

# Nickel

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Abbreviations used in this review include:

Al Aluminum; Au Gold; Co Cobalt; Cu Copper;  
Fe Iron; FeNi Ferronickel; Mg Magnesium;  
Mn Manganese; Ni Nickel; PAL Pressure acid leach;  
Pd Palladium; PGMs Platinum group metals;  
Pt Platinum; Zn Zinc.

## SUMMARY

### WORLD NICKEL DATA

|                         | 2002    | 2003  |
|-------------------------|---------|-------|
|                         | (000 t) |       |
| Mine production         | 1 247   | 1 264 |
| Finished production (1) | 1 182   | 1 201 |
| Usage (consumption)     | 1 177   | 1 233 |

Source: International Nickel Study Group (INSG),  
*World Nickel Statistics, June 2004*.

(1) Class I + Class II nickel, which includes production  
of nickel in chemicals.

Notes: Data have been rounded to the nearest 1000  
tonnes. See Tables 8, 9 and 10 in this article for data  
from 2000 to 2003.

### LME ASK PRICES, 2003

| Cash    | Month    |        |        |        |
|---------|----------|--------|--------|--------|
|         | 3        | 15     | 27     |        |
|         | (US\$/t) |        |        |        |
| Average | 9 640    | 9 615  | 9 005  | 8 500  |
| Maximum | 16 670   | 16 700 | 14 365 | 12 310 |
| Minimum | 7 210    | 7 190  | 7 145  | 7 060  |

Source: [Metalprices.com](http://Metalprices.com)

Note: Cash ask price = settlement price.

### CANADIAN DATA

|                                | 2002     | 2003       |
|--------------------------------|----------|------------|
|                                | (tonnes) |            |
| Ni mine production (1)         | 189 297  | 162 756    |
| Ni in concentrates shipped (2) | 179 800  | 152 541    |
| Ni refined production (3)      | 144 476  | 124 418    |
| Ni usage (4)                   | 18 955   | (p) 13 018 |
| Co mine production (1,5)       | 5 150    | (p) 4 300  |
| Co mineral production (2,5)    | 2 065    | (p) 1 750  |
| Co metal production (3)        | 4 303    | (p) 3 850  |
| Co usage (4)                   | 92       | (p) 88     |

Source: Nickel data: Table 7 of *Production of Canada's  
Leading Minerals*, ISSN 0709-292X, SS # 02-12; available at  
<http://mmsd1.mms.nrcan.gc.ca/mmsd/data/2003/03mty12.pdf>.  
Co = cobalt; Ni = nickel; (p) Preliminary.

(1) Metal in concentrates produced from Canadian mines.

(2) Recoverable metal in concentrates shipped from Canadian  
mines. (3) Metal produced whether from domestic or foreign

origin. (4) Use includes metal in scrap and other secondary  
forms. (5) Preliminary Co data rounded to nearest 50 t.

Note: Reader should round to three significant figures.

## UPDATED REFERENCE DOCUMENTS

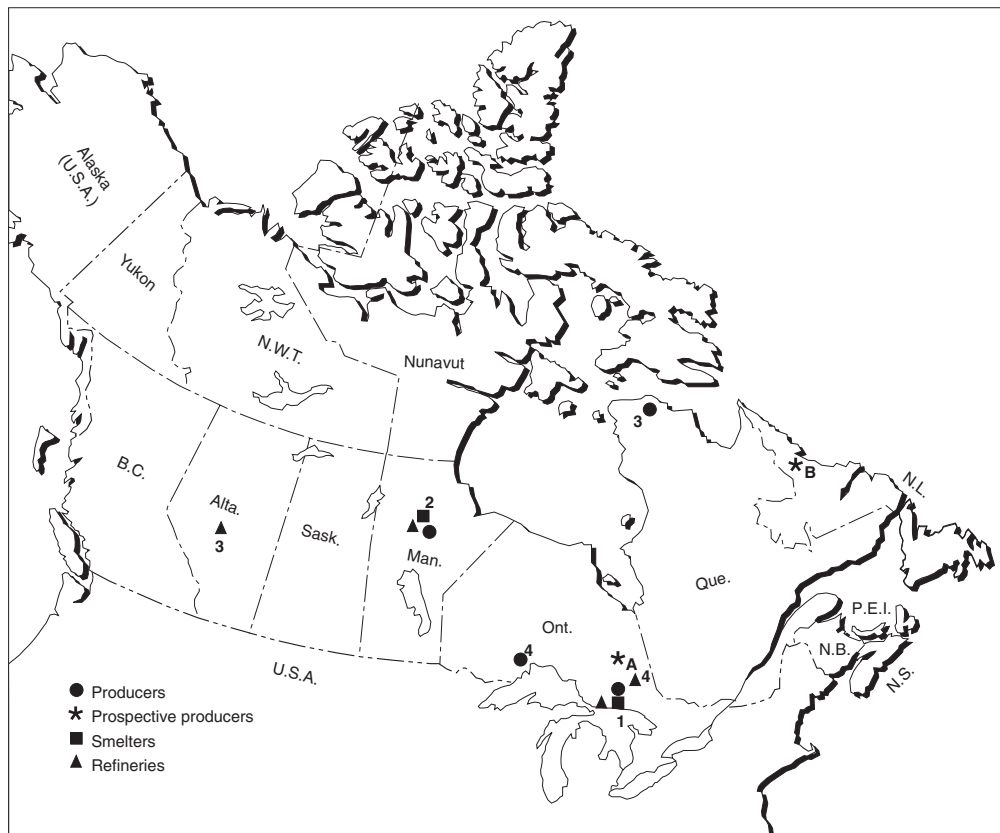
Readers may obtain more current data from a publica-  
tion showing Canadian mine production, mill shipments,  
refined production and domestic shipments for nickel, as  
well as data for many other metals and minerals. The pub-  
lication, updated monthly, is available on the Internet at  
[http://mmsd1.mms.nrcan.gc.ca/mmsd/data/default\\_e.asp](http://mmsd1.mms.nrcan.gc.ca/mmsd/data/default_e.asp).

To obtain copies of previous nickel reviews from the  
*Canadian Minerals Yearbook* for the period 1994 to 2002,  
readers should go to [www.nrcan.gc.ca/mms/cmy/  
com\\_e.html](http://www.nrcan.gc.ca/mms/cmy/com_e.html).

Historical information about nickel and other metals and  
minerals prior to 1994 is also available on the Internet at  
[www.nrcan.gc.ca/mms/cmy/info-hist\\_e.htm](http://www.nrcan.gc.ca/mms/cmy/info-hist_e.htm).

For complete company names, refer to Tables 3 and 6; the  
text below may contain the commonly used name, which  
may not be the official corporate name.

**Figure 1**  
**Nickel and Cobalt in Canada, 2003**



Numbers and letters refer to locations on map above

#### PRODUCERS

1. Falconbridge Limited (Fraser, Lindsley, Onaping-Craig, Lockerby)
1. Inco Limited (Copper Cliff North, Copper Cliff South, Creighton, Garson, Gertrude, McCreedy/Coleman, Stobie)
1. Sudbury Joint Venture (McCreedy West)
2. Inco Limited (Thompson, Birchtree)
3. Falconbridge Limited (Raglan)
4. North American Palladium Ltd. (Lac des Iles)

#### 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)
4. Canmine Resources Corporation (Cobalt, Ontario)

#### PROSPECTIVE PRODUCERS

- A. Falconbridge Limited (Moncalm Township) (mine)
- B. Inco Limited (Voisey's Bay mine)

## OVERVIEW

Nickel's principal use is as an alloying element in stainless steels. Nickel is derived from three sources: sulphide ores (minerals containing nickel and sulphur), laterite ores (mainly soils containing nickel oxides and nickel silicates), and scrap/recyclables. Nickel is very valuable compared to iron, aluminum or copper; therefore, it is intensively recycled. Most of the nickel recycled is in the form of nickel-bearing stainless steels. Nickel coming directly from mineral deposits is referred to as primary nickel; nickel that has been previously used in consumer and industrial applications is called secondary nickel.

