r	27r	30	158
	United Kingdom	1	5	–	–
	Total	6r	32r	30	158
7501.00c	Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy				
	Australia	6 062	25 169	3 125	16 566
	United States	1 138	1 870	1 913	3 680
	Bermuda	–	–	203	1 128
	United Kingdom	110	415	319	507
	Cuba	39 178r	209 629	–	–
	Other countries	60	342	36	307
	Total	46 548r	237 425	5 596	22 188
7502.10	Nickel unwrought, not alloyed				
	Norway	803	6 359	952	8 044
	Russia	43	489	588	4 170
	Finland	63	675	271	2 327
	United Kingdom	26	197	248	2 036
	United States	255	1 097	102	781
	Other countries	58	449	142	890
	Total	1 248	9 266	2 303	18 248
7502.20	Nickel unwrought, alloyed				
	Bermuda	507	2 933	547	3 077
	United States	146	951	189	1 260
	United Kingdom	44	1 015	207	1 021
	Other countries	–	8	75	443
	Total	697	4 907	1 018	5 801
7503.00	Nickel waste and scrap				
	United States	15 332r	51 030r	18 345	40 426
	Bermuda	33	202	557	2 781
	Norway	147	964	347	2 753
	United Kingdom	486	1 955	704	2 621
	Other countries	642r	2 388r	496	1 839
	Total	16 440	56 539	20 449	50 420
7504.00	Nickel powder and flakes				
	Australia	836	6 305	912	8 356
	United States	267	3 971	260	3 886
	Finland	169	1 672	186	1 991
	Other countries	229	1 458	227	2 594
	Total	1 501	13 406	1 585	16 827
7505.11	Bars, rods and profiles of nickel, not alloyed				
	United States	23	389	26	399
	Other countries	2	44	1	36
	Total	25	433	27	435
7505.12	Bars, rods and profiles of nickel alloys				
	United States	463	9 201r	407	9 187
	Germany	15	252r	33	631
	Other countries	23	398	10	186
	Total	501	9 851r	450	10 004
7505.21	Nickel wire, not alloyed				
	United States	35	413r	95	1 051
	France	–	–	43	413
	Japan	18	171	16	132
	Other countries	2	27	6	76
	Total	55	611r	160	1 672
7505.22	Wire, nickel alloy				
	United States	488r	7 717r	302	5 859
	Germany	51	1 198	70	1 176
	Other countries	21	434	91	1 275
	Total	560r	9 349r	463	8 310

TABLE 1 (cont'd)

Item No.		1998		1999p	
		(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)					
7506.00	Nickel plates, sheets, strip and foil				
	United States	599	11 840r	652	13 344
	Germany	182	4 432	1 099	5 849
	Japan	185	1 840	78	732
	Other countries	95	1 071	52	699
	Total	1 061	19 183r	1 881	20 624
7507.00	Nickel tubes, pipes, and tube or pipe fittings				
	United States	446r	11 560r	429	9 337
	Japan	135r	8 580r	259	9 108
	France	26	1 053	97	2 617
	Norway	284	2 057	218	2 313
	United Kingdom	29	836	69	1 775
	Singapore	55	2 534	28	1 630
	Other countries	291	3 538	76	1 405
	Total	1 266r	30 158r	1 176	28 185
7508.00	Other articles of nickel				
	United States	587r	11 324r	462	8 916
	France	104	1 198	114	1 278
	United Kingdom	40	613	39	646
	Taiwan	42	360r	58	385
	Canada	39	317	32	351
	China	19	153	21	162
	Other countries	20r	265r	25	403
	Total	851	14 230r	751	12 141

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . Not available or not applicable; p Preliminary; r Revised.
a Included in the data are HS codes 7506.10 and 7506.20. b Included in the data are HS codes 7507.11, 7507.12 and 7507.20.
c Included in the data are HS codes 7501.10 and 7501.20.
1 Recoverable nickel in concentrates shipped. 2 Imports from "Other countries" may include re-imports from Canada.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, NICKEL PRODUCTION AND CONSUMPTION, 1970, 1975, 1980 AND 1985-99

	Production[1] (Mine Output)	Consumption[2]
	(tonnes)	
1970	277 490	10 699
1975	242 180	11 308
1980	184 802	9 676
1985	169 971	7 206
1986	163 640	8 865
1987	193 391	9 732
1988	216 589	9 250
1989	200 899	10 421
1990	196 225	8 410
1991	192 259	13 322a,r
1992	186 384	15 528r
1993	188 080	17 384a,r
1994	149 886	20 746r
1995	181 820	20 973r
1996	192 649r	24 504r
1997	180 624r	19 447
1998	197 947r	19 243
1999p	177 229	. .

