

# Nickel

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## **Bill McCutcheon**

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

The year started with good prospects for nickel. Stainless steel producers who had reduced inventories over 1996 were optimistic about the prospects for increased demand in 1997. Based on data from the January 1998 issue of the International Nickel Study Group's *World Nickel Statistics*, supply and demand were almost balanced. Estimated world refined nickel production was running at just less than 3% above the rate for the same period in 1996, implying a total for the year of 980 000 t. Meanwhile, consumption was running 6% higher compared to the same period in 1996, implying a total of 996 500 t in 1997. With estimated stock changes adding nearly 18 000 t to supply, the implied supply and demand for 1997 were about equal.

Nickel's price performance did not reflect any worries about a supply deficit. Production disruptions due to accidents at two smelters, strikes at two Canadian operations, and blockades at nickel operations in New Caledonia did not support prices. Russia's nickel production increased as its major producer overcame difficulties; with continued low domestic demand, Russian exports of primary nickel were consequently up substantially. Exports of Russian scrap were also higher than in 1996.

In 1997, the market remained enthralled by the potential of the Voisey's Bay's development. Inco Limited's plans for Voisey's Bay called for production capacity of 122 500 t/y, an amount equal to over 12% of the world's primary production in 1996. This spurred a race among other nickel projects to "beat Voisey's Bay into production" in order to reap the maximum profit from the higher prices that would end once Voisey's Bay started up. However, lower nickel prices in the latter part of 1997 slowed enthusiasm for financing new nickel facilities. One major project could not secure financing and others experienced delays.

The year started with prices increasing from US\$2.89/lb to \$3.37/lb in the first month. The settlement price peaked at \$3.69/lb in early March. By August, the price had sunk to below \$3.00/lb. At year-end, the price was US\$2.72/lb (Figure 3). The average settlement price in the first half of the year was US\$3.36/lb; it declined to \$2.92/lb for the final six months of 1997. London Metal Exchange (LME) month-end stocks increased from February onward to the end of the year. However, reported producer stocks fell during the course of the year (Table 9) so that combined stocks were relatively constant.

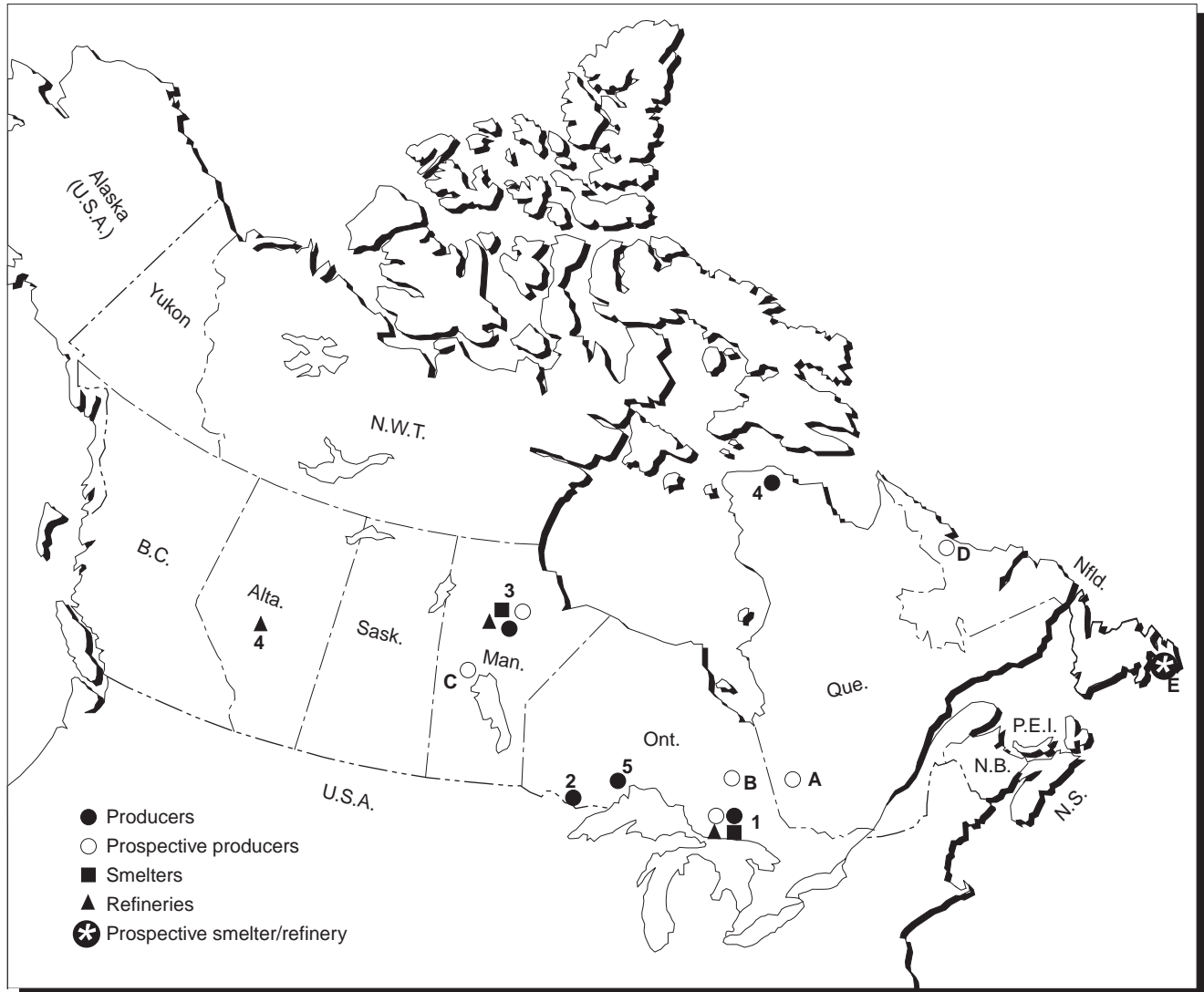
The year 1997 brought another change to the industry's structure with a merger between Gencor Ltd.'s Billiton plc and QNI Ltd. of Australia, which created the fourth largest nickel producer. In addition, low prices forced companies such as Inco and WMC Limited to announce work force reductions and other cost-cutting measures.

## **CANADIAN DEVELOPMENTS**

Canadian nickel production (i.e., nickel contained in concentrates produced) was 190 785 t in 1997, down slightly from a revised figure of 192 649 t in 1996 (Table 2). Canadian exports of nickel in 1997 were worth \$2.1 billion, down nearly 10% in value, but tonnage declined only 1%. The big export earners were nickel matte, accounting for 37% of nickel export earnings; unwrought unalloyed nickel, accounting for 46% of nickel export earnings; and nickel powders, accounting for 9.6% of nickel export earnings. Canadian imports of nickel were down by 24% to \$491 million, while the import tonnage declined by only 8.6%. The bulk of the imports was nickel matte, which accounted for more than 58.5% of nickel imports. When imports are subtracted from exports, the net export earnings were \$1.6 billion, down 3.7% from 1996. The main net export earners were: nickel matte at 30.7% of net earnings; unwrought, unalloyed nickel at 59.4% of net earnings; and nickel powder and flakes at 11.5% of net earnings.

Falconbridge Limited operated nickel-copper mines in Sudbury, Ontario, and northern Quebec. The concentrate from the Sudbury mines was smelted in the company's smelter near Sudbury while the matte was shipped to its refinery in Norway. The refinery recovered refined nickel, copper, cobalt and precious

**Figure 1**  
**Nickel in Canada, 1997**



Numbers refer to locations on map above.

**PRODUCERS**

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

**SMELTERS**

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

**REFINERIES**

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

**PROSPECTIVE PRODUCERS**

- A. Timmins Nickel Inc. (Dumont)
1. Inco Limited (Murray, Totten, Victor)
- B. Outokumpu Mines Ltd. (Moncalm Township)  
Timmins Nickel Inc. (Langmuir)  
Black Hawk Mining Inc. (Redstone)
3. Inco Limited (Soab North, Soab South, Pipe No. 1, Pipe No. 2)
- C. Black Hawk Mining Inc. (Minago)
- D. Inco Limited (Voisey's Bay mine site)

**PROSPECTIVE SMELTER/REFINERY**

- E. Inco Limited (Voisey's Bay smelter/refinery), Argentina

metals. The company also has a subsidiary in the Dominican Republic that produced 32 000 t of nickel in ferronickel in 1996. Falconbridge is considering nickel projects in New Caledonia and the Ivory Coast. The company also operated copper and zinc facilities, including mines, mills, smelters and refineries, in Ontario, and plans to start up a large copper operation in Chile in 1998. Noranda Inc. owned 47.5% of Falconbridge at year-end. (Falconbridge's web site<sup>1</sup> is located at <http://www.falconbridge.com/>.)

Falconbridge's Raglan mine was completed ahead of schedule and began production in December 1997. The first shipment of concentrate was expected to occur in March 1998. The \$500 million project will produce 20 800 t/y of nickel, 5200 t/y of copper and 200 t/y of cobalt contained in concentrate once fully into production. Ore reserves were 20.6 Mt grading 3.17% nickel and 0.88% copper. The concentrate will be shipped from Deception Bay, 100 km north of the mine, to Québec City and then railed to Falconbridge's Sudbury smelter. In 1998, Falconbridge will evaluate the feasibility of expanding the Raglan mine.