Primary nickel is produced in many forms. Over half<sup>1</sup> of the primary nickel produced in 2003 was in the form of electrolytic nickel. This form is used in many applications such as making stainless steels and use in high-nickel alloys, electroplating, etc. Nickel in ferronickel (FeNi) accounted for 22% of world production in 2003; this type of nickel is used in making stainless steels. The other forms of primary nickel in 2003 were briquettes, which accounted for 12%, sinter and oxides at 11%, and powders at 3%.

In 2003, world nickel mine production and primary nickel production increased by about 1.5% while use (formerly called "consumption") rose by 4.8%. World mine production for 2003 (and 2002) was 1.264 Mt<sup>2</sup> (1.247 Mt – figures in brackets refer to 2002 data); primary nickel production (production of Class I plus Class II nickel)<sup>3</sup> was 1.201 Mt in 2003 (1.182 Mt). Nickel use increased by 56 000 t to 1.223 Mt in 2003 (1.177 Mt).

In 2003, nickel prices<sup>4</sup> began the year at US\$7210/t, trended upward to the end of December, and peaked at US\$16 670/t on December 29. The price at year-end was US\$16 650/t. The average settlement price for nickel for the year was US\$9640/t (US\$4.37/lb), up from US\$6772/t (US\$3.07/lb) in 2002. Figure 2 shows daily nickel prices in 2003, as well as prices from 1986 to 2003, in current U.S. dollars per tonne (no adjustment for inflation).

There was a general expectation that future demand would continue to outstrip supply as few new projects were scheduled to start up in the 2004-06 period, while demand is forecast to remain robust, barring economic downturns. Hence, prices are expected to remain above historical levels and above projected future long-term averages for the next few years.

A figure showing the world mine production of nickel in 2003 by country was presented in Eramet Group's June presentation "Challenges and Opportunities for the Eramet Nickel Division," page 18. Slide 19 of the same presentation shows the distribution of world production by ore type as:

- sulphide ores, 58%;
- laterite oxide ores (limonites), 28%; and
- garnierite oxide ores (saproplites), 14%.<sup>5</sup>

Cobalt data are not as well documented as nickel data. A principal source of world information is The Cobalt Development Institute (CDI). Data from the CDI are shown in Table 13, which shows cobalt production, plus deliveries from stockpiles, for the period 1995-2003.<sup>6</sup>

A list of Canadian nickel producers, their web sites, and the locations from which Canadian securities filing information can be obtained are provided in Table 3 and 4. The reader should note that the SEDAR web site changed its web page addressing format since 2002 and the addresses that were published in the 2002 *Canadian Minerals Yearbook* nickel chapter are no longer valid. The reader may also go to the main site at [www.sedar.com](http://www.sedar.com) and then find the company site under "Company Profiles" using the first letter of the company name to find company data.

The most significant change to Canadian production in 2003 was the decrease, due largely to a six-week strike at Inco's Ontario operations. The production "lost" during the strike plus decreased production due to difficulties associated with restarting operations after the strike were largely responsible for the 14% decline in Canadian production of nickel in concentrates in 2003 relative to 2002. Canadian mine production of nickel (nickel contained in concentrates produced) was 162 756 t in 2003, compared to a revised production total of 189 297 t in 2002. Canadian primary nickel production of Class I and Class II nickel was 124 418 t, compared to 144 476 t in 2002.<sup>7</sup>

The locations of Canadian nickel production facilities are shown in Figure 1.

Canadian exports of various forms of nickel are shown in Table 1a and imports are shown in Table 1b; some data refer to contained nickel and other data refer to gross weights, according to the definitions of the Harmonized Commodity Description and Coding System (Harmonized System) for trade classification. Additional detail has been presented in Tables 1a and 1b to clarify whether the tonnage is nickel content or the weight of material shipped.

Canadian trade data published in Table 1a in 2002 were inaccurate with respect to the imports of nickel in concentrates in 2002. As noted in the 2002 nickel review, the data may have shown gross tonnage of nickel concentrates imported rather than the nickel content of such concentrates. No details about what the data showed were released. Concentrate shipped from the Cosmos and Emily Ann mines in Australia graded about 19% and 15% Ni, respectively. It is believed that a factor has been applied to the tonnage of nickel concentrates imported to attempt to quantify the contained nickel for 2003; it is not

known how representative the factor is or whether it changes with time. Hence, imports of nickel in concentrates are not as precise as the number of significant digits would seem to indicate. The reader may wish to refer to the web sites of the exporting companies for more precise data. Questions about reported imports of concentrates in 2002 from Germany (6179 t) and the United States (10 772 t) reported in Table 1a in the 2002 version of this chapter have been investigated since that time. Such materials are believed to have been mis-classified and it is not known whether the data referred to metal content or the gross weight of the shipments. The problem continued in 2003. With respect to imports of ashes and residues, the Moa Bay operations in Cuba export a nickel-cobalt sulphide residue resulting from the leaching of nickel laterite ore. This material is believed to constitute the bulk of the imports of "Ash and Residue" imported into Canada from Cuba. Only gross weights of such imports are reported. Moa Bay exports all of its output of leached material only to the refinery in Fort Saskatchewan; Sherritt International reports the production of nickel plus cobalt from the mine, as well as the output of refined nickel and cobalt metals from the Fort Saskatchewan plant.

Table 1c provides an historical summary of nickel production and use from 1970 to date for selected years.

Additional trade information is presented in Table 1d, which shows the total trade of cupro-nickel, nickel-silver, stainless steel, and nickel-containing batteries. These data do not show the weight of the contained nickel but, rather, the entire weight of the material; thus, stainless steel data show the weight of nickel plus iron plus chromium plus other alloying elements.

Canadian shipments of recoverable cobalt in concentrate from Canadian mines totaled 1750 t in 2003, compared to 2065 t in 2002. The decrease was in part due to the strike at Inco's Ontario division. Refined cobalt production was 3850 t in 2003, compared to 4303 t in 2002. Tables 2a and 2b show totals for cobalt trade data for 2002 and 2003. Note that the unit of measurement for the data in Tables 2a and 2b is kilograms. Table 2c provides an historical summary of Canadian cobalt production and use from 1975 to 2003 for selected years.

The content of cobalt in the ore mined and concentrates produced is significantly higher than the recoverable content. Inco reported a recovery factor of about 35% for cobalt in Thompson ores and estimates a recovery factor of about 39% will be applicable to cobalt in Voisey's Bay ore (see below). No details were found on the recovery factors for cobalt at Falconbridge's operations or at Inco's Sudbury operations.

Sustained high nickel prices are likely to prompt re-examination of a number of other former nickel properties and mines in Canada and to result in increased exploration activities directed at nickel and cobalt.

Canada uses only a small amount of nickel compared to national production. A very large user of nickel in all forms in Canada was Slater Stainless Corp., a subsidiary of Slater Steel Inc. Slater Stainless operated two facilities in Canada: a mill in Welland, Ontario, and a mill in Sorel, Quebec. In early June, Slater Steel Inc. announced that it was seeking financial protection under the *Companies' Creditors Arrangement Act* (CCAA) in order to finalize a restructuring plan. In addition, Slater was seeking similar relief in the United States under Chapter 11 of the U.S. Bankruptcy Code. As of the end of 2003, no purchaser had been found for either stainless plant in Welland or Sorel.<sup>8</sup>

Canadian nickel usage has also been affected by substitution. For example, The Royal Canadian Mint reduced its nickel usage by switching to steel coin blanks plated with nickel using its patented process.<sup>9</sup> There were a number of design changes made between 1999 and 2000 that reduced the usage of nickel by the Mint. The 25¢ coin had been made of nickel, but its composition since 2000 is 94% steel, 2.8% Cu and only 2.2% Ni. The 10¢ coin changed from nickel to 92% steel, 5.5% Cu and only 2.5% Ni. Similarly, the 5¢ coin or "nickel," which had been made of cupro-nickel, is now 94.5% steel, 2.5% Cu and 2% Ni.<sup>10</sup>

## CANADIAN DEVELOPMENTS

Estimated Canadian production in 2003 declined by 14% to 162 800 t of nickel in concentrates and 124 400 t of refined nickel,<sup>11</sup> due mainly to the strike at Inco Limited's Ontario production facilities. As of April 2004, the forecast for Canadian production in 2004 was estimated at 184 000 t and 149 000 t, respectively.<sup>12</sup> "Refined" production refers to Class I nickel (greater than 99% Ni), Class II nickel (less than 99% Ni, including such materials as FeNi, nickel oxides, etc.), and nickel in chemicals. Canadian "refined production" does not include the nickel in matte exported (e.g., to Norway) for refining nor does it include the nickel in intermediate chemicals and intermediate nickel oxides produced in Canada but not processed to final forms in Canada.