Source: Natural Resources Canada.
. . Not available; p Preliminary; r Revised.
a Increase in number of companies being surveyed.
1 Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. Data for 1987-99 are nickel contained in concentrates produced.
2 Consumption of metallic nickel, all forms (refined metal, nickel in ferronickel oxides and salts, and other forms of nickel including nickel in purchased scrap) as reported by consumers on the Natural Resources Canada survey "Consumption of Nickel."

TABLE 3. CANADA, NICKEL PROCESSING CAPACITY, 1998

	Inco Limited		Falconbridge Limited	Sherritt International Corporation	Canmine Resources Corporation[1]
	Sudbury	Thompson	Sudbury	Fort Saskatchewan	Cobalt
	(t/y of contained nickel)				
Smelter	100 000	63 000	70 000	n.a.	n.a.
Refinery	59 000	55 000	n.a.	27 000	450

Source: Natural Resources Canada.
n.a. Not applicable.
[1] Plant was formerly owned by Cobatec Inc., which went bankrupt in 1998; it was purchased by Canmine in 1999.

TABLE 4. WORLD MINE PRODUCTION OF NICKEL,[1] 1995-99

	1995	1996	1997	1998	1999[e]
	(000 tonnes)				
Russia	235.0	232.0	235.0	235.0	245
Canada	181.8	192.6	190.5	208.2	188
New Caledonia	120.7	124.8	137.1	125.3	112
Australia	104.0	113.0	123.4	143.5	108
Indonesia	86.6	87.9	71.1	74.1	89
Cuba	42.7	53.6	61.5	67.8	67
China	41.8	43.8	46.7	47.7	50
Brazil	19.2	20.5	20.5	32.5	40
Colombia	24.2	27.7	31.2	29.4	39
South Africa	29.8	33.9	34.8	36.4	36
Botswana	21.1	24.2	22.9	24.8	26
Dominican Republic	30.9	30.4	32.5	25.2	25
Other	70.7	66.8	65.5	59.2	47
Total	1 008.5	1 051.2	1 072.7	1 109.1	1 071

Sources: Natural Resources Canada for Canada; *World Nickel Statistics*, International Nickel Study Group, March 2000.
[e] Estimated.
[1] Nickel content in concentrate produced (except for Russian Federation, which may refer to nickel content of ore mined).
Notes: NRCan data used for 1999 for Canada and for total. Numbers may not add to totals due to rounding.

TABLE 5. WORLD PRODUCTION OF PRIMARY NICKEL, 1995-99

	1995	1996	1997	1998	1999[e]
	(000 tonnes)				
Russia	200.0	190.0	230.0	227.0	230
Japan	135.0	130.5	128.4	126.5	134
Canada	125.3	130.1	131.6	146.7	124
Australia	76.9	74.0	73.6	79.6	78
Norway	53.2	61.6	62.7	70.2	74
New Caledonia	42.2	42.2	44.3	44.5	45
China	38.1	44.2	39.9	40.1	45
United Kingdom	35.2	38.6	36.1	39.1	38
South Africa	29.8	33.9	34.8	36.4	36
Cuba	21.6	27.0	34.0	38.7	36
Colombia	24.6	22.9	25.2	28.1	28
Dominican Republic	30.9	30.4	32.5	25.2	25
Other	106.0	127.8	139.2	132.4	134
Total	918.8	953.2	1 012.3	1 034.5	1 027

Sources: Natural Resources Canada for Canada; *World Nickel Statistics*, International Nickel Study Group, March 2000.
[e] Estimated.