In Sudbury, Falconbridge and the Canadian Auto Workers/Mine-Mill Local 598 failed to reach an agreement for a new contract before the existing contract expired and workers went on strike for three weeks in August. A new labour agreement that will expire on August 1, 2000, contains provisions to improve pension and sickness/accident benefits.

Inco operates nickel mines, mills, smelters and refineries in Sudbury, Ontario, and in Thompson, Manitoba, as well as a copper smelter and refinery in Sudbury. The company produces refined nickel in Canada and at Clydach in the United Kingdom. Inco recycles nickel-cadmium (Ni-Cd) batteries at its subsidiary, The International Metals Reclamation Company, Inc. (INMETCO) based in the United States. It also owns 59% of a large ferronickel operation in Indonesia, P.T. International Nickel Indonesia (P.T. Inco). Inco's other interests in Asia include: a 51% interest in the Tokyo Nickel Company, Ltd. in Japan; a 49.9% interest in the Taiwan Nickel Refining Corporation; a 25% interest in the Korea Nickel Corporation in the Republic of 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%. Early in the year, Inco sold Doncasters plc, a producer of engineered alloys, in the United Kingdom. At year-end, Inco was awaiting regulatory approval to sell Inco Alloys International, Inc., its U.S. alloy producer. (Inco has a web site at

<http://www.incoltd.com/>, and Voisey's Bay Nickel Company Ltd.'s site can be found at <http://www.incoltd.com/invest/voisey/vbtoc-g.htm>.)

Inco's Sudbury facilities were closed by a 26-day strike in June after the United Steelworkers of America Local 6500 and the company failed to reach an agreement on a new contract. Pensions were an important factor in settling the labour dispute as Inco's work force consists of many workers who will be eligible to retire by 2003. The settlement included provision for a maximum annual pension of \$32 500. This labour agreement ends in June 2000.

With much of its revenue dependent upon nickel prices, Inco faced financial pressures due to the lower nickel prices. In November, Inco announced plans for cost reductions and a restructuring of the Ontario and Manitoba divisions to maximize profit and cash flow. The measures announced in 1997 included closing higher-cost mines and a 7% reduction in employment in the Ontario Division, as well as reduced employment levels and other cost reductions in the Manitoba Division. Planned capital expenditures for the two divisions for 1998 were cut from \$209 million to \$130 million. Capital expenditures for 1999 were also to be cut by an undisclosed amount. In early 1998, Inco announced that the Shebandowan mine would be closed in the second quarter of the year. According to a press report in mid-January, the Little Stobie and Levack mines will also close in 1998. The same press report noted that the McCreedy West mine had already been closed.

Inco's Voisey's Bay project did not progress as quickly as the company had intended. Inco had planned to build an airstrip and a road to support more intensive exploration of the orebody, including underground drilling. Two Aboriginal groups, the Innu Nation and the Labrador Inuit Association (LIA), objected. A series of court cases ensued. On September 22, 1997, the Newfoundland Court of Appeal ruled that the road and airstrip were integral elements of the mine project to be assessed by a federal-provincial panel. Three days earlier, on September 19, Inco had announced that the target date of late 1999 for initial concentrate production would be delayed by at least one year.

In mid-September, The Citizens Mining Council of Newfoundland and Labrador announced that it would launch a court case to force the environmental hearing of the mine/mill project in Labrador to include an evaluation of the nickel smelter and refinery planned for Argentina. A legal action was filed in Toronto, financed by the Canadian Environmental Defence Fund. Earlier, the federal government had decided that a comprehensive environmental review of the site of a former naval base was appropriate.

In January, Inco released information about a new ore zone partially contiguous with the Western

<sup>1</sup> The exact internet address (URL) is underscored and does not include those periods, brackets, etc., that form part of the sentence's punctuation.

Extension. This was later called the Reid Brook Zone. At the end of 1997, more details of the new ore zones were contained in the Environmental Impact Statement (EIS) filed by Voisey's Bay Nickel Company Limited. This information is provided in Table 10, along with additional information from various quarterly earnings reports.

Inco's Fourth Quarter Earnings Report noted that a southward extension to the Ovoid orebody had been found, and that a new deposit model and ore reserve calculation would be completed by the end of the first quarter of 1998. In addition, a disseminated mineral zone potentially amenable to open-pit mining had also been found 150 m in the direction of the Southeast Extension Zone. Grades of between 0.75% and 1% nickel were noted in this shallow deposit, but no orebody tonnage and grades were released. Additional geophysical targets remain to be drilled near the existing ore zones, as well as one located 60 km to the north.

In late 1997, representatives of the federal and provincial governments and the LIA, which represents approximately 5000 Inuit, met in an attempt to resolve the issues that had produced an impasse at the negotiating table. The Newfoundland government released some details of the resulting agreement dealing primarily with economic issues, land quantum, and matters related to self-government. Negotiations to finalize an Agreement in Principle have been ongoing since that time.

In December, there were press reports that Inco was considering different production scenarios at Voisey's Bay and that the company might delay building a smelter and refinery in Newfoundland for an unspecified period of time. Also in December, the premier of Newfoundland stated that unless a smelter and refinery complex were built, there would be no nickel mine at Voisey's Bay.

As of the end of 1997, two separate negotiations for an Impact and Benefit Agreement (IBA) continued between Inco and the LIA and between Inco and the Innu Nation. Inco submitted an EIS for the Voisey's Bay mine and mill on December 15. The EIS provided more details about plans for the operation, including the possibility that the open pit might operate 9 months out of 12 for the first few years. The EIS will be reviewed for adequacy and, once the panel judges that it contains adequate information, public hearings will take place. If no delays are necessary in order to obtain additional information, the entire process will take a maximum of just over 300 days before a recommendation is made to the federal government.

Sherritt International Corporation completed the debottlenecking of its nickel-cobalt refinery in 1996. Its production in 1997 was 25 600 t of refined nickel in powder and briquette form and 2268 t of cobalt. Sherritt and General Nickel Company S.A. of Cuba

each have a 50% interest in a joint-venture operation that operates a lateritic nickel mine in Cuba and a hydrometallurgical nickel-cobalt refinery at Fort Saskatchewan, Alberta. The mine output is converted to sulphide concentrate in Cuba, shipped to Canada by boat, and then railed to Fort Saskatchewan for final processing.

North American Palladium Ltd. operates an open-pit palladium mine near Thunder Bay, Ontario. It produces by-product platinum, nickel, copper and gold. The mine increased its operating rate in 1997 after it connected to the provincial power grid and a new crushing system was completed. The mine's reported nickel production for the first three quarters of 1997 was 294 t. Its production in 1998 is expected to be higher because of the new crushing system. (North American Palladium Ltd.'s web site can be found at <http://www.napalladium.ca/>.)

Cobatec Ltd., formerly Ego Resources Limited, operates a cobalt recovery plant in Cobalt, Ontario. During 1997, the Cobatec cobalt plant did not produce any by-product nickel; however, the company signed a long-term contract with Cuba to import and process cobalt-nickel sulphate precipitates. The original agreement was for 450 t of cobalt and 1130 t of nickel annually starting in December 1997. In December, the parties agreed to increase the annual totals to 800 t of cobalt and 2000 t of nickel in precipitates.

## Exploration

Exploration activities for nickel in Canada were primarily centred in: Labrador; Manitoba, near Thompson; the Ungava and Sept-Îles areas of Quebec; and northwestern Ontario, as well as near existing mines in the Sudbury Basin. Donner Minerals Ltd.'s South Voisey's Bay project attracted attention in mid-October when assay results for hole 97-75 were reported as 1.1 m grading 11.75% nickel, 9.70% copper and 0.43% cobalt. On December 12, assay results for hole 97-96 were released; these showed a 15.7-m-wide zone of massive sulphide mineralization grading 1.13% nickel, 0.78% copper and 0.20% cobalt. Located about 90 km south of Inco's Voisey's Bay project, Donner's South Voisey's Bay project comprises over 1000 km<sup>2</sup> involving Donner and 13 other companies. (A claim map can be found on the internet at <http://www.donner-resources.com/svbproject/index.html>.) A \$5 million exploration program is planned for 1998.

## WORLD OVERVIEW

### Russian Federation

The major nickel producer in Russia and the largest in the world is Rossiskoe Aktionernoe Obshestvo Noril'sky Nickel, or RAO Noril'sk Nickel (Noril'sk). The largest and most important producer and subsidiary of this company is the Noril'sk Mining and Metallur-

gical Combinat, which is located in Siberia and is accessible only by air or Arctic shipping. This site produces refined nickel, copper and cobalt, as well as concentrate containing platinum group metals. Norilsk also sends nickel and copper in ore and in matte to the Severonickel and Monchegorsk subsidiaries in western Russia, and sends ore to the Pechanganickel subsidiary in the Kola Peninsula. For more details, refer to the United City Bank report on Norilsk by Grant Sinitsin, (e-mail: grant\_sinitsin@vcbank.com), published in November 1997. Russian nickel consumption in 1997 was running at less than 30% of the level reported in 1992.

At the start of 1997, Norilsk was faced with grave difficulties: unpaid wages and salaries threatened to provoke strikes; the market economy meant that the operation could not continue to support a city of 300 000 above the Arctic Circle; unpaid taxes threatened to provoke government action; and the company needed a large cash infusion for modernization. Despite these problems, a trend of falling production was reversed, back salaries and wages were paid, rehabilitation work on the smelting facilities began, many tax debts were repaid, and a plan to increase share capital was launched before year-end. During the summer, Uneximbank won a bid for the 38% share in Norilsk. Uneximbank had held the Norilsk shares since 1995 as collateral for a US\$170 million loan to the government.