The Sudbury Basin in Ontario and the Thompson nickel belt in Manitoba are the most significant nickel production areas in Canada. Together they have accounted for 99% of all recoverable nickel mined from Canadian sources in the 115-year period of 1889 to 2003. During the period 1953-2003, Sudbury and Thompson accounted for 98% of all recoverable nickel mined from Canadian sources. Of the two regions, Sudbury has made the larger contribution to Canadian nickel production, accounting for 10 Mt of recoverable nickel in the period 1889-2003, of which 7.2 Mt was produced in the period 1953-2003.

A detailed review of the exploration activities in the Sudbury area during 2003 is presented in a 46-page report by

the Province of Ontario.<sup>13</sup> The companies noted in that review include Aurora Platinum Corporation, Champion Bear Resources Limited, Crowflight Minerals Incorporated, Dynatec Corporation, FNX Mining Company Inc., Mustang Minerals Corporation, Namex Exploration Incorporated, Pacific North West Capital Corporation, United Reef Limited, Ursa Major Minerals Incorporated, and Wallbridge Mining Company Limited.

Table 7 of the same report noted two deposits not being mined in the Sudbury District in 2003: Kidd Copper, owned by Crowflight Minerals Inc., and Sudbury Shakespear, owned by Falconbridge Limited and Ursa Major Minerals Inc.

A new producer began operation in Canada in 2003: the **Sudbury Joint Venture** (SJV) is a joint venture owned 75% by FNX Mining Company Inc. and 25% by Dynatec Corporation, pursuant to an option agreement with Inco announced in December 2001.<sup>14</sup> Further exploration work and study allowed the SJV to convert 1.25 Mt of McCreedy West resources to reserves. In May, the SJV began shipping at a rate of 180 t/d of ore from the McCreedy West mine<sup>15</sup> (previously shut down by Inco in 1998). The ore was trucked to Inco's Clarabelle mill for delivery to Inco. Inco processes this ore and then sends the concentrate to Inco's smelter and refinery for final processing. Inco pays the SJV for the metals; the details of the sales agreement are not public. The six-week strike at Inco's Ontario operations interrupted the ore shipments from McCreedy West. In 2003, 47 600 t of ore was mined at McCreedy West, crushed, and trucked to Inco. The commercial production status at the McCreedy West mine was declared in November 2003.<sup>16</sup> A monthly production record from McCreedy West is shown on page 7 of FNX's annual report, available on the Internet at [www.sedar.com/cfsprod/data45/filings/00634401/00000001/e%3A%5CFortKnox%5CFNX%3F03Complete.pdf](http://www.sedar.com/cfsprod/data45/filings/00634401/00000001/e%3A%5CFortKnox%5CFNX%3F03Complete.pdf).

In December, the SJV acquired all the mineral rights to five former Inco properties: the McCreedy West, Levack, Norman, Kirkwood, and Victoria properties.<sup>17</sup> The historical production from these properties was:<sup>18</sup>

| Mine                 | Mt   | Ni   | Cu   | Co    | Pd        | Pt    | Au    |
|----------------------|------|------|------|-------|-----------|-------|-------|
|                      |      | (%)  | (%)  | (%)   | (g/t)     | (g/t) | (g/t) |
| McCreedy West        | 14.3 | 1.44 | 1.70 | ..    | 0.48      | 0.48  | 0.25  |
| Levack               | 54.9 | 2.00 | 1.31 | ..    | 0.56      | 0.56  | 0.25  |
| Norman (Whistle pit) | 5.2  | 0.95 | 0.33 | 0.034 | (3.1 TPM) |       | ..    |
| Kirkwood             | 2.4  | 0.90 | 1.00 | ..    | ..        | ..    | ..    |
| Victoria             | 1.4  | 1.57 | 2.26 | ..    | ..        | ..    | ..    |

.. Not available or no information.

TPM = Au + Pd + Pt; Victoria TPM estimated to be in order of 2 g/t.

Notes: Tonnage rounded to nearest 100 000 t. Units have been converted to metric from imperial.

In early 2004, the SJV forecast that approximately 270 000 t of ore containing 3200 t of payable Ni, 1815 t of

recoverable Cu and nearly 110 kg of precious metals would be sent to Inco in 2004 from McCreedy West.<sup>19</sup> The mine was expected to achieve a production rate of about 900 t/d by mid-2004.<sup>20</sup>

The SJV planned to complete a feasibility study of the former Levack mine and, if favourable, to begin development in late 2004. The production from this project could produce 900-1800 t/d of ore starting in early 2005. Measured and indicated reserves for the Levack mine were 4.6 Mt grading 1.9% Ni and 0.9% Cu plus 0.9 Mt of inferred resources grading 2% Ni and 0.9% Cu.<sup>21</sup> Assuming Inco's average recovery for nickel at the Clarabelle mill through the smelter and refinery to finished nickel product of 74.5%<sup>22</sup> applies to this ore production, the nickel output from Phase 2 would be in the range of 4500 to 9000 t/y of finished nickel (e.g., nickel in nickel pellets, NiO, etc.). The shaft and the 1600-level connection to the McCreedy West mine are to be reconditioned in early 2004.<sup>23</sup>

For Phase 3, the SJV planned to complete a feasibility study and to start mining at the PM deposit of the McCreedy West mine before the end of 2004. If a decision to proceed were to be taken, mining could begin in late 2004 at a rate of between 900 and 2700 t/d, depending upon the mining method chosen. No grade for the PM orebody was available. An access ramp to the orebody was completed by year-end and further development within the orebody in 2004 was planned in conjunction with bulk sampling and drilling.<sup>24</sup>

At the Norman deposit, the SJV will consider a US\$25 million advanced exploration program to further define the orebodies and provide input to a feasibility study. The Norman property includes the former Whistle open pit operated by Inco. The advanced exploration program would include sinking an exploration shaft and underground development to provide a base for drilling to define the 2000 deposit. A ramp to provide access for drilling of the North deposit may also be constructed. The prefeasibility study was ongoing at year-end and the companies expected to complete it in 2004. If the economics were to be favourable, a decision to proceed with the advanced exploration program at Norman could be taken later in 2004.<sup>25</sup>

The nickel produced from the SJV ore should be considered as "replacement ore" or "purchased feed" for Inco Limited as Inco includes the nickel recovered from purchased and recycled materials in its production reports of "finished nickel."

**Falconbridge Limited** produced nickel from mines in Canada; this material was smelted in Sudbury and sent to the company's refinery in Norway for recovery of nickel, cobalt, copper, precious metals and platinum group metals. As well, Falconbridge operates a laterite nickel mine and smelter in the Dominican Republic. Falconbridge is

thought to be the world's largest recycler of cobalt, much of which is processed in the smelter in Sudbury. The company's Sudbury smelter produced 1100 t of cobalt from secondary sources in 2003, compared to 900 t in 2002.<sup>26</sup> Falconbridge also processes matte from BCL in Botswana<sup>27</sup> from which it recovers nickel and cobalt, and other metals. Falconbridge is also very likely the refiner of cobalt for WMC Resources of Australia, which reported that its Kwinana refinery produces a nickel-cobalt sulphide that is then treated by a third party who returns the cobalt to WMC Resources for subsequent sale.<sup>28</sup> (WMC sold about 900 t of cobalt in 2003<sup>29</sup> and, as WMC Resources' site lists "Falconbridge 1" x 1" cut electrolytic cobalt cathodes"<sup>30</sup> for sale, it is judged likely that Falconbridge's refinery produced WMC Resources' cobalt in 2003.