TABLE 6. WORLD CONSUMPTION OF PRIMARY NICKEL, BY COUNTRY AND BY REGION, 1995-99

	1995	1996	1997	1998	1999e
			(000 tonnes)		
BY COUNTRY					
Japan	205.1	190.2	202.4	169.2	182
United States	155.2	153.1	155.6	150.0	152
Germany	93.1	74.9	91.0	97.4	105
Taiwan	48.0	50.0	68.0	70.0	82
South Korea	44.0	50.0	66.0	67.8	79
Italy	49.0	44.0	49.5	53.3	57
France	48.5	45.9	49.8	55.0	53
China	40.2	42.0	43.0	42.0	45
Finland	31.9	30.1	36.0	37.1	41
Sweden	27.2	28.5	30.0	31.0	38
United Kingdom	40.9	38.7	33.0	31.5	28
Russia	36.2	35.0	20.0	18.0	19
Other	164.8	164.1	176.4	187.4	199
Total	984.1	946.5	1 020.7	1 009.7	1 080
BY REGION					
Africa	20.6	24.8	31.0	31.2	34
Americas	190.6	189.8	189.5	184.5	189
Asia	327.0	320.0	365.6	334.3	374
Europe	358.8	324.8	360.2	385.6	404
Oceania	1.8	1.9	1.9	2.1	2
East[1]	85.3	85.2	72.6	72.0	8
Total	984.1	946.5	1 020.7	1 009.7	1 080

Source: *World Nickel Statistics*, International Nickel Study Group, March 2000.
e Estimated.
1 "East" includes China, the Czech Republic, Poland, Romania, Russia and the Ukraine.

TABLE 7. AVERAGE ANNUAL NICKEL PRICES, 1981-99

	Settlement Price	
	(US$/t)	(Converted to US$/lb)
1981	5 985	2.71
1982	4 808	2.18
1983	4 695	2.13
1984	4 783	2.17
1985	4 987	2.26
1986	3 887	1.76
1987	4 849	2.20
1988	14 206	6.44
1989	11 955	5.42
1990	8 880	4.03
1991	8 158	3.70
1992	7 000	3.18
1993	5 283	2.40
1994	6 344	2.88
1995	8 237	3.74
1996	7 500	3.40
1997	6 916	3.14
1998	4 617	2.09
1999	6 027	2.73

Source: International Nickel Study Group, except for 1999 average, which is from *Metal Bulletin.*

TABLE 8. AVERAGE MONTHLY NICKEL PRICES, 1996-99

	1996	1997	1998	1999
		(US$/t)		
January	7 866	7 047	5 495	4272
February	8 219	7 737	5 390	4630
March	8 024	7 899	5 399	5015
April	8 047	7 318	5 397	5106
May	8 030	7 485	5 023	5403
June	7 712	7 065	4 479	5198
July	7 207	6 838	4 329	5704
August	7 057	6 763	4 084	6452
September	7 321	6 507	4 106	7031
October	7 034	6 383	3 875	7325
November	6 946	6 142	4 135	7953
December	6 584	5 949	3 881	8087
		(converted to US$/lb)		
January	3.57	3.20	2.49	1.94
February	3.73	3.51	2.44	2.10
March	3.64	3.58	2.45	2.27
April	3.65	3.32	2.45	2.32
May	3.64	3.40	2.28	2.45
June	3.50	3.20	2.03	2.36
July	3.27	3.10	1.96	2.59
August	3.20	3.07	1.85	2.93
September	3.32	2.95	1.86	3.19
October	3.19	2.90	1.76	3.32
November	3.15	2.79	1.88	3.61
December	2.99	2.70	1.76	3.67

Source: International Nickel Study Group.