Total Russian nickel exports in 1997 were estimated at 215 000 t, of which perhaps 15 000 t is thought to have originated from stockpiles. The source of most of the exports was the increased production at Norilsk, which rose to about 210 000 t, up 19% compared to 1996. Because nickel consumption in Russia remains depressed, the increased production resulted in increased exports.

In December, Outokumpu Oyj and Norilsk created a 50:50 joint-venture company called RAO Polar. RAO Polar will examine the feasibility of developing new orebodies in the Kola Peninsula to provide feed to Norilsk's Pechanganickel and Severonickel smelters. In addition, the company may study the modernization of Norilsk's mining methods for the Northern and Central orebodies in the Kola Peninsula. Later, the joint venture might also participate in the development of feasible projects.

The Ufaleynikel operation, which is not part of Norilsk, continued to experience difficulties in maintaining output. This 17 000-t/y plant is situated in Chelyabinsk in the Urals. Its production was cut back significantly after the break-up of the Former Soviet Union. Problems continued as the Serovsky pit and other mines in the region were unable to maintain their previous output levels.

## Australia

The new A\$46 million Silver Swan mine and mill began operations on June 1. Owned by Outokumpu Oyj of Finland (formerly Outokumpu Oy), the mine will produce 12 000 t/y of nickel in concentrate from the 640 000-t sulphide orebody, which grades 9.5% nickel (after dilution). The concentrate will be smelted at Outokumpu's smelter in Finland. The mine's life is estimated at five years.

At the Murrin Murrin project of Anaconda Nickel Limited and Glencore International AG, Aboriginal groups withdrew their appeal of the government's environmental approval following their agreement with the companies in the first quarter of 1997. The A\$950 million project is based on Sherritt's pressure acid leach technology and a measured lateritic resource of 88 Mt grading 1.03% nickel and 0.065% cobalt. Its initial output is expected to be 45 000 t/y of nickel and 3000 t/y of cobalt. Start-up in late 1998 is planned. A subsequent expansion to 75 000 t/y of nickel and 5000 t/y of cobalt is anticipated.

In November, Centaur Mining & Exploration Limited finalized US\$225 million in financing to complete the development of the Cawse project. Earthwork began in May 1997. The lateritic ore will be processed by ammonia leaching and electrowinning. Initial production is expected in 1999 at a rate of 8400 t/y of nickel cathodes and 2000 t/y of cobalt in sulphides. The initial proven and probable ore reserves are estimated at 24.6 Mt grading 1.0% nickel and 0.08% cobalt.

Resolute Limited intends to start the commissioning of the first stage of its Bulong nickel project in April 1998. The lateritic ore will be processed with acid pressure leaching and solvent extraction-electrowinning to yield 9000 t/y of nickel and 630 t/y cobalt. The proven and probable mining reserves total 39.9 Mt grading 1.14% nickel and 0.09% cobalt. Two additional autoclave lines are planned in the second phase to take total production to 22 200 t/y of nickel and 1700 t/y of cobalt.

WMC Limited's smelter was closed for 41 days for rebricking and maintenance following an accident. In late October, WMC announced a 10% reduction in its work force, citing low nickel prices and rising operating costs. For a while, WMC was rumoured to be the target of a takeover by Falconbridge but nothing materialized.

Vancouver-based Calliope Metals Corporation announced plans to build a nickel refinery in Queensland to process imported lateritic ore using the Sherritt process. The plans called for an A\$330 million refinery to process 2 Mt/y (wet) of lateritic ore to yield nearly 20 000 t/y of nickel and 1950 t/y of cobalt. In May, Calliope signed a conditional supply contract

with two companies in New Caledonia to ship a total of 1 Mt/y of ore. At year-end, the company was awaiting the completion of a feasibility study that was needed to obtain financing.

Dominion Mining Ltd.'s plans to finance its Yakabindie project were delayed by lower nickel prices. The project is based on 193 Mt of sulphide ore reserves grading 0.51% nickel at the Goliath North and Six Mine orebodies, and a 0.95-Mt sulphide orebody grading 0.97% nickel at Serp Hill. Dominion had planned to develop the site in stages. Stage 1 was set at 3000 t/y of nickel and 60 t/y cobalt. By Stage 3, output would have risen to 32 000 t/y of nickel and 900 t/y of cobalt. Dominion had hoped to reach Stage 3 by 2001. The costs to progress to each stage were estimated at A\$40 million to Stage 1, an additional A\$340 million to Stage 2, and an additional A\$250 million to Stage 3. Daewoo Corporation's 10% participation for A\$9 million plus 10% of the financing had been contingent upon securing the balance of the financing by the end of 1997. By November, with continued low nickel prices, Dominion had announced that it could not secure the financing.

Gencor Ltd. and Canadian-based LionOre Mining International Ltd.'s joint venture owns 100% of the Maggie Hays deposit and 75% of the nearby Emily Ann deposit. Gencor obtained its 50% share in the joint venture by contributing A\$5 million and by demonstrating that its BioNIC technology could successfully treat concentrate from Maggie Hays. Maggie Hays' inferred reserves were 13.4 Mt grading 1.5% nickel and 0.05% cobalt using a 0.7% nickel cut-off grade. The reserves increased to 17 Mt grading 1.2% nickel for a 0.4% nickel cut-off grade.

Gencor Ltd. unbundled its non-precious metals assets into the newly formed Billiton plc and merged its nickel assets with those of QNI Ltd., which operates a hydrometallurgical nickel refinery in Queensland. At the time of the merger, Billiton's nickel assets included the Cerro Matoso ferronickel operation in Colombia and an interest in the Gencor-LionOre joint venture in Australia (referred to above). Through the merger, QNI became the fourth largest nickel producer with production of about 60 000 t/y. This level could rise to 85 000 t/y by 2002.

Note: The reader is invited to send an e-mail to the author of this chapter to request web sites for additional information about industry developments in Australia for the following companies (and deposits):

- Jubilee Gold Mines NL (Cosmos deposit);
- Morgans Gold Ltd. (Abednego deposit);
- Mt. Kersey Mining NL (Gindalbie, Four Corners);
- Outokumpu Oyj (Honeymoon Well);
- Titan Resources NL (Goodyear);
- Preston Resources NL (Marlborough);
- Sons of Gwalia Ltd. (Coglia Well, Weld Range);
- and
- Dragon Mining N.L. (Weld Range).

## New Caledonia

New Caledonian mines produce about 125 000 t/y of nickel in lateritic ore. The ore goes to smelters and refineries in Australia, Japan and the United States, as well as to the Doniambo smelter of Société Le Nickel-SLN (SLN) of the ERAMET Group.

In September, Inco announced intentions to build a 12-t/d pilot operation at Goro to evaluate its proprietary acid pressure leaching and solvent extraction technologies. The Goro lateritic deposit has reserves of 165 Mt grading 1.6% nickel and 0.16% lateritic cobalt. Goro is owned 85% by Inco and 15% by Bureau de Recherches Géologiques et Minières (BRGM) of France. Construction of the pilot plant is scheduled to be completed by early 1999. An initial mining zone of 47 Mt at an undisclosed grade would supply a commercial operation with an initial capacity of 27 200 t/y of nickel and 2720 t/y of cobalt.

The future of SLN's Koniambo deposit and the proposed ferronickel smelter for the northern end of New Caledonia was an important issue throughout 1997. The French government proposed that ERAMET give this orebody to Société Minière du Sud Pacifique (SMSP) in exchange for the smaller Poum orebody. Koniambo's reserves are needed to support plans by SMSP to develop a ferronickel smelter with Falconbridge. The indigenous people of New Caledonia, the Kanaks, own a majority of SMSP. ERAMET initially objected to the exchange without compensation. The Kanaks subsequently organized labour strikes in New Caledonia to support the exchange, and a government mediator was appointed to review the situation. By year-end, an agreement had been reached whereby the title to both Koniambo and Poum would be given to an independent commission that would hand over ownership of Koniambo only if Falconbridge's feasibility study was favourable and a commitment was made to proceed with the ferronickel smelter. At the time of such a handover, ERAMET would receive compensation and the Poum orebody.

In 1998, a referendum may be held to decide the future of the island. The Kanak population is more concentrated in the northern part of the island and the French government appears to have sought ways to encourage investment in that region. Falconbridge did not expect to make a decision before January 2005 on whether a smelter would be feasible.

SLN announced plans to increase the capacity of its Doniambo smelter to 65 000 t/y early in the next decade. The cost of the upgrade and the development of new mine capacity to support operations was estimated at US\$350 million. Doniambo's capacity is to increase to 60 000 t/y at the end of 1998 when the fifth kiln is commissioned. SLN and QNI Ltd. announced their intentions to complete a feasibility study for a nickel-processing facility on the northern portion of the island. They were considering an ammonia leach process for limonitic ore. Such a

plant, with a capacity of between 20 000 and 30 000 t/y, would cost about US\$700 million. The intermediate carbonate nickel-cobalt could be sent to QNI's facility in Queensland and to SLN's plant at Sandouville, France, for further processing.