Falconbridge's nickel production rose by 13% in 2003 to 77 183 t, mainly due to increased custom feed, much of it from LionOre's expansion in Botswana. Noranda Inc. holds a majority interest in Falconbridge, owning 59.5% of the company.<sup>31</sup>

In Canada, Falconbridge produced 24 143 t of Ni in concentrate from Sudbury mines, a decrease of 13%. This decrease was due to a 3% reduction in ore mined and to lower grades being mined (1.35% Ni compared to 1.58% Ni in 2002). The Raglan mine, located in northern Quebec, produced 25 110 t of nickel in concentrate, an increase of 2%. Raglan's higher production resulted from higher head grades, which more than offset the 4% decline in tonnage processed. Cobalt production in 2003 was 611 t from Sudbury and 381 t from Raglan; these totals were lower by 11% and 1%, respectively, compared to 2002 production.<sup>32</sup>

Falconbridge's smelter produced 50 831 t of nickel in 2003; this included 6436 t of Ni from secondary and custom sources, as well as 5000 t of copper from secondary sources and 1100 t of cobalt from secondary sources.<sup>33</sup> The matte produced by the smelter also contained 1121 t of cobalt from its Canadian mines and 1075 t from secondary and custom sources.<sup>34</sup> As noted, Falconbridge sends its nickel-copper-cobalt matte to its Nikkelverk facility in Norway for final recovery.

In November, Falconbridge made the decision to proceed with development of its Montcalm deposit and began construction.<sup>35</sup> Discovered in 1976, Montcalm had been acquired by Outokumpu Mines Inc., which subsequently sold it to Falconbridge in 2001. Development of the project was expected to create about 145 direct jobs; the plan was to truck ore from the underground mine to Falconbridge's Kidd metallurgical site for processing.<sup>36</sup> The resulting concentrate would then be sent to Sudbury for smelting. Falconbridge expected Montcalm to commence in early 2005, producing over 8000 t/y of Ni in concentrates. Probable reserves at Montcalm were 5.3 Mt grad-

ing 1.46% Ni and 0.71% Cu; inferred reserves were 0.7 Mt grading 1.7% Ni and 0.70% Cu.<sup>37</sup> Operating costs were projected at US\$2.47/lb;<sup>38</sup> capital expenditures for Montcalm were projected as US\$5 million in 2003, US\$55 million in 2004 and US\$20 million in 2005.<sup>39</sup>

Much of Falconbridge's exploration work in 2003 centred on the Nickel Rim South and Fraser Morgan orebodies in the Sudbury basin. Falconbridge planned to develop a shaft at the Nickel Rim South property to further define the orebody, which would allow the company to convert resources to the reserves category. Assuming a favourable decision to proceed were to be reached after the exploration work and the study, the exploration shaft would be used for mining. Nickel Rim South has inferred resources of 11.7 Mt grading 1.6% Ni, 3.7% Cu, 5 g/t precious metals (platinum plus palladium plus gold), 16 g/t Ag and 0.04% Co.<sup>40</sup>

**Inco Limited** operated nickel production facilities (mines, mills, smelters and refineries) in two locations in Canada: Sudbury in Ontario and Thompson in Manitoba (locations are shown in Inco's 10-K report for 2003). In addition, the company produced nickel metal at its refinery in Port Colborne, Ontario, and cobalt oxide in its Thompson plant. Inco is in the process of building a nickel mine and mill at Voisey's Bay (see below) in Newfoundland and Labrador and a hydrometallurgical test facility on the Island of Newfoundland. Inco produces finished nickel in Canada; this includes electrolytic nickel from Thompson, nickel pellets and discs from the carbonyl refinery in Ontario, and Ni oxide, which is sent to Asia. As well, Inco sends intermediate Ni oxide to Clydach in the United Kingdom where it recovers nickel by the carbonyl process. PGMs are concentrated and sent to Acton in the United Kingdom for refining.

Inco's Sudbury operations (seven mines, a mill, two smelters, and a nickel refinery) were shut for six weeks starting June 1, 2003,<sup>41</sup> because of a labour dispute that lasted until August 28.<sup>42</sup> The strike, plus various start-up problems after the strike, meant that Inco's production of nickel in ore from its Ontario mines was reduced to 85 500 t in 2003,<sup>43</sup> down 28 400 t from 2002. As well as start-up problems, which included difficulties at the smelter's oxygen and acid plants,<sup>44</sup> there were delays due to ground control conditions in the mines. As a result, Inco's exports of feed to Clydach and to Asian refineries in which Inco holds interests were lower than the 2002 exports by 4700 t and 4900 t, respectively (see Table 1a for details).

Inco forecast in early 2004 that its production in 2004 from Ontario and Clydach, U.K., would be between 105 700 and 107 500 t.<sup>45</sup> Production from the refinery at Clydach is included in the preceding total; if one assumed production in Clydach at 34 000 t for 2004, as it was in 2002 and 2001, then Inco's nickel production from Sud-

bury facilities would be in the order of 72 500 t. If Clydach were to produce 38 000 t, as in 2000 or 1999, then Ontario production would be in the order of 68 500 t. Inco forecast, at the same time, that production from Thompson would be nearly 50 000 t for 2004, which included material derived from purchased feed principally from Australia. Of this, 10 900 t was expected to be “external feed.”

Inco’s Canadian mine feed and “external” (or purchased) feed for the period 2000 to 2003 and a forecast for 2004 were presented in February 2004.<sup>46</sup> These data have been converted to tonnes and rounded to the nearest 500 t as shown below:

#### INCO NICKEL PRODUCTION BY SOURCE

|                                | 2002           | 2003           | 2004 (f)       |
|--------------------------------|----------------|----------------|----------------|
|                                | (tonnes)       |                |                |
| <b>Canadian Inco mine feed</b> | <b>129 000</b> | <b>98 500</b>  | <b>123 000</b> |
| of which Ontario               | 93 500         | 62 000         | 106 500        |
| and Manitoba                   | 36 500         | 36 000         | 34 500         |
| <b>External feed</b>           | <b>19 000</b>  | <b>23 000</b>  | <b>33 500</b>  |
| of which Ontario took          | 9 000          | 12 000         | 22 000         |
| of which Manitoba took         | 8 500          | 11 000         | 11 000         |
| <b>Total</b>                   | <b>148 000</b> | <b>121 500</b> | <b>156 500</b> |

(f) Forecast.

Note: As data have been converted from millions of pounds and rounded independently to nearest 500 t, columns may not add to totals shown.

“External” feed is thought to include nickel derived from the ore supplied by the Sudbury Joint Venture (see above) milled at the Clarabelle mill in Sudbury.

#### INCO NICKEL PRODUCTION (SULPHIDE ORIGIN) BY PLANT

|                   | 2002           | 2003           | 2004 (f)       |
|-------------------|----------------|----------------|----------------|
|                   | (tonnes)       |                |                |
| Manitoba          | 45 500         | 47 000         | 45 500         |
| Ontario + Clydach | 102 500        | 74 500         | 106 500        |
| <b>Total</b>      | <b>148 000</b> | <b>121 500</b> | <b>156 500</b> |

(f) Forecast.

Notes: Data have been converted from millions of pounds and rounded independently to nearest 500 t. Thus, columns may not add to totals shown. Forecast range for 2004 was: 2004 is  $\pm 2700$  t for Canada, of which  $\pm 1800$  t for Ontario plus Clydach and  $\pm 900$  t for Manitoba. Clydach’s production was about 38 000 t in 1999 and 2000, 33 800 t in 2001 and 2002, and 24 200 t in 2003 (in 2003, a six-week strike reduced production). If Clydach were to produce 34 000 t, then the forecast Ontario plant output of finished nickel would be 72 500 t; if Clydach were to produce 38 000 t, then forecast Ontario output would be 68 500 t.