TABLE 9. COMPANIES HAVING NICKEL EXPLORATION PROPERTIES IN CANADA IN 1999 KNOWN TO HAVE WEB SITES

Company	Web Site	Projects or Area
Altius Minerals Corp.	http://www.alt-min.com	Taylor Brook, Plateau, Tadpole, Seahorse
Anvil Resources Ltd.	http://www.anvilltd.com	Voisey's Bay West, Harp Lake
Avalon Ventures Ltd.	http://www.avalonventures.com/devon.htm	Devon Township property
Billiton Exploration Canada Ltd.	http://www.billiton.com	Gayot
Black Pearl Minerals Inc.	http://web.idirect.com/~blackp	Nickel Offset, Harp Lake
Blackstone Resources Inc.	http://www.bzz-blackstone.com	Taiga property
Bren-Mar Resources Ltd.	http://www.bren-mar.com	Turnagain
Canaco Resources Ltd.	http://www.canaco.ca	Powder Horn Lake
Cypress Minerals Corp.	http://www.cypressminerals.com	South Voisey's Bay, Lac Rocher
Darnley Bay Resources Limited	http://www.darnleybay.com	Darnley Bay
Diadem Resources Ltd.	http://www.diademresources.com	Pekan River
Dianor Resources Inc.	http://www.dianor.com/html/nipisso.html	Nipisso property
Donner Minerals Ltd.	http://www.donner-resources.com	Lac Rocher, South Voisey's Bay
Dumont Nickel Inc.	http://dumontnickel.com	Blake, Albany, Louvicourt property, Lac Raglan
Essex Resource Corporation	http://www.essexresource.com/operations/Canada.html	Staghorn Lake
Flag Resources (1985) Limited	http://www.flagresources.com	Wanapitei anomaly
Freewest Resources Canada Inc.	http://www.freewest.com	Folson Lake, Lac Rocher
Gallery Resources Limited	http://www.gallery-gold.com	Cabot Lake, Harp Lake, Sango Bay, Okak Bay
International Kirkland Minerals Inc.	http://www.internationalkirkland.com	Foreurs
Major General Resources Ltd.	http://www.majorgeneral.com	Sarah Lake
Mandorin Goldfields Inc.	http://www.mandorin.com	Disappointment Lake and Mealy Mountain
Manson Creek Resources Ltd.	http://www.gold.ca/manson/mc.html	Suluk, Rankin Inlet
NDT Ventures Ltd.	http://www.northair.com/ndt	South Voisey's Bay
Norcal Resources Ltd	http://www.northair.com/norcal/index.html	Lac Rocher
Noront Resources Ltd.	http://www.noront-resources.com	Lac Rocher, Okak Bay
Northern Abitibi Mining Corp.	http://www.gold.ca/abitibi/proframe.html	South Voisey's Bay
Novawest Resources Inc.	http://www.novawest.com/index.htm	Lac Rocher
Nuinsco Resources Limited	http://www.nuinsco.ca	Lac Rocher
Pacific North West Capital Corporation	http://www.pfncapital.com	Sudbury
ProAm Explorations Corporation	http://www.proam.ca	Samuels Lake, Agnew Lake
Starcore Resources Ltd.	http://www.starcore.com/s/Default.asp	Samuels Lake
Starfield Resources Inc.	http://www.starfieldres.com	Fergusen Lake
Troymin Resources Ltd.	http://www.troymin.com	Okak Bay, Hawk Ridge prospect

Source: Natural Resources Canada.
Notes: This table may not show all the companies engaged in nickel exploration and which have web sites. Readers can send updates to this table providing the company name, the web site, and the project or property name by e-mail to bmccutch@nrcan.gc.ca for inclusion in the Nickel chapter of the next edition of this publication. The terms "project," "property" or "prospect," or lack of such a term, does not indicate in any way a judgement by NRCan or the author about the relative merit of the entries.