## Cuba

Three Cuban mines produced over 53 000 t of nickel in 1996. As of November 1997, production was running 15% higher than in 1996. Two of the mines are owned by the government and one is a joint venture involving Sherritt International Corporation. The combined capacity of the three mines is nominally 73 000 t/y.

In 1994, Sherritt and General Nickel Company S.A. formed Metals Enterprise, a jointly owned, vertically integrated nickel-cobalt producer. Its business is carried on through three companies: Moa Nickel S.A., International Cobalt Company Inc. (ICCI), and The Cobalt Refinery Company Inc. (Refco). At the mine, lateritic ore is converted to sulphide concentrate by an acid leaching process. The concentrate is shipped to Canada for further processing. Canada and the European Union continued to object to the Helms-Burton Law (Public Law 104-114) in the United States which restricts the entry of key Sherritt personnel into the United States and provides rights to sue in U.S. courts.

KWG Resources Inc. announced plans to complete the development of the Las Camariocas mine and plant, and to build a 30 000-t/y nickel refinery in Canada. KWG had until November 1997 to raise the required US\$300 million, but declining nickel prices and internal financial difficulties at KWG scuttled the deal. Reserves were estimated at 107 Mt grading 1.32% nickel and 0.115% cobalt; 22 Mt were classified as proven using a cut-off grade of 1% nickel.

## The Americas

Outokumpu Oyj agreed to purchase 10 000 t/y of nickel in matte from Rio Tinto plc's **Brazilian** subsidiary Mineração Serra da Fortaleza Ltda for a period of 10 years. The commissioning of the flash smelter began in December. Twenty years of reserves have been delineated; an open pit will run for five years before the operation moves underground. Brazil tried to sell the mineral rights to 36 Mt of reserves in Goiás State with a minimum price of US\$5.45 million, but no bids were submitted.

After Billiton and QNI merged, the new board announced that the Cerro Matoso plant in **Colombia** would be de-bottlenecked to raise its operating rate from 25 000 t/y of ferronickel to 35 000 t/y by the year 2000. In addition, a feasibility study to expand the operation to 45 000 t/y was announced in November.

Cominco Limited announced at the end of January 1998 that its subsidiary, Glenbrook Nickel Company,

in the **United States** would close due to low nickel prices effective the end of March when ore stockpiles at the ferronickel smelter would be exhausted.

Minorco Société Anonyme, Canadian-based Jordex Resources Inc., and Corporación Caracas of **Venezuela** arranged US\$215 million in financing for Minera Lomo de Niquel C.A. in Venezuela. The 34-Mt deposit, grading 1.48% nickel, will produce 16 000 t/y of nickel in ferronickel beginning in early 2000. By year-end, Jordex had decided that it would not contribute capital in proportion to its initial share in the project, which will result in a decline in its ownership level.

## Africa

Falconbridge Limited continued exploration work on the Touba-Biankouma laterite nickel property in the **Ivory Coast**. Falconbridge is earning a 60% interest in the joint venture; the other partners are Trillion Resources Ltd. of Canada (15%) and the government of the Ivory Coast (25%). Development plans were submitted to the government in mid-1997. A US\$15 million program of exploration and metallurgical testing will continue during the 1997/98 period. Recent natural gas finds may allow the government to offer lower-priced power for a possible project. (Trillion Resources has a web site at <http://www.trillion-resources.com/>.)

Sutton Resources Ltd. of Canada signed a joint-venture agreement with Anglo American Corporation of South Africa Limited to investigate the Kabanga nickel-cobalt deposit in **Tanzania**. Additional drilling was undertaken concurrently with a review of current mine plans. Ore reserves total 31 Mt, but a higher-grade zone of 12.7 Mt grading 2.1% nickel and 0.16% cobalt has been identified. The estimated capital cost of an operation that would produce 15 900 t/y of nickel and 680 t/y of cobalt is about US\$135 million.

In September, the government of **Zimbabwe** announced that it would purchase 20% of the Bindura Nickel Corporation Ltd. for Z\$6.25 per share. The Hartley platinum mine will produce by-product nickel cathode at a rate of about 3200 t/y; initial nickel production is expected by the end of 1998.

## Asia

**China** produced 40 000 t of nickel in 1997, with the majority coming from the Jinchuan Nonferrous Metals Corporation in Gansu Province. Jinchuan cut its production in October, citing a build-up of inventory.

The largest nickel producer in **Indonesia** is P.T. International Nickel Indonesia (P.T. Inco), which is owned 59% by Inco Limited. The ferronickel operation is in the midst of a 50% expansion to 68 000 t/y

of contained nickel. By September, a drought had forced the operation to shut down two of its three furnaces because of low water levels at the company's 165-MW hydro-electric facilities. With the completion of the water channel to the station and the moderation of the El Niño drought, the company announced in mid-December that full production would resume in early January 1998. Its production in 1997 was estimated at 31 750 t of contained nickel; the target for 1998 is 45 350 t. P.T. Inco reported that the US\$580 million expansion was on schedule and within budget. Full production of 68 000 t/y of nickel contained in matte is expected in 2000.

The government of Indonesia sold a 35% interest in its nickel-gold producer P.T. Aneka Tambang in a public offering in November. In December, the company announced an expansion of its ferronickel operation in Pomalaa in southeastern Sulawesi. A new 12 000-t/y production line was planned at a cost of US\$235 million. An 11-MW coal-fired thermal power plant and a modernization program for the existing facilities would also be required at an additional cost of US\$130 million.

Highlands Pacific Ltd. and Nord Pacific Limited began a final feasibility study of the Ramu project in **Papua New Guinea**. Preliminary data indicated that for US\$770 million in capital costs, an operation could begin production at a rate of 33 000 t/y of nickel plus 2800 t/y of cobalt by early 2001. The estimated operating cost after cobalt by-product credits was US\$67¢/lb of nickel. The measured and inferred reserves were 24.2 Mt grading 0.9% nickel and 0.08% cobalt.

There was speculation that the Nonoc lateritic mine and nickel smelter in the **Philippines** would be reactivated during the year, but arrangements unravelled in September. The Nonoc mine was shut down in 1986 when banks foreclosed. Refurbishing costs were estimated at between US\$200 million and \$500 million.

Elsewhere in the Philippines, Stellar Metals Inc. of Vancouver worked at obtaining environmental permits for a joint venture (with a local partner) to operate a mine on the island of Palawan. A contract was signed in October 1997 to ship 300 000 t/y (wet) of saprolitic ore grading 2.3% or better to Nippon Metals and Alloy Inc., payable at 23% of the LME spot nickel price for contained nickel. In November, the Palawan Council for Sustainable Development endorsed the Berong project, a prerequisite for an Environmental Compliance Certificate that is required to begin mining. Stellar has two other lateritic nickel prospects: the Isabela property, and a property in Suriagao.

## Europe

At the end of June, Outokumpu Oyj lost 10 weeks of production due to an accident at its nickel smelter in

**Finland**. The 40 000-t/y smelter was expected to produce only about 35 000 t in 1997 from domestic and imported concentrates. In October, the company signed a 10-year agreement with Fortaleza to process 10 000 t/y of nickel matte beginning in 1998.

Falconbridge's Nikkelverk refinery in **Norway** had to reduce its operating rate in mid-year due to the effects of the strike in Sudbury. The plant processes material from Sudbury and about 15 000 t/y from the Phikwe smelter in Botswana. Its capacity, which increased in 1997, is currently 85 000 t/y of nickel, 40 000 t/y of copper and 4000 t/y of cobalt.

## CONSUMPTION

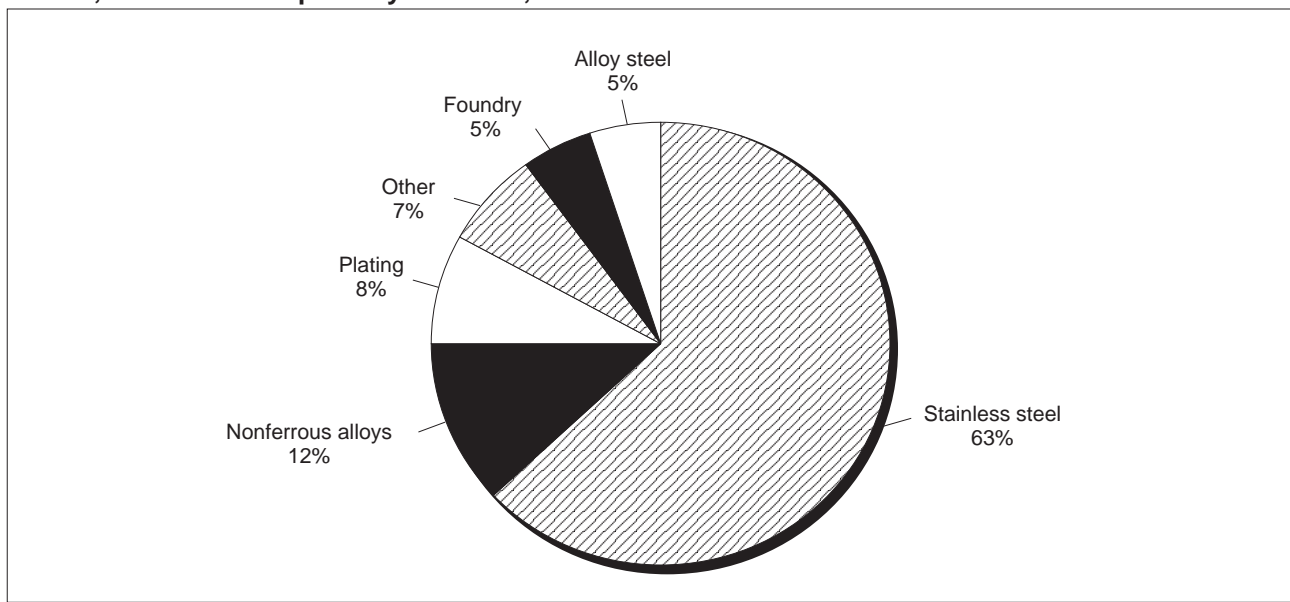
The stainless steel industry is the largest consumer of primary nickel, accounting for about two thirds of consumption. Other important consuming sectors include the nonferrous, plating, alloy steel and foundry sectors (Figure 2). Stainless steel is "stainless" or corrosion-resistant because it contains a minimum of 10% chromium by weight. A thin film of chromium oxide adheres to the surface of stainless steel. If damaged, this film is self-healing so long as 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, both hot and cold. 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% chromium and 8% nickel. While austenitic stainless steel contains nickel, ferritic stainless steel does not. A guide to these two types of stainless steel and others can be found at the web site of the Specialty Steel Industry of North America on the following pages: <http://www.ssina.com/stainless.html>, and <http://www.ssina.com/student.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 cars.