Work continued on increasing the throughput and efficiency of the Copper Cliff smelter.<sup>47</sup> Inco began construction of a weak acid plant, due for completion in 2004. The acid plant is part of a US\$90 million program to reduce SO<sub>2</sub> emissions at the Copper Cliff smelter.<sup>48</sup> To increase output from the Ontario division in 2004, Inco intended to run its smelter at 4535 t/d, process purchased feed, and reduce the maintenance shut-down time<sup>49</sup> by increasing the intervals between shut-downs from 12 months to 18 months.<sup>50</sup>

The US\$33 million Phase II at the McCreedy/Coleman mine was under way. This is intended to raise production at the mine by 60% by 2005.<sup>51</sup> Inco planned to follow this project with a US\$35 million Phase III project.<sup>52</sup> At the Creighton mine, the first phase of the Creighton Deep project produced 111 800 t of ore grading 4.0% Ni and 2.5% Cu in 2003; Inco anticipated completing the first phase of Creighton Deep in 2006. A second phase was being evaluated and, if approved, the company expected ore production from Creighton Deep to increase to 300 000 t/y and be maintained at that level until 2015. The Phase II ore reserves are estimated at 4 Mt grading 3.7% Ni and 3.9% Cu plus by-product metals.<sup>53</sup> Work continued at the Garson mine where Dynatec Corporation deepened the main shaft from 1360 m to 1550 m in order to access 7 Mt of ore grading 1.76% Ni, 1.37% Cu and 1.1 g/t precious metals. The additional ore will permit the mine to increase output by 10% to 2087 t/d and extend the mine life to 2012. The ramp-up to the new rate was expected to begin in late 2004.<sup>54</sup>

Inco Limited’s Manitoba operations consist of two mines, a mill, a smelter and a refinery. The smelter processes purchased concentrates, as noted above, in order to increase smelter capacity utilization and therefore to decrease unit costs.

In 2003, despite a 50% increase in the tonnage mined at the Birchtree mine, nickel in ore mined in Manitoba by Inco declined by 4.6%.<sup>55</sup> The amount of nickel in ore mined in Manitoba declined in 2003 by nearly 17% compared to 2002 as the tonnage of ore mined decreased by 3% and the grade declined from 2.58% Ni to 2.21% Ni.<sup>56</sup> Inco expected production from its Manitoba division to recover by about 8% in 2004 compared to 2003 due to the mill modifications and higher production at the Birchtree mine.<sup>57</sup>

As the project to deepen the Birchtree mine continued, increased production from that mine with its higher magnesium oxide content caused problems at the Thompson smelter,<sup>58</sup> but the matter was resolved in 2003 when Inco modified its mill. By building a new flotation circuit, Inco was able to resolve the MgO issue and to increase the concentrate grade by 10% with no loss of nickel recovery.<sup>59</sup>

With the higher-grade concentrate, Inco might be able to reduce costs by US\$10 million annually if it can operate using only one furnace at Thompson.<sup>60</sup> Inco intended to produce 54 400 t of Ni at its Thompson refinery by the second half of 2006 when it planned to be processing some of the concentrates from Voisey's Bay at the Thompson smelter and refinery.<sup>61</sup> Inco expected to operate its Thompson smelter and refinery at about 45 000 t/y until the Voisey's Bay concentrates arrive.<sup>62</sup>

Inco completed a feasibility study of the 1-D Lower orebody and scheduled the start of production in early 2004. The 1-D Lower orebody contains 1.9 Mt of proven ore grading 2.2% Ni and 2.9 Mt of probable ore grading 2.2% Ni.<sup>63</sup> In addition to ongoing exploration at its Thompson mines, Inco hopes to identify and develop additional reserves in Manitoba (see **Canadian Royalties** and **Nuinsco** below).

In 2003, Inco released information about operations in 2003 that apparently has not been previously publicized; the production tonnage and grade for individual Canadian mines was published in the 2003 10-K report.<sup>64</sup> Inco also reported average recoveries of metal values in the crushing, milling, smelting and refining processes for certain metals in its Ontario and Manitoba operations in 2003, as well as the estimated recoveries from the future Voisey's Bay production. These recoveries were:<sup>65</sup>

|             | Ontario | Manitoba | Voisey's Bay (f) |
|-------------|---------|----------|------------------|
| • nickel    | 74.5%   | 86.1%    | 82%              |
| • copper    | 89.4%   | 79.5%    | 79.5%            |
| • platinum  | 69.7%   | n.s.     | n.s.             |
| • palladium | 69.7%   | n.s.     | n.s.             |
| • gold      | 62.9%   | n.s.     | n.s.             |
| • cobalt    | n.s.    | 34.6%    | 39%              |

(f) Forecast; n.s. Not stated.

Inco's subsidiary, **Voisey's Bay Nickel Company Limited**, will operate the Voisey's Bay project in Newfoundland and Labrador. Inco completed a feasibility study and reported that estimated capital costs for the project were US\$776 million, an increase of 15% from the earlier pre-feasibility estimate.<sup>66</sup> The capital costs were allocated as:<sup>67</sup>

- US\$582 million for the mine/concentrator and infrastructure in Labrador;
- US\$134 million for the hydrometallurgical program;
- US\$47 million for modifications at Inco's existing smelters to take feed from Voisey's Bay; and
- US\$13 million for exploration.

The bankable feasibility study average for the first seven years of production showed concentrate grades of:<sup>68</sup>

- high-grade nickel concentrate 25.0% Ni, 0.42% Cu
- copper concentrate 32.3% Cu, 0.58% Ni
- middling concentrate 12.7% Ni, 4.4% Cu

Most of the concentrate from Voisey's Bay from will be sent to Inco's Sudbury and Thompson smelters for processing until a facility is built at Argentia in Newfoundland and Labrador. Annual production was expected to average about 50 000 t/y Ni and 2270 t/y Co plus 6800 t/y Cu recovered from nickel concentrates; in addition, about 31 700 t/y of copper in concentrates<sup>69</sup> was expected to be sold. Start-up of the mine/mill and hydrometallurgical test facilities was expected to begin in late 2005 to allow initial concentrate shipments in July 2006.<sup>70</sup> As ore produced in Manitoba contains nickel with little copper compared to the nickel (reserves had 15 times as much nickel as copper) and the Sudbury ore mined in 2002 and 2003 contained roughly 9% more copper than nickel, it is anticipated that the nickel concentrates will be smelted and refined in Thompson and that the mixed nickel-copper concentrates will be smelted and refined in Sudbury.

Nearly 1500 people were employed on the Voisey's Bay project in November 2003, two-thirds of them working on the mill/concentrator part of the project.<sup>71</sup> In October, Inco began operating its mini-pilot plant located at Inco's Mississauga, Ontario, research facilities<sup>72</sup> as part of its program to develop a hydrometallurgical process to recover nickel and cobalt from Voisey's Bay concentrate. Technology Partnerships Canada (TPC) will provide conditional repayable funding of C\$60 million to the development of the proposed hydrometallurgical process.<sup>73</sup>

**Sherritt International Corporation** owns 50% of Metals Enterprise, which operates The Cobalt Refining Company Inc. in Fort Saskatchewan, Alberta.<sup>74</sup> The refinery produces nickel and cobalt metal; about 95% of its feed is from Metal Enterprise's mine and leach plant at Moa Bay, Cuba, where a nickel-cobalt sulphide residue is produced from a lateritic nickel feed.<sup>75</sup> The mine sends the limonitic ore to the leaching plant; the underlying saprolitic ore is not mined, but left in situ.<sup>76</sup> In 2003, refined nickel production was 31 106 t, down about 600 t from the record production in 2002,<sup>77</sup> while cobalt production increased 76 t to a record 3141 t.<sup>78</sup> The refinery also sold 250 000 t of by-product fertilizer in 2003.<sup>79</sup> Sherritt continued to evaluate a plan to increase nickel production at Moa and Fort Saskatchewan by 60%<sup>80</sup> to 50 000 t/y, but a decision was still pending at year-end. It is thought that the cobalt production would rise roughly in proportion to the nickel expansion to reach perhaps 5000 t/y depending upon the ore grades and recoveries.

**North American Palladium Ltd.** operated an open-pit mine and mill in northwestern Ontario that produced



palladium as its main product. The mine produced 1846 t of by-product nickel during 2003<sup>81</sup> after processing nearly 5.5 Mt of ore. The recovery rates for the by-product nickel and cobalt were 36% and 15%, respectively.<sup>82</sup> The company completed the installation of a new crusher in mid-year<sup>83</sup> and production increased to an average of 16 300 t/d in the fourth quarter compared to 12 700 t/d for the same period in 2002.<sup>84</sup> In February, the company commissioned a prefeasibility study of an underground mine after evaluating the results of an exploration program in 2002.<sup>85</sup> The study examined a 2000-t/d operation at a capital cost of \$37 million<sup>86</sup> based upon probable underground reserves estimated at 5 Mt grading 5.86 g/t Pd and 0.07% Ni plus platinum, gold and copper.<sup>87</sup> Some cobalt has been recovered from the ore and periodically the company receives payment for cobalt and rhodium;<sup>88</sup> cobalt amounts to less than 0.5% of the company's revenue from the mine.<sup>89</sup>

In December, **Canadian Arrow Mines Ltd.** received permission to extract a 10 000-t bulk sample from an open pit at the Alexo property about 50 km from Timmins, Ontario. The company planned to start the extraction in early 2004; ore will be trucked to Falconbridge's Strathcona mill near Sudbury, Ontario. The Alexo mine had produced about 50 000 t grading 4.5% Ni over the interval 1913 to 1943.<sup>90</sup> A technical report about the company's Timmins area nickel properties was commissioned in December 2003 to be completed in early 2004. More detailed information about the property is shown in a presentation on the company's web site at [www.canadianarrowminesltd.com/presenta.htm](http://www.canadianarrowminesltd.com/presenta.htm).