TABLE 10. CANADA, COBALT PRODUCTION AND TRADE, 1998 AND 1999, AND CONSUMPTION, 1996-98

Item No.		1998		1999p	
		(kilograms)	($000)	(kilograms)	($000)
PRODUCTION[1]	(all forms)				
	Quebec	150 260	10 536	190 000	10 752
	Ontario	1 636 172	114 727	1 522 247	86 141
	Manitoba	476 045	33 380	302 546	17 120
	Total	2 262 477	158 643	2 014 793	114 013
	Refined[2]	4 053 721	..	3 963 533	..
EXPORTS					
2605.00	Cobalt ores and concentrates	–	–	9 553	21
2822.00	Cobalt oxides and hydroxides; commercial cobalt oxides				
2915.23	Cobalt acetates	–	–	–	–
8105.10	Cobalt, mattes and other intermediate products of cobalt metallurgy, unwrought cobalt, waste, scrap and powders				
	Norway	2 268 291	138 092	2 256 812	86 533
	Japan	886 500	67 738	1 140 565	56 722
	Netherlands	751 600	59 509	794 800	41 259
	United States	1 121 782	73 438	839 032	38 136
	Singapore	623 300	47 208	483 300	26 464
	Other countries	905 922	55 885	764 420	32 380
	Total	6 557 395	441 870	6 278 929	281 494
8105.90	Cobalt and articles thereof, n.e.s.				
	United States	22 646	3 700	14 999	2 967
	Germany	9 593	1 633	10 443	1 903
	United Kingdom	461	91	370	99
	Other countries	1 866	157	380	65
	Total	34 566	5 581	26 192	5 034
IMPORTS					
2605.00	Cobalt ores and concentrates				
	Germany	4 688	286	71 964	825
	Other countries	26 575	586	8 674	394
	Total	31 263	872	80 638	1 219
2822.00.00.10	Cobalt hydroxides				
	United States	9 108	441	10 434	500
	Other countries	452	34	109	6
	Total	9 560	475	10 543	506
2822.00.00.20	Cobalt oxides				
	Finland	7 370	387	54 976	2 173
	Belgium	1 250	82	30 625	1 599
	United States	24 532	1 502	16 064	692
	Other countries	1 801	425	29	1
	Total	34 953	2 396	101 694	4 465
2822.00.00.30	Commercial cobalt oxides				
	United States	357	7	748	14
	United Kingdom	26	1	1 486	30
	Total	383	8	2 234	44
2822.00.10	Cobalt hydroxides				
	United States	9 108	441	10 434	500
	Other countries	452	34	109	6
	Total	80 232	5 283	218 399	9 524
2827.34	Cobalt chlorides				
	United States	1 932	29	16 878	305
	Other countries	3 043	50	21	–
	Total	4 975	79	16 899	305
2833.29.00.40	Cobalt sulphate				
	United States	39 317	715	24 576	485
	Finland	2 505	50	14 648	249
	China	2 000	30	3 804	48
	Other countries	2 449	45	1 457	23
	Total	46 271	840	44 485	805
2836.99.10.30	Cobalt carbonates				
	United States	..	179	..	205
	Other countries	–	–	..	109
	Total	–	179	..	314

TABLE 10 (cont'd)

Item No.		1998		1999p	
		(kilograms)	($000)	(kilograms)	($000)
IMPORTS (cont'd)					
2836.99.90.20	Other cobalt carbonates				
	Finland	424	14	11 144	293
	United States	10 132	354	10 228	282
	Other countries	5 761	259	5 831	190
	Total	16 317	627	27 203	765
2915.23	Cobalt acetates				
	United States	52 353	592	45 919	517
	Other countries	25	. . .	16	. . .
	Total	52 378	592	45 935	517
8105.10.10.10	Cobalt waste and scrap fit only for remelting and recovery of the metal content				
	United States	260 177	1 045	180 025	679
	United Kingdom	7 190	11	55 720	257
	Other countries	21 295	1 316	55 110	223
	Total	288 662	2 372	290 855	1 159
8105.10.10.20	Cobalt powders				
	Australia	2 420	64	194 467	7 402
	South Africa	89 172	5 753	120 814	5 588
	United States	56 685	3 434	44 007	2 374
	Other countries	228 026	6 030	50 457	2 385
	Total	376 303	15 281	409 745	17 749
8105.10.10.30	Unwrought cobalt, not alloyed				
	Congo	303 860	17 852	54 400	1 499
	United States	29 097	1 908	27 560	1 357
	Other countries	228 633	10 365	23 677	1 138
	Total	561 590	30 125	105 637	3 994
8105.10.20.10	Unwrought cobalt, not alloyed	–	–	–	–
8105.10.20.20	Cobalt powders, not alloyed	–	–	–	–
8105.10.90	Unwrought cobalt, alloyed, mattes and other intermediate products of cobalt metallurgy				
	United States	18 266	925	9 820	408
	Russia	19 247	1 084	–	–
	Total	37 513	2 009	9 820	408
8105.90.00.10	Cobalt bars and rods, not alloyed				
	United States	1 642	146	2 479	204
	Other countries	14	1	2	. . .
	Total	1 656	147	2 481	204
8105.90.00.90	Cobalt and articles thereof, n.e.s.				
	United States	52 467	6 434	41 468	5 140
	Other countries	7 033	619	2 048	141
	Total	59 500	7 053	43 516	5 281
8105.90.10	Cobalt bars and rods, not alloyed	–	–	–	–
8105.90.90	Cobalt and articles thereof, n.e.s.	–	–	–	–

CONSUMPTION[2]	**1996**	**1997**	**1998p**
		(kilograms)	
Cobalt contained in:			
Cobalt metal and metallic compounds	46 936	43 544	48 381
Cobalt pigments, feed and ground coat frit	9 335	x[4]	6 901
Cobalt salts and driers and other uses[3]	91 079	92 838	90 701
Total	147 350	136 382	145 983

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . Not available; n.e.s. Not elsewhere specified; p Preliminary.
[1] Production includes recoverable cobalt in concentrates shipped. [2] Available data as reported by consumers. [3] Other uses include glass and chemicals. [4] Included in "cobalt salts and driers and other uses" due to confidentiality constraints.
Note: Numbers may not add to totals due to rounding.