**Figure 2**  
**Nickel, World Consumption by First Use, 1997**



Source: Inco Limited.

## HEALTH AND THE ENVIRONMENT

Nickel is a naturally occurring element that exists in all soils 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 mg of nickel, with nickel also being present in human fetal tissue. Food is the major route for nickel intake by humans. It has not been shown that ingested nickel is a cause of cancer in humans, or that ingestion makes people sensitive to nickel. 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. However, many nickel alloys, including stainless steel, do not react with sweat and therefore do not cause a nickel allergy. 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 associated with it.

In Europe, the issue of the use of nickel in alloys used for coins was recently debated. Sweden petitioned the European Union to remove coins that contained nickel from circulation due to a perceived risk of dermal sensitization in the general public. Scientific input from academic, government and private-sector researchers and specialists resulted in a general consensus that nickel alloy coins present little risk to the general public. It was further determined that a limited number of persons who had previously been sensitized to nickel might develop a rash from handling coins in a manner that caused prolonged contact with nickel alloy coins (e.g., employees in a bank). In addition, people with hand eczema who are also pre-sensitized to nickel could experience an aggravation of their condition if their tasks involve intense handling of coins, and the hand eczema may be further aggravated by mechanical irritation due to repeated coin handling. The one and two Euro coins will contain nickel, while the lower-denomination coins will not.

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.

## RECYCLING

Nickel is a metal that is intensively recycled. This recycling is driven by economic incentives, not

government subsidies. Stainless steel is the largest end use for nickel, consuming about two thirds of primary nickel. On a worldwide basis, about 45% of the nickel needed by the stainless steel industry is obtained in the form of stainless steel scrap. Such stainless steel scrap not only contains nickel, but also needed chrome and iron.

A number of countries registered increasing imports of stainless steel scrap (gross tonnes) in 1997 compared to 1996. For the first seven months of 1997, the European Union's imports were up 33% to 395 000 t, compared to the same period a year earlier. Japanese imports were up 34% to 167 600 t for the first 10 months of 1997 compared to the same period a year earlier. Imports into Taiwan and the Republic of Korea were about 45% higher during the first nine and eight months of 1997, respectively. On average, stainless steel scrap contains between 8% and 10% nickel.

The Rechargeable Battery Recycling Program began across Canada in 1997, modelled after a successful ongoing program in the United States. Although many Ni-Cd batteries can be recharged up to 1000 times, there comes a time when these batteries reach the end of their service lives. The members of the rechargeable power industry developed and funded the "Charge Up to Recycle!" program. The Rechargeable Battery Recycling in Canada organization will manage this program, whose goal is to divert Ni-Cd batteries from the waste stream to recycling facilities. As of late October, over 1900 outlets had begun to take back rechargeable Ni-Cd batteries from consumers. The batteries were shipped to the INMETCO plant in the United States for the recovery of nickel and cadmium.

## NICKEL ORGANIZATIONS

Fifteen nickel-producing and consuming nations are members of the **International Nickel Study Group** based in The Hague. The group publishes comprehensive monthly nickel statistics (refer to Table 11 for details).

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 the Republic of 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 and is published twice a year. Both are available free upon request. (NiDI has a web site at <http://www.nidi.org/>.)

The **Nickel Producers Environmental Research Association** (NiPERA) conducts and sponsors inde-

pendent research into the health and environmental effects of nickel and nickel compounds. NiPERA sponsored a workshop on dermal sensitization in the spring of 1997. One of the issues discussed was the use of nickel alloys in coins. The work that was started at that workshop formed the basis for the evaluation of the use of nickel alloys in the upcoming standardized European currency referred to as Euro coins. Nickel alloys will be used in the one and two Euro denomination coins. (NiPERA has a web site at <http://www.nipera.org/>.)

## PRICES AND STOCKS

Prices did not achieve the levels expected by many forecasters at the start of 1997. One of the main reasons why prices weakened over the course of the year was that supply was far more plentiful than expected. Russian primary nickel production reversed its falling trend of recent years; Norilsk overcame many difficulties and produced an estimated 33 000 t more than in 1996. As Russian consumption was still low, the higher production resulted in more exports. These increased exports were exacerbated by the increased amount of stainless steel and nickel alloy scrap exported from Russia; an estimated 50 000 t of nickel in scrap was exported in 1997 compared to an estimated 40 000 t in 1996.

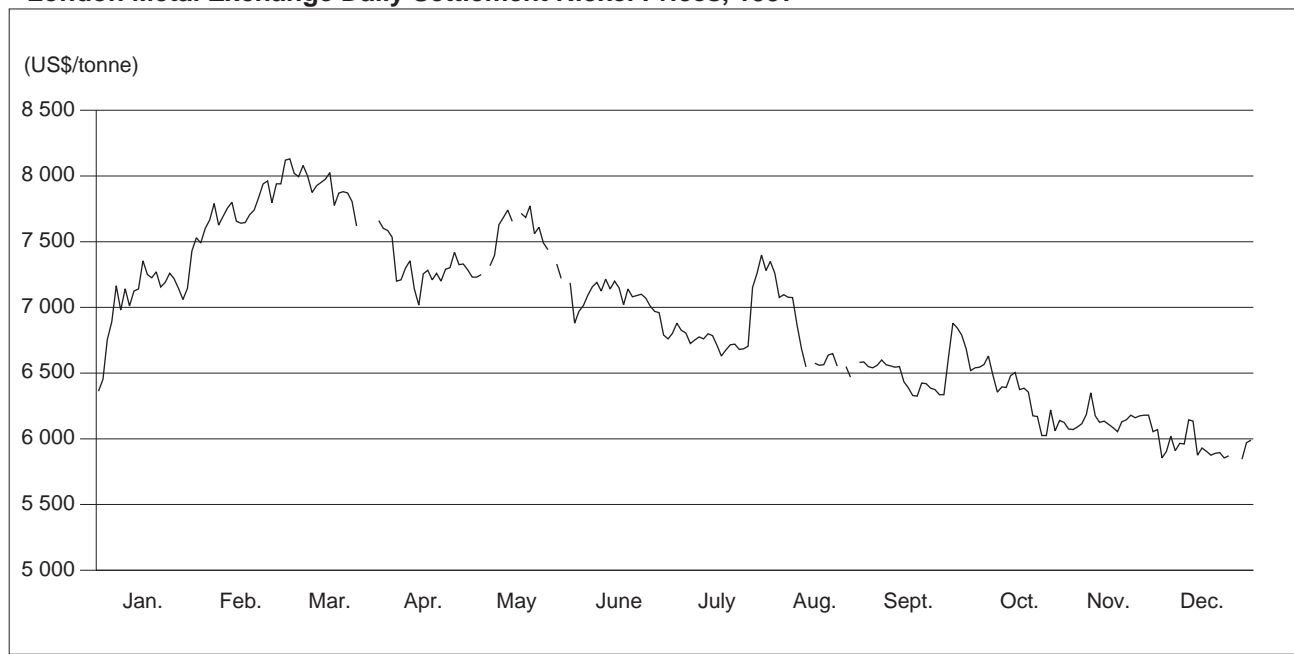
As noted in the introduction, the price of nickel averaged US\$3.14/lb (US\$6916/t) in 1997, compared with US\$3.40/lb (US\$7500/t) in 1996 (refer to Table 7 for yearly prices for the period 1981-97). Monthly settlement prices peaked in March at US\$3.58/lb (US\$7899/t) (refer to Table 8 for average monthly prices during the period 1994-97).

Month-end LME stocks decreased from 48 900 t at the start of 1997 to February's low of 45 600 t, and then increased to 67 000 t in October and November before dropping back to 66 200 t at year-end. At the same time, reported producer stocks started the year at 84 500 t, declined somewhat but recovered to 84 000 t by the end of May, and then declined to 72 900 t by the end of September and to 72 100 t by the end of November. Thus, between January and November, month-end combined LME plus reported producer stocks varied by only a maximum of 8500 t from the January 1997 month-end total of 132 200 t. Combined LME plus reported producer month-end stocks, as measured by weeks of consumption, began the year at 12 weeks and varied from 11.8 to 13.3 weeks throughout the year; at the end of November, they were at 12.9 weeks of supply.