Falconbridge's decision to proceed with the development of the Montcalm mine and to process Montcalm ore at the its Kidd metallurgical site may offer a potential for lower transportation costs<sup>91</sup> for future output from the Alexo mine if the Montcalm mine were to begin production.

After going into receivership in mid-2002, **Canmine Corporation** remained shut on care and maintenance during 2003. The refinery was sold during 2003, but the owner was not identified and no plans for the hydrometallurgical refinery were publicized during the year.

**Liberty Mineral Exploration Inc.** acquired the Redstone mine by purchasing Timmins Metals Corp., effective December 31, 2003;<sup>92</sup> the Redstone mine had produced 0.28 Mt grading 2.38% Ni between 1989 and 1996. In December 2002, Timmins Metals Corp. granted Inco Limited an option to earn a 60% interest in the property and a further right to acquire an additional 10%. As of October 2003, Inco was continuing an exploration program on the property. Resource estimates for mineral inventory when the mine closed were stated as an inferred resource of 0.17 Mt grading 3.28% Ni and 0.038% Co above the 244-m level (the author of the report cautioned that the estimates may not be in accordance with current CIM Standards on Mineral Resources and Reserves).<sup>93</sup>

**Wallbridge Mining Company Limited's** interests include mineral properties in Ontario, Manitoba and Minnesota. During 2003, the company entered into two joint ventures, one with Nuinsco Resources Ltd. in the Timmins area and one with Falconbridge and Noranda Inc. in the Kirkland Lake area. These joint ventures were in addition to existing joint ventures with Falconbridge Limited and Lonmin plc.<sup>94</sup> Details about the various properties, including technical reports, can be obtained from the company's documents filed on the SEDAR site at [www.sedar.com/DisplayCompanyDocuments.do?lang=EN&issuerNo=00010252](http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&issuerNo=00010252).

The company has 21 properties in the Sudbury area.<sup>95</sup> Of those, the ones described by the company as "advanced drill stage properties" included Ministic Lake, Windy Lake and Parkin.<sup>96</sup> Various technical reports about Wallbridge properties were posted on the SEDAR site noted above.

**Canadian Royalties Inc.** has nickel properties in four areas: the Raglan nickel belt in northern Quebec, the Abitibi belt in Ontario and Quebec, the Southern Nunavik area of central Quebec, and the Thompson nickel belt.<sup>97</sup> In November, Inco reached agreement with Canadian Royalties for an option/joint venture whereby Canadian Royalties would spend \$5 million in five years to obtain a 50% share of the TNC South property.<sup>98</sup> The company spent \$5 million on exploration in the Raglan area in 2003. Details of the properties in the Raglan area were available in the company's 2003 Annual Information Form.<sup>99</sup>

**Nuinsco Resources Limited** continued exploration in the vicinity of Inco's mines in Manitoba, with much of the effort centred on the Mel deposit. The Mel deposit had an indicated mineral resource of 0.29 Mt grading 1.7% Ni and an inferred mineral resource of 0.26 Mt grading 1.7% Ni. Nuinsco's goal was to develop a ramp-accessible resource of 1 Mt and to ship ore to Inco's Thompson mill for processing.<sup>100</sup> Nuinsco also held 100% of the Minago nickel deposit; estimated resources there were put at 10.6 Mt grading 1.19% Ni in 1991, an estimate that was made prior to current reporting standards for reserve and resource estimates.<sup>101</sup>

## Activities of Other Canadian-Listed Companies With Nickel Projects

Various companies have nickel projects in various phases of development in other countries. These include Canico Resource Corp. in Brazil, Jaguar Nickel and Skye Resources in Guatemala, Weda Bay Minerals in Indonesia, Goro Nickel and an SMSP-Falconbridge joint venture in New Caledonia, Rio Narcea Gold Mines in Spain, and Franconia Minerals and Teck Cominco American in the United States.

## Brazil

Canico Resource Corp. purchased the Onça-Puma project, a laterite property in Brazil, from Inco Limited in February 2003.<sup>102</sup> Canico obtained 100% of the rights in exchange for 18% of Canico's common shares, subject to certain agreements including an off-take agreement (see below). Based upon 485 drill holes, Canico released updated inferred resource estimates in August of 198 Mt grading 1.72% Ni and 0.113% Co using a cut-off grade of 1.0% Ni, and 104 Mt grading 2.15% Ni and 0.105% Co using a cut-off grade of 1.5% Ni.<sup>103</sup> In November, a scoping study completed by Hatch Ltd. was released.<sup>104</sup> The press release presented two technologies to produce nickel: nickel in ferronickel and nickel in matte. For each technology, both a single and a double production line were investigated. All four cases were based upon inferred resources of 110 Mt grading 1.80% Ni using a cut-off grade of 1.08% Ni and a silica-to-magnesia ratio of 1.84. Some of the details from that report are presented below:

|                              | FeNi (s) | FeNi (d) | Matte (s) | Matte (d) |
|------------------------------|----------|----------|-----------|-----------|
| Project Cost (US\$ millions) | 556      | 855      | 622       | 957       |
| Average Year 1-10            |          |          |           |           |
| Ore feed (Mt/y)              | 1.17     | 2.33     | 1.15      | 2.31      |
| Ni produced (t/y)            | 28 875   | 52 090   | 27 285    | 49 423    |
| Life of Mine Average         |          |          |           |           |
| Mine Life (Years)            | 89       | 45       | 89        | 45        |
| Ore feed (Mt/y)              | 1.23     | 2.43     | 1.22      | 2.43      |
| Ni produced (t/y)            | 19 583   | 38 685   | 18 647    | 37 138    |

Where (s) = single line plant and (d) = double line plant; US\$ as of second quarter of 2003.

The November 2003 scoping study done by Hatch is available on the SEDAR web site at [www.sedar.com/csfsprod/data41/filings/00592935/00000001/m%3A%5CG\\_drive%5C100%5C5789-1%5CSEDAR%5Cnov03%5Cscoping.pdf](http://www.sedar.com/csfsprod/data41/filings/00592935/00000001/m%3A%5CG_drive%5C100%5C5789-1%5CSEDAR%5Cnov03%5Cscoping.pdf).

The SEDAR web site for Canico also listed the agreements of December 2003 between Inco and Canico. The Technical Services Agreement was available at [www.sedar.com/csfsprod/data42/filings/00596397/00000010/m%3A%5CG\\_drive%5C100%5CV24792%5Csedar%5Cfinal%5Ctechagmt.pdf](http://www.sedar.com/csfsprod/data42/filings/00596397/00000010/m%3A%5CG_drive%5C100%5CV24792%5Csedar%5Cfinal%5Ctechagmt.pdf). The off-take agreement was available at [www.sedar.com/csfsprod/data42/filings/00596397/00000010/m%3A%5CG\\_drive%5C100%5CV24792%5Csedar%5Cfinal%5Cofftake.pdf](http://www.sedar.com/csfsprod/data42/filings/00596397/00000010/m%3A%5CG_drive%5C100%5CV24792%5Csedar%5Cfinal%5Cofftake.pdf).

Matte produced by Canico meeting the specifications of a minimum 75% Ni, a maximum 1% Fe, and a minimum 20% S, or such composition that Inco could process in its facilities, would result in Canico being paid for 100% of

the contained Ni, 80% of the contained Co, and varying proportions of the precious metals and copper contained; the nickel prices paid would be a percentage of the LME price for each quotation period and would vary in stages between 75% if the LME price is below US\$3.15/lb and 71% if the LME price exceeds US\$5.00/lb.<sup>105</sup>

With respect to cobalt, the "accountable metal content" would be deemed to be 80% of the contained cobalt in the shipment. The refining charge for cobalt in the matte would be US\$2.50/lb (or US\$5511/t) of accountable cobalt content if cobalt prices were less than or equal to US\$10/lb (or US\$22 046/t) and thereafter would rise at the rate of US\$0.15/lb (US\$331/t) per US\$1/lb (US\$2205/t) increase in the cobalt price, based upon the *Metal Bulletin* free market price for 99.3% cobalt in warehouse as quoted by the *Metal Bulletin*.<sup>106</sup>

Canico commissioned Hatch Ltd. to complete a full feasibility study of the Onça-Puma project based upon producing FeNi via a single-line rotary kiln-electric furnace technology. The study was expected to be completed by late 2004.<sup>107</sup>

## Guatemala

Through its 100%-owned subsidiary, Minera Mayamerica S.A., **Jaguar Nickel Inc.** held exploration licences for properties in Guatemala in the Lake Izabal region of the country.<sup>108</sup> Some of the properties were close to properties of Exploraciones y Explotaciones Mineras Izabal S.A. (Exmibal), a company in which Inco held a 70% interest. Jaguar applied for an extension of its exploration licence for the Sechol property in December 2003.<sup>109</sup> Jaguar's annual report for 2003 showed the Sechol property with measured resources of 14 Mt grading 1.46% Ni and 0.08% Co, and indicated resources of 23 Mt grading 1.34% Ni and 0.08% Co; factors used to estimate resources were dry specific gravity of 1.0, minimum thickness of 1.5 m, and a cut-off grade of 1% Ni.<sup>110</sup>

Jaguar planned to use a chloride leach technology to produce a mixed nickel-cobalt hydroxide from the laterite ore. The mixed hydroxide could be sold to nickel refineries seeking to replace diminishing feed sources, to replace higher-cost feeds, or to expand, thereby reducing unit fixed costs.

Jaguar's Atmospheric Chloride Leach Process (ACLP) was intended to treat both the limonitic and saprolitic portions of the orebody without having to resort to pressurized processing. Jaguar's goal was to recycle the hydrochloride acid and magnesium oxide reagents. Reported recoveries were more than 90% for Ni and 85% for Co. Jaguar engaged Process Research ORTECH Inc. to work on the process development. The four-step process was:<sup>111</sup>

- leaching ore to dissolve Ni and Co in an acid chloride and rejecting Fe and Mg;
- removal of impurities such as Al, Mn, Cu, Zn and remaining Fe;
- precipitation of NiCo hydroxide via recycled magnesium oxide; and
- pyrohydrolysis to recover hydrochloric acid and magnesia for recycling.

Idealized flow sheets of the ACLP were shown on page 13 of the 2003 Annual Report and on page 26 of the Annual Information Form. These reports can be obtained, respectively, at [www.sedar.com/csfsprod/data46/filings/00644217/00000001/i%3A%5CData%5CTous%5C120400%5C120423%5CSedar%5C2004%5CPreside1.pdf](http://www.sedar.com/csfsprod/data46/filings/00644217/00000001/i%3A%5CData%5CTous%5C120400%5C120423%5CSedar%5C2004%5CPreside1.pdf) and at [www.sedar.com/csfsprod/data46/filings/00648495/00000001/i%3A%5CData%5CTous%5C120400%5C120423%5CSedar%5C2004%5CAIFang.pdf](http://www.sedar.com/csfsprod/data46/filings/00648495/00000001/i%3A%5CData%5CTous%5C120400%5C120423%5CSedar%5C2004%5CAIFang.pdf). A technical paper is available at the company's web site at [www.jaguarnickel.com/reports/alta.pdf](http://www.jaguarnickel.com/reports/alta.pdf).

A preliminary baseline study for environmental and social purposes was completed in 2003 and plans called for a more complete study to be done over an 18- to 24-month period.<sup>112</sup> Pilot test work is estimated to cost about US\$500 000.<sup>113</sup>

Jaguar targeted completion of a bankable feasibility study, obtaining permits, starting procurements, and letting construction contracts before the end of 2006.<sup>114</sup>

**Skye Resources Inc.** announced its intention to acquire 400 km<sup>2</sup> of Inco's mining concessions in Guatemala, including the mine, power plant and smelter operated by Inco through its subsidiary, **Exploraciones y Explotaciones Mineras Izabal, S.A.** (Exmibal), between 1977 and 1980. Inco reported that Exmibal's capacity was 11 300 t/y of Ni in matte. The Exmibal operation has been on indefinite care and maintenance status since 1982.<sup>115</sup>

## Indonesia

**Weda Bay Minerals Inc.** held 90% of P.T. Weda Bay Nickel, with P.T. Antam Tbk, an Indonesian ferronickel producer and laterite ore exporter, owning the remaining 10%. Weda Bay Minerals' interest was held through its Singaporean subsidiary Strand Minerals (Indonesia) Pte. Ltd.<sup>116</sup> Weda Bay had a Contract of Work (COW) for its Halmahera nickel-cobalt project located on Halmahera Island. As of year-end 2003, measured resources were 16 Mt grading 1.27% Ni and 0.18% Co and indicated resources were 98 Mt grading 1.49% Ni and 0.08% Co at a 1% Ni cut-off. Using a 0.1% Co cut-off, measured resources were 2.3 Mt grading 0.91% Ni and 0.15% Co and indicated resources were 17 Mt grading 0.82% Ni and 0.17% Co. If both the 1% Ni cut-off and the 0.1% Co cut-off were used, then inferred resources were 82 Mt grading

1.33% Ni and 0.12% Co.<sup>117</sup> A detailed report about the deposit can be found on the SEDAR site at [www.sedar.com/csfsprod/data38/filings/00540548/00000002/h%3A%5Cweda\\_2%5Creport.pdf](http://www.sedar.com/csfsprod/data38/filings/00540548/00000002/h%3A%5Cweda_2%5Creport.pdf).

Indonesia's *Law 41* of 1999 banning mining in protection forests continued to cause uncertainty about the project; the company's view was that while there would be no direct impact on operations due to the law, it would restrict areas that the company would be able to mine.<sup>118</sup>

A pre-feasibility study in 2002 by Kvaerner Process (Australia) Pty Ltd. and Hatch Associates Pty Ltd. examined an operation producing 60 200 t/y Ni and 5000 t/y Co with a capital cost of US\$902 million.<sup>119</sup> During 2003, Weda Bay released details of a scoping study of a project with lower capital costs – a US\$600 million project that would produce 40 000 t/y Ni and 3000 t/y Co in an intermediate sulphide material using pressure acid leaching in conjunction with atmospheric leaching and saprolite neutralization.<sup>120</sup> The company intended to start a US\$15 million bankable feasibility study in 2004.<sup>121</sup>

## New Caledonia

New Caledonia contains extensive nickel laterite reserves. Two Canadian companies have projects on the island. Significant financial incentives may be offered to both projects. For example, Inco reported that there was discussion of a 15-year tax holiday and an additional five years at half the normal tax rate, subject to adjustment depending upon the rate of internal return of the project.<sup>122</sup> France made a proposal to Inco to increase France's existing US\$350 million commitment of the *Paul Act*, proposing to give additional assistance to another company to construct a power plant for Goro.<sup>123</sup> Falconbridge reported that a formal application had been made in 2003 under the *Loi Girardin* incentive program to promote investments in France's overseas territories.<sup>124</sup>

**Goro Nickel S.A.**, which started the project to develop its Goro deposit in the south of New Caledonia, was owned 85% by Inco Limited and 15% by Bureau de Recherches Géologiques et Minières.<sup>125</sup> After site test work, including a pilot plant, the decision to develop the project was taken in April 2001. The project was designed to produce 55 000 t/y of Ni in the form of nickel oxide and 4500 t/y of Co in the form of cobalt carbonate. Nickel oxide can be further refined in existing refineries in South Korea and Taiwan in which Inco has interests. There was also a possibility that the material could be used by a future refinery to be built in China.