TABLE 11. CANADA, COBALT PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1980-99

		Exports			Imports	
	Production[1]	Cobalt Metal	Cobalt Oxides and Hydroxides	Cobalt Ores and Concentrates[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	37	159
1989	2 344	3 262	371	22	33	147
1990	2 184	3 039	391	–	73	194
1991	2 171	3 456	459	–	42	166
1992	2 223	2 963	489	–	64	205
1993	2 150	3 581	394	–	52	187
1994	1 846	3 922	204	–	81	193
1995	2 016	4 227	–	–	41	148
1996	2 150	4 488[r]	632	–	33	147
1997	2 168	5 829	526	–	39	136
1998	2 262	6 592	457	–	45	146
1999[p]	2 015	6 305	224	10	112	..

Sources: Natural Resources Canada; Statistics Canada.
– Nil; .. Not available; [p] Preliminary; [r] Revised.
[1] Production includes recoverable cobalt in concentrates shipped. [2] Cobalt content. [3] Gross weight.
[4] Consumption of cobalt in metal, oxides and salts; available data as reported by consumers.

TABLE 12. REFINED COBALT[1] AVAILABILITY, 1995-99

Company	1995	1996	1997	1998	1999
			(tonnes)		
PRODUCTION OF COMPANIES BELONGING TO THE COBALT DEVELOPMENT INSTITUTE					
Falconbridge	2 804	3 099	3 417	3 851	4 009
Gécamines	3 422	3 540	2 808	4 490	2 145[a]
ICCI	1 730	2 070	2 250	2 640	2 770
Inco	1 362	1 544	1 500	1 740	1 420
OMG	3 610	4 160	5 000	5 250	6 200
QNI	–	–	617	1 395	1 539
Sumitomo	222	228	263	329	221
Zambia[2]	2 934	4 799	3 949	5 011	3 946
CTT	–	80	220	241[b]	470
Eramet	161	174	159	172	180
Union Minière	1 200	1 200	1 200	1 200	950
Murrin Murrin					83
Kasese					77
Subtotal	17 445	20 894	21 383	26 319	24 010
PRODUCTION OF OTHERS					
South Africa	190	292	294	320	320[e]
Brazil	166	193	266	364	630
India	–	–	110[e]	120[e]	120[e]
China	1 076	1 200	1 200	1 200	1 200
Bulong					79
Subtotal	1 432	1 685	1 870	2 004	2 349
EXPORTS AND SALES FROM STOCKPILES					
DLA sales	1 554	2 052	1 621	2 310	1 679
Sales from other stocks	270	500	–	–	–
C.I.S. exports	2 787	1 654	3 200	2 800	2 678
Subtotal	4 611	4 206	4 821	5 110	4 357
Total[3] availability	**23 488**	**26 785**	**28 074**	**33 433**	**30 716**

Source: Cobalt Development Institute.

ICCI = International Cobalt Corporation Ltd. (marketed by Sherritt International)
OMG = OM Group
CTT = Cie. de Tifnout-Tiranimine
DLA = Defense Logistics Agency
ZCCM = Zambia Consolidated Copper Mines
RAMZ = Roan Antelope Mining Corporation
Gécamines = La Générale des Carrières et des Mines

– Nil; [e] Estimated.
[a] Excludes the Central Mining Group production.
[b] Includes correction for CTT.
[1] "Refined cobalt" means all cobalt units whether in metal or chemicals derived from feed requiring further refining. The following materials are not counted as feed: DLA or other stockpile releases, Russian output, Lisaki output, and lower grade Moroccan output.
[2] Zambian production includes ZCCM, RAMZ and Avmin.
[3] Numbers may not add to totals due to rounding.