## OUTLOOK

The outlook for nickel at the end of 1997 is more negative than it was a year ago. The Asian financial crisis in the third and fourth quarters of 1997 was pre-

**Figure 3**  
**London Metal Exchange Daily Settlement Nickel Prices, 1997**



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

ceded by weak nickel prices. These financial troubles dampened expectations that higher growth would pull up nickel prices in the short term.

The demand for nickel is largely a function of the demand for austenitic stainless steel and high-nickel alloy steels. Stainless steel production was estimated to have risen to above 16 Mt for 1997, up from less than 15 Mt in 1996. The major factor in nickel and stainless steel demand is the growth in industrial production. Infrastructure growth demands heavy use of stainless steel, and development in Asia is not expected to be stalled indefinitely. The growth rate for austenitic (nickel-containing) stainless steel is expected to exceed that for ferritic (containing 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 about 3% per year on average.

The non-stainless demand for nickel is not expected to grow as fast as the demand for nickel fuelled by stainless steel. As well, the relative importance of the other sectors is not expected to remain constant. Nickel use in iron and steel castings for the automotive industry is expected to decline due to substitution by lower-cost alternatives. However, the automotive industry's demand for nickel may increase rapidly if nickel metal hydride batteries become the battery of choice for electric vehicles.

A number of new technologies appear to be vying with each other to be the lowest-cost technology to

recover nickel and cobalt from lateritic ores. Australia is the main proving ground at present. The proven Sherritt technology is being installed in the Murrin Murrin operation. Sherritt technology is also the choice for the proposed Calliope plant on the east coast of Australia. Resolute Limited will treat ore at its Bulong project with acid pressure leaching and solvent extraction-electrowinning starting in April 1998, and Centaur will use an ammonia leach and electrowinning process starting in 1999. In New Caledonia, Inco will test its proprietary process at its Goro property beginning in 1998.

The result of these new operations trying different approaches may lead to lower-cost nickel production from lateritic ores. With the associated cobalt recovery, such operations have the potential to lower the average operating costs for lateritic nickel producers and reduce the nickel production cost curve. This will put increased strains on nickel sulphide producers. It is also likely to reduce cobalt prices to perhaps the US\$8-\$12/lb range, especially if a number of new cobalt deposits in the Congo proceed as well.

Many existing producers have the potential to increase their production in order to reduce fixed costs. Inco's Voisey's Bay project offers an opportunity to produce nickel at reduced production costs after making a substantial investment. The start-up of Voisey's Bay is expected to push the market further into oversupply. In the nearer term, as Norilsk obtains access to investment capital, it too may increase production or may concentrate on production that yields increased profits.

An average nickel price of US\$2.75/lb (US\$6060/t) is forecast for 1998, based upon substantial progress in resolving the financial problems in Asia, continued Chinese economic growth, and a balance or a slight surplus in the supply/demand balance. In 1998, inventories are not expected to be worked down to levels that would promote sustained concerns about availability of adequate supply (i.e., in the order of less than 5-6 weeks of supply in the LME's plus producers' inventories, or less than 12 weeks of supply in the LME's plus producers' plus consumers' inventories).

The longer-term price for nickel is expected to range between US\$2 and \$4/lb (US\$4400-\$8800/t). This long-term range may be pulled lower, perhaps by US25¢/lb (US\$550/t), if potential cost reductions are achieved by the application of new lateritic production technologies during the next five to seven years.

While average annual prices 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. Such events would include serious technical problems at leading producers, extended labour or transportation problems at Norilsk, or problems associated with the political future of New Caledonia. On the other hand, major new discoveries of high-grade orebodies should lead to lower prices.

It is difficult to say if these prices are in constant or current terms. Economists prefer to use constant dollars, but the past trends have been greatly influenced by the changing value of the U.S. dollar, which is the currency that is used to express nickel prices.

In the longer term, some decline in nickel prices is expected in "real terms," or if denominated in "constant dollars," 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 one country. In the medium term, inflation rates are not expected to be significant; hence, the entry into production of large high-grade deposits or the changing patterns in demand are expected to have more effect on nickel prices than would the rate of inflation. In the short term, the size of the nickel inventory compared to demand is the dominant factor.

Canadian mine production of nickel in concentrate in 1998 is forecast to rise to about 200 000 t. However, because Inco was still engaged in a restructuring of its Canadian operations at year-end, any changes made in Inco's (or Falconbridge's) production plans or unforeseen circumstances will affect this forecast of Canadian nickel production.

*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 February 6, 1998. (3) To obtain other web site addresses relevant to nickel, please send an e-mail request to [bmccutch@nrca.gc.ca](mailto:bmccutch@nrca.gc.ca) and include the words "web sites for nickel" in the subject line of your message. (4) Some company internet sites have been identified in this article. Please note that Natural Resources Canada has no control over the material presented on these web sites. The companies who run these web sites may modify, update or delete information; the URL can be modified or substantively changed; or the web site may become inaccessible to the public at any time.*

## TARIFFS

Item No.	Description	Canada			United States	EU	Japan <sup>1</sup>	Brazil	India	Taiwan	Korea <sup>2</sup>
		MFN	GPT	USA	Canada	MFN	WTO	MFN	MFN	MFN	MFN
2604.00	Nickel ores and concentrates	Free	Free	Free	Free	Free	Free	2%	5%	Free	1%
2825.40	Nickel oxides and hydroxides	Free	Free	Free	Free	Free	5.2%	2-10%	30%	2.5%	8%
7202.60	Ferronickel	6.5%	Free	Free	Free	Free	4.6%	6%	10%	Free	5%
7501.10	Nickel mattes	Free	Free	Free	Free	Free	Free	6%	10%	Free	2%
7501.20	Nickel oxide sinters and other intermediate products of nickel metallurgy	Free	Free	Free	Free	Free	Free-58.8 yen/kg <sup>3</sup>	6%	10%	Free	2%
7502.10	Unwrought nickel, not alloyed	Free	Free	Free	Free	Free	58.8 yen/kg	6%	10%	1.25%	5%
7502.20	Unwrought nickel alloys	Free	Free	Free	Free	Free	Free-5.4% <sup>4</sup>	6%	10%	1.25%	5%
7503.00	Nickel waste and scrap	Free	Free	Free	Free	Free	Free	2%	10%	Free	1%
7504.00	Nickel powders and flakes	Free	Free	Free	Free	Free	Free-50.6 yen/kg-4.2%	6%	10%	Free	5%
7505.11	Bars, rods and profiles of nickel, not alloyed	Free	Free	Free	Free	1.8%	4.7%	12%	10%	2.5%	8%
7505.12	Bars, rods and profiles of nickel alloys	Free	Free	Free	Free	3.5%	4.1%	12%	10%	2.5%	8%
7505.21	Nickel wire, not alloyed	Free	Free	Free	Free	1.8%	4.7%	12%	10%	1.25%	8%
7505.22	Wire of nickel alloys	Free	Free	Free	Free	3.5%	4.1%	12%	10%	1.25%	8%
7506.00	Nickel plates, sheets, strip and foil	Free	Free	Free	Free	2-3.9%	Free-4.7%	12%	10%	2.5%	8%
7507.00	Nickel tubes, pipes, and tube or pipe fittings	Free	Free	Free	Free	2.1-3%	2.6-4.7%	14%	10%	2.5%	8%
7508.00	Other articles of nickel	Free-3%	Free	Free	Free	1.8%	4.1%	16%	10%	1.25-5%	8%

Sources: Customs Tariff, effective January 1998, Revenue Canada; Harmonized Tariff Schedule of the United States, 1998; Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of the European Union (37th Annual Edition: 1997); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of Brazil (4th Annual Edition: 1997); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of India (4th Annual Edition: 1997); Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of Taiwan (2nd Annual Edition: 1997); Customs Tariff Schedules of Japan, 1997, WTO column.

<sup>1</sup> WTO rate is shown; lower tariff rates may apply circumstantially. <sup>2</sup> Republic of Korea (South Korea). <sup>3</sup> Free except for nickel oxide sinters containing by weight not less than 88% nickel, for which the tariff rate is 58.8 yen/kg, and nickel oxide containing by weight not more than 1.5% copper, for which the tariff rate is 4.7%. <sup>4</sup> The tariff rate of 5.4% applies to nickel alloys other than those containing by weight less than 50% nickel and not less than 10% cobalt.