In December 2002, Inco announced that construction of the Goro project would be put on hold because the projected capital costs had risen to about US\$2 billion from an earlier estimate of US\$1.45 billion. Through 2003, Inco continued the project review, seeking to reduce

capital costs and achieve other improvements with a target cost of US\$1.8 billion. Inco's expenditures on Goro to the end of 2003 were US\$600 million; capital cost reductions of US\$225 million had been identified as of that time taking capitals cost estimates down to US\$1.89 billion with the review ongoing. <sup>126, 127</sup>

At year-end, Goro's ore reserves contained proven reserves of 44 Mt grading 1.41% Ni and 0.13% Co, and probable reserves of 13 Mt grading 1.92% Ni and 0.08% Co. Measured resources were 56 Mt grading 1.40% Ni and 0.14% Co, and indicated resources were 39 Mt grading 1.84% Ni and 0.12% Co, with inferred resources of 144 Mt grading 1.7% Ni and 0.12% Co. <sup>128</sup>

**Falconbridge Limited** continued work on its joint venture with **La Société Minière du Sud Pacifique S.A.** (controlled by Société de Financement et d'Investissement de la Province Nord) with respect to the development of the Koniambo project in the northern part of New Caledonia. <sup>129</sup> Since 1998, Falconbridge has been earning a 49% interest in the project. Falconbridge began the bankable feasibility study for the project in September <sup>130</sup> and expected that its total expenditures would reach US\$160 million by the completion of the bankable feasibility study, expected in the third quarter of 2004. <sup>131</sup>

The measured plus indicated saprolite reserves at Koniambo were 142 Mt grading 2.13% Ni with inferred mineral resources of 156 Mt grading 2.2% Ni. There were additional inferred limonite resource of 125 Mt grading 1.6% Ni and 0.2% Co. <sup>132</sup>

In mid-2003, Falconbridge indicated that a bankable feasibility study would be completed in mid-2004 and that financing and permitting were targeted at the 2004 to mid-2005 period with construction from mid-2005 to mid-2008 and start-up commencing in mid-2008. The projected project cost was US\$2 billion for a plant to produce 60 000 t/y of nickel in FeNi. <sup>133</sup> By year-end, the company projected start-up in the period of late 2008 to early 2009, based upon a development decision by year-end 2004. <sup>134</sup>

### Spain

In January, **Rio Narcea Gold Mines, Ltd.** released the feasibility study of its Aguablanca property located 140 km from the port of Huelva. <sup>135</sup> A bulk Cu-Ni-PGM concentrate will be produced, although separate Cu and Ni concentrates could be produced. <sup>136</sup> Also in January, the company announced that it had negotiated a 10-year contract with Glencore International AG for the sale of Aguablanca concentrates. <sup>137</sup>

In June, the government announced a positive environmental impact declaration. <sup>138</sup> In August it was announced that the Spanish Council of Ministers had

approved the mineral licence to exploit the deposit. <sup>139</sup> The project cost, including VAT and working capital, was put at €62.5 million (US\$70 million). Rio Narcea received a subsidy equal to 2.5% interest on €35 million of a loan draw-down and a non-reimbursable subsidy of €6.7 million from the Spanish Regional Development Department. <sup>140</sup> The mine was scheduled to produce about 940 000 t/y of concentrates grading 8-9% Ni, 6-7% Cu, 5-8 g/t PGMs and 0.15-0.2% Co. Reserves at year-end 2003 were 15.7 Mt grading 0.66% Ni, 0.46% Cu, 0.47 g/t PGMs and 0.13 g/t Au. Construction began in October. In December, Rio Narcea announced plans to construct a decline below the pit to access higher-grade ore and to undertake additional drilling. <sup>141</sup>

### United States

In November, **Franconia Minerals Corporation** purchased over 80% of the Birch Lake PGM deposit located near Babbitt, Minnesota, from the Beaver Bay Joint Venture. <sup>142</sup> Inferred resources for the large, low-grade Cu-Ni-PGM deposit appear to be in the order of 20 Mt grading 0.2% Ni plus Cu, PGMs, Au, Ag and Co. A review of the mineral resources for the property was released in 2004. <sup>143</sup>

In December, Franconia began an exploration program, targeting Osier Lake, Chow Lake, Partridge Lake and Big Lake, also located in the Duluth Complex. The State of Minnesota will pay for 40% of the direct costs to drill at Osier Lake. <sup>144</sup>

**Teck Cominco American, Inc.** took an option on the Mesaba Metals property in 2001. Longyear Mesaba Company then held the mineral rights for most of the property. <sup>145</sup> The deposit resources were estimated at about 700 Mt grading 0.46% Cu and 0.12% Ni. Cominco Engineering Services Ltd. (CESL) <sup>146</sup> developed a hydrometallurgical process using nickel and copper concentrate to produce refined metals. A technical paper about this process published in 2002 presented a process to handle a bulk Cu-Ni-Zn concentrate from Mesaba; at that time, CESL was in the "early stages" of evaluating a mine, mill and CESL refinery to produce 110 000 t/y Cu and 20 000 t/y Ni in mixed Ni-Co hydroxide. <sup>147</sup> The paper is available at [www.cesl.com/downloads/alta\\_ni\\_02.pdf](http://www.cesl.com/downloads/alta_ni_02.pdf).

### Other Producers

Space does not permit a discussion of other producers of nickel. Details about most producers are found in Table 6. Due to the size and importance of the largest nickel producer, some details in addition to those found in Table 6 are presented below about Norilsk Nickel.

**MMC Norilsk Nickel** is the world's largest producer of nickel. In the past few years, the company has released more information about its operations than had earlier been the case. Company information, including annual reports, press releases, presentations, etc., is available in English on the company's web site.<sup>148</sup> The following review of some information available about production, reserves, etc., is based upon the company's annual report available on the company's web site as a "zip" file at [www.nornik.ru/\\_upload/editor\\_files/file0023.zip](http://www.nornik.ru/_upload/editor_files/file0023.zip).<sup>149</sup>

Norilsk's production in 2003 was 239 000 t of Ni, 451 000 t of Cu and about 4650 t of Co plus an undisclosed amount of Pd, Pt, Rh, Au and Ag. The company released 70 000 t of Ni from its stockpile so that sales were 308 000 t of nickel in 2003.<sup>150</sup>

Norilsk showed ore reserves at the end of 2003 by division as:<sup>151</sup>

- Kola 173 Mt grading 0.75% Ni, 0.35% Cu; and
- Talnakh 222 Mt grading 2.41% Ni, 4.12% Cu.

The Talnakh ore is contained in three deposits: the Talnakh, Oktyabrysky and Norilsk-1 orebodies. The ore in those deposits is divided into three classifications: rich, cuprous, and disseminated ores. Those reserves totaled:

- rich 149 Mt grading 3.08% Ni, 3.98% Cu;
- cuprous 71 Mt grading 1.03% Ni, 4.45% Cu; and
- disseminated 1 Mt grading 0.57% Ni, 1.12% Cu.

Reserves by individual mine were published on page 32 of the Annual Report.

In addition to the reserves, Norilsk has resources estimated at:<sup>152</sup>

- measured plus indicated resources at Talnakh of 1420 Mt grading 0.57% Ni and 1.11% Cu;
- inferred resources at Talnakh of 484 Mt grading 0.93% Ni and 1.91% Cu; and
- inferred resources at Zhdanovskoye of 64 Mt grading 0.73% Ni and 0.37% Cu.

Production by mine (tonnage and grade) was shown on page 53 of the Annual Report. Recovery factors for the operations were shown on page 51. Pages 54 and 55 showed details about the production of metal in concentrate and production of metal products, including nickel production at Severonickel from shipments of nickel in matte from the Taimyr plants.

All mines in the Taimyr peninsula are underground operations with the exception of the Medvezhy Ruchey mine, which is an open-pit mine. The mines feed two mills; the mills also process stockpiled pyrrhotite concentrates.

The Nadezhda metallurgical plant and the nickel and copper plants process the concentrates into refined nickel and copper. A high-grade matte is also produced and shipped to Severonickel for refining. Platinum group metals refining is contracted out to third parties. The production of cobalt was not released by Norilsk, so The Cobalt Development Institute data have been used. Third-party tolling of Norilsk cobalt has been noted; perhaps up to half of the cobalt recovered from Norilsk's ores is processed by third parties such as Ufaleynickel Joint Stock Co. (see entry in Table 6). Selenium and tellurium are