TABLE 1. CANADA, NICKEL PRODUCTION AND TRADE, 1996 AND 1997

Item No.		1996		1997P	
		(tonnes)	(\$000)	(tonnes)	(\$000)
<b>PRODUCTION<sup>1</sup></b>					
	All forms				
	Ontario	146 844	1 545 977	135 631	1 334 742
	Manitoba	35 560	374 371	44 953	442 385
	Total	182 404	1 920 348	180 584	1 777 127
	Refined	126 593	—	127 069	—
<b>EXPORTS</b>					
2604.00.40	Nickel ores and concentrates, nickel content				
	China	—	—	19	118
	United States	...	7	—	—
	Total	...	7	19	118
2825.40	Nickel oxides and hydroxides				
	United States	635	9 655	388	5 964
	China	246	3 754	183	2 638
	Taiwan	219	3 809	136	1 716
	Singapore	365	5 159	120	1 550
	Other countries	487	7 510	152	2 350
	Total	1 952	29 887	979	14 218
7202.60	Ferronickel	—	—	—	—
7501.10	Nickel mattes				
	Norway	40 462	453 339	39 038	400 909
	United Kingdom	43 195	497 425	36 947	386 293
	Total	83 657	950 764	75 985	787 202

TABLE 1 (cont'd)

Item No.		1996		1997P	
		(tonnes)	(\$000)	(tonnes)	(\$000)
<b>EXPORTS (cont'd)</b>					
7501.20	Nickel oxide sinters and other intermediate products of nickel metallurgy				
	Korea, Republic of	7 664	76 425	6 298	52 768
	United States	479	4 867	2 409	21 335
	Taiwan	3 710	37 465	1 295	12 697
	Belgium	351	3 870	704	7 126
	Other countries	381	4 153	23	216
	Total	12 585	126 780	10 729	94 142
7502.10	Nickel unwrought, not alloyed				
	United States	47 970	511 184	47 541	461 283
	Belgium	14 404	159 063	9 719	93 700
	Netherlands	3 807	35 719	7 057	67 826
	Taiwan	9 607	101 781	5 374	55 232
	Japan	3 402	34 782	4 970	48 232
	Italy	160	1 582	4 365	41 063
	China	3 007	34 367	3 857	39 760
	Korea, Republic of	1 453	15 225	2 629	26 802
	Switzerland	1 500	14 879	2 688	24 515
	Other countries	11 743	123 572	12 347	119 340
	Total	97 053	1 032 154	100 547	977 753
7502.20	Nickel unwrought, alloyed				
	United States	75	817	286	2 513
	Other countries	...	3	19	59
	Total	75	820	305	2 572
7503.00	Nickel waste and scrap				
	United States	2 223	8 830	3 409	17 660
	Japan	181	547	363	2 410
	Other countries	152 <sup>r</sup>	527 <sup>r</sup>	246	1 358
	Total	2 556 <sup>r</sup>	9 904 <sup>r</sup>	4 018	21 428
7504.00	Nickel powders and flakes				
	United States	6 660	96 370	7 267	105 928
	Japan	3 344	42 322	4 635	53 312
	Netherlands	440	5 084	622	8 737
	China	458	7 291	531	8 681
	Belgium	685	8 649	532	5 793
	Other countries	688 <sup>r</sup>	11 447 <sup>r</sup>	1 491	20 446
	Total	12 275 <sup>r</sup>	171 163 <sup>r</sup>	15 078	202 897
7505.11	Bars, rods and profiles of nickel, not alloyed				
	New Zealand	—	—	78	236
	United States	...	10	...	2
	Total	...	10	78	238
7505.12	Bars, rods and profiles of nickel alloy				
	United States	9	390	2	80
	Other countries	1	19	3	49
	Total	10	409	5	129
7505.21	Nickel wire, not alloyed				
	United States	2	30	...	10
	Total	2	30	...	10
7505.22	Wire, nickel alloy				
	United States	65	1 731	86	2 015
	Brazil	—	—	...	15
	Total	65	1 731	86	2 030
7506.00 <sup>a</sup>	Nickel plates, sheets, strip and foil				
	United States	11	306	5	205
	Poland	25	226	9	102
	Other countries	16 <sup>r</sup>	143 <sup>r</sup>	16	86
	Total	52 <sup>r</sup>	675 <sup>r</sup>	30	393

TABLE 1 (cont'd)

Item No.		1996		1997P	
		(tonnes)	(\$000)	(tonnes)	(\$000)
<b>EXPORTS (cont'd)</b>					
7507.00 <sup>b</sup>	Nickel tubes, pipes, and tube or pipe fittings				
	United States	..	4 672	..	3 739
	United Arab Emirates	..	13	..	177
	Other countries	..	154	..	137
	Total	..	4 839	..	4 053
7508.00	Other articles of nickel				
	United States	..	4 807	..	7 788
	Japan	..	-	..	208
	United Kingdom	..	48	..	192
	Other countries	..	791	..	283
	Total	..	5 646	..	8 471
<b>IMPORTS<sup>2</sup></b>					
2604.00.00.20	Nickel ores and concentrates, nickel content				
	Australia	915	5 491	6 323	10 599
	United States	929	5 142	1 065	6 270
	Other countries	272	1 336	36	156
	Total	2 116	11 969	7 424	17 025
2825.40	Nickel oxides and hydroxides				
	Finland	82	783	330	2 222
	Other countries	106	1 218	627	591
	Total	188	2 001	957	2 813
7202.60	Ferronickel				
	United States	64	337	...	...
	Total	64	337	...	...
7501.00 <sup>c</sup>	Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy				
	Cuba	46 134	316 755	46 723	273 743
	Australia	1 016	12 354	670	6 948
	United Kingdom	235	369	601	2 886
	United States	5 232	7 837	1 603	2 703
	Other countries	4 126	15 365	306	1 493
	Total	56 743	352 680	49 903	287 773
7502.10	Nickel unwrought, not alloyed				
	Norway	2 626	24 865	969	8 996
	United Kingdom	97	1 075	146	1 615
	Russia	619	6 857	99	1 229
	Other countries	405	4 565	270	1 493
	Total	3 747	37 362	1 484	13 333
7502.20	Nickel unwrought, alloyed				
	United States	2 615	12 810	1 097	5 193
	United Kingdom	68	1 038	17	346
	Other countries	19	213	...	16
	Total	2 702	14 061	1 114	5 555
7503.00	Nickel waste and scrap				
	United States	13 935	43 906	14 638	44 212
	United Kingdom	975	6 014	904	4 294
	Netherlands	340	1 185	415	1 480
	Other countries	842	2 559	616	2 405
	Total	16 092	53 664	16 573	52 391
7504.00	Nickel powder and flakes				
	Australia	1 003	10 664	816	8 253
	United States	709	5 475	353	3 855
	Finland	122	1 433	202	3 011
	Other countries	2 107	23 706	90	1 282
	Total	3 941	41 278	1 461	16 401
7505.11	Bars, rods and profiles of nickel, not alloyed				
	United States	6	117	11	186
	Other countries	...	3	1	18
	Total	6	120	12	204

TABLE 1 (cont'd)

Item No.		1996		1997 <sup>P</sup>	
		(tonnes)	(\$000)	(tonnes)	(\$000)
<b>IMPORTS (cont'd)</b>					
7505.12	Bars, rods and profiles of nickel alloys				
	United States	290	6 597	375	7 500
	Germany	10	138	19	312
	Other countries	18	452	23	458
	Total	318	7 187	417	8 270
7505.21	Nickel wire, not alloyed				
	Germany	. . .	5	10	154
	Japan	20	147	19	151
	Other countries	5	95	10	118
	Total	25	247	39	423
7505.22	Wire, nickel alloy				
	United States	364 <sup>r</sup>	6 623 <sup>r</sup>	409	7 016
	Germany	58	1 150	69	1 363
	Other countries	7	165	9	178
	Total	429 <sup>r</sup>	7 938 <sup>r</sup>	487	8 557
7506.00	Nickel plates, sheets, strip and foil				
	United States	910 <sup>r</sup>	16 941 <sup>r</sup>	690	12 073
	Germany	145	2 717	115	2 440
	Japan	55	399	332	2 272
	Other countries	145	1 861	73	952
	Total	1 255 <sup>r</sup>	21 918 <sup>r</sup>	1 210	17 737
7507.00	Nickel tubes, pipes, and tube or pipe fittings				
	Japan	404	36 260	441	26 071
	United States	545 <sup>r</sup>	12 832 <sup>r</sup>	449	10 927
	Spain	-	-	332	4 711
	Norway	. . .	7	218	2 208
	Italy	23	429	61	1 798
	Other countries	119	2 926	33	1 056
	Total	1 091 <sup>r</sup>	52 454 <sup>r</sup>	1 534	46 771
7508.00	Other articles of nickel				
	United States	504	10 650	601	11 879
	China	122	910	94	715
	United Kingdom	24	551	42	587
	France	528 <sup>r</sup>	4 521 <sup>r</sup>	37	409
	Germany	1 382 <sup>r</sup>	27 357 <sup>r</sup>	6	85
	Other countries	41	386	46	475
	Total	2 601 <sup>r</sup>	44 375 <sup>r</sup>	826	14 150

Sources: Natural Resources Canada; Statistics Canada.

- Nil; . . Not available or not applicable; . . . Amount too small to be expressed; <sup>P</sup> Preliminary; <sup>r</sup> Revised.<sup>a</sup> Included in the data are HS codes 7506.10 and 7506.20. <sup>b</sup> Included in the data are HS codes 7507.11, 7507.12 and 7507.20.<sup>c</sup> Included in the data are HS codes 7501.10 and 7501.20.<sup>1</sup> Recoverable nickel in concentrates shipped. <sup>2</sup> 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 1985-97**

	Production <sup>1</sup> (Mine Output)	Consumption <sup>2</sup>
	(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	13 322 <sup>a,r</sup>
1992	186 384	15 528 <sup>r</sup>
1993	188 080	17 384 <sup>a,r</sup>
1994	149 886	20 746 <sup>r</sup>
1995	181 820	20 973 <sup>r</sup>
1996	192 649 <sup>r</sup>	24 504 <sup>r</sup>
1997 <sup>p</sup>	190 785	. .

Source: Natural Resources Canada.

. . Not available; <sup>p</sup> Preliminary; <sup>r</sup> Revised.

<sup>a</sup> Increase in number of companies being surveyed.

<sup>1</sup> Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. Data for 1987-97 are nickel contained in concentrates produced.

<sup>2</sup> 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, 1997**

	Inco Limited		Falconbridge Limited	Sherritt International Corporation
	Sudbury	Thompson	Sudbury	Fort Saskatchewan
	(t/y of contained nickel)			
Smelter	100 000	63 000	60 000	n.a.
Refinery	59 000	55 000	n.a.	25 000

Source: Natural Resources Canada.

n.a. Not applicable.

**TABLE 4. WORLD MINE PRODUCTION<sup>1</sup> OF NICKEL,<sup>2</sup> 1994-97**

	1994	1995	1996	1997 <sup>e</sup>
	(000 tonnes)			
Russian Federation	212.0	251.0	230.0	249.6
Canada	149.9	181.8	192.6	190.8
New Caledonia	97.3	120.7	124.8	138.2
Australia	75.9	104.0	113.0	127.5
Indonesia	81.2	86.6	87.9	76.7
Cuba	26.9	42.7	53.6	61.5
China, People's Republic of	36.9	42.2	47.4	43.2
South Africa	30.1	29.8	33.9	32.0
Dominican Republic	30.8	30.9	30.4	31.7
Brazil	20.1	19.2	20.5	20.9
Other	115.4	116.0	125.0	122.3
Total	876.5	1 024.9	1 059.1	1 094.5

Sources: Natural Resources Canada; *World Nickel Statistics*, International Nickel Study Group, January 1998.  
<sup>e</sup> Estimated.

<sup>1</sup> Production for 1997 has been estimated by prorating 11 months of data, except for Canada, which uses later data. Totals have been changed to reflect changes in Canadian data. <sup>2</sup> Nickel content in concentrate produced (except for Russian Federation, which may refer to nickel content of ore mined).

**TABLE 5. WORLD PRODUCTION<sup>1</sup> OF PRIMARY NICKEL, 1994-97**

	1994	1995	1996	1997 <sup>e</sup>
	(000 tonnes)			
Russian Federation	180.9	200.0	190.0	209.3
Canada	105.1	121.5	126.6	127.3
Japan	112.6	135.0	130.5	124.6
Australia	66.6	76.9	74.0	72.1
Norway	68.0	53.2	61.6	62.3
New Caledonia	39.5	42.2	42.2	42.8
China, People's Republic of	31.3	38.1	44.2	41.5
United Kingdom	28.4	39.0	42.0	36.7
South Africa	30.1	29.8	33.9	33.4
Dominican Republic	30.8	30.9	30.4	31.7
Other	131.3	152.2	177.3	194.6
Total	824.6	918.8	952.7	976.3

Sources: Natural Resources Canada; *World Nickel Statistics*, International Nickel Study Group, January 1998.  
<sup>e</sup> Estimated.

<sup>1</sup> Production for 1997 has been estimated by prorating 11 months of data, except for Canada, which uses later data. Totals have been changed to reflect changes in Canadian data.

**TABLE 6. WORLD CONSUMPTION<sup>1</sup> OF PRIMARY NICKEL, BY COUNTRY AND BY REGION, 1994-97**

	1994	1995	1996	1997 <sup>e</sup>
	(000 tonnes)			
<b>BY COUNTRY</b>				
Japan	181.1	205.1	187.1	194.8
United States	136.3	155.2	153.1	156.3
Germany	87.8	93.1	74.9	89.5
Taiwan, China	26.0	48.0	50.0	64.8
Korea, Republic of	39.0	44.0	50.0	61.2
France	45.6	48.5	45.9	47.6
Italy	44.0	49.0	44.0	45.7
China, People's Republic of	40.0	40.2	42.0	43.0
United Kingdom	38.0	43.0	42.2	36.8
Russian Federation	35.0	36.2	35.0	35.6
Other	195.4	218.0	212.5	219.5
Total	868.2	980.3	936.7	994.7
<b>BY REGION</b>				
Asia	273.1	327.0	316.2	348.4
Europe	326.9	356.0	321.5	341.7
Americas	170.4	190.6	188.8	191.6
East <sup>2</sup>	81.2	84.3	83.7	86.2
Africa	14.9	20.6	24.6	24.9
Oceania	1.7	1.8	1.9	1.9
Total	868.2	980.3	936.7	994.6

Source: *World Nickel Statistics*, International Nickel Study Group, January 1998.

<sup>e</sup> Estimated.

<sup>1</sup> Consumption for 1997 has been estimated by prorating 11 months of data. <sup>2</sup> "East" includes China, the Czech Republic, Poland, Romania, the Russian Federation and the Ukraine.

**TABLE 7. AVERAGE ANNUAL NICKEL PRICES, 1981-97**

	Settlement Price	
	(US\$/t)	(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

Source: International Nickel Study Group.

**TABLE 8. AVERAGE MONTHLY NICKEL PRICES, 1994-97**

	1994	1995	1996	1997
	(US\$/t)			
January	5 580	9 596	7 866	7 047
February	5 827	8 509	8 219	7 737
March	5 590	7 536	8 024	7 899
April	5 410	7 400	8 047	7 318
May	6 089	7 236	8 030	7 485
June	6 284	7 874	7 712	7 065
July	6 229	8 599	7 207	6 838
August	5 861	8 947	7 057	6 763
September	6 367	8 408	7 321	6 507
October	6 750	8 065	7 034	6 383
November	7 559	8 509	6 946	6 142
December	8 650	8 094	6 584	5 949
	(converted to US\$/lb)			
January	2.53	4.35	3.57	3.20
February	2.64	3.86	3.73	3.51
March	2.54	3.42	3.64	3.58
April	2.45	3.36	3.65	3.32
May	2.76	3.28	3.64	3.40
June	2.85	3.57	3.50	3.20
July	2.83	3.90	3.27	3.10
August	2.66	4.06	3.20	3.07
September	2.89	3.81	3.32	2.95
October	3.06	3.66	3.19	2.90
November	3.43	3.86	3.15	2.79
December	3.92	3.67	2.99	2.70

Source: International Nickel Study Group.

**TABLE 9. NICKEL STOCKS AND PRICE, 1992-97**

	Year-End Stocks	Price
	(000 tonnes) <sup>a</sup>	(US\$/t)
1992	164.6	7 000
1993	215.9	5 283
1994	227.3	6 344
1995	138.4	8 237
1996	135.0	7 500
1997	139.7	6 916

Sources: International Nickel Study Group; World Bureau of Metal Statistics (WBMS).

<sup>a</sup> London Metal Exchange (LME) stocks plus WBMS reported producer stocks.

Note: Some double-counting may occur between producer and LME stocks.

**TABLE 10. VOISEY'S BAY MINERAL RESERVES AND RESOURCES**

Orebody	Proven Reserves	Indicated Resources	Inferred Resources
(million tonnes)			
Ovoid Zone	31.7		
Eastern Deeps - Main Zone		47.0	
Eastern Deeps - Far Zone		5.6	
Southeastern Extension Zone			2.4
Discovery Hill - Upper Zone <sup>1</sup>		7.3	
Discovery Hill - Lower Zone <sup>1</sup>			5.6
Reid Brook Zone			16.7
Future discoveries <sup>2</sup>			33.7
<b>Total</b>	<b>31.7</b>	<b>59.9</b>	<b>58.4</b>

Source: Voisey's Bay Mine/Mill Environmental Impact Statement, pp. 3-12, Table 3.4 (with Footnote 1 added for explanation).

<sup>1</sup> Previously referred to as part of the Western Extension. <sup>2</sup> Expected to be found.

	Tonnage (millions)	Grade		
		(% Ni)	(% Cu)	(% Co)
<b>ADDITIONAL INFORMATION</b>				
Eastern Deeps (indicated) <sup>3</sup>	50.0	1.36	0.67	0.09
Ovoid (amenable to open-pit) <sup>4</sup>	31.7	2.83	1.68	0.12
Reid Brook (inferred) <sup>5</sup>	16.7	1.46	0.65	0.10
Ovoid Extension <sup>6</sup>	n.r.	n.r.	n.r.	n.r.
New ore zone (amenable to open-pit) <sup>6</sup>	n.r.	n.r.	n.r.	n.r.

Sources: <sup>3</sup> Inco Third Quarter Earnings Report, 1996 (in later reports, tonnage is shown as 52.6 Mt, but no grades are shown). <sup>4</sup> Inco Third Quarter Earnings Report, 1996. <sup>5</sup> Inco Third Quarter Earnings Report, 1997. <sup>6</sup> Inco Fourth Quarter Earnings Report, 1997 (shows reference to the Ovoid Extension and a new ore zone, but without tonnages or grades).  
n.r. Not reported.

**TABLE 11. INTERNATIONAL NICKEL STUDY GROUP PUBLICATIONS**

*World Nickel Statistics* - Monthly Bulletin (annual special issue in October contains annual statistics for preceding 11 years)

- annual subscription
- single copy (except October issue)
- October issue

*World Directory of Nickel Production Facilities* - June 1996

- single copy

To purchase these reports contact:

International Nickel Study Group  
Scheveningseweg 62  
2517 KX The Hague  
The Netherlands

Tel.: 31-70-354-3326  
Fax: 31-70-358-4612  
E-mail: INSG@compuserve.com

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Note: As of January 1998, prices for single issues were in the range of C\$60-\$120, depending upon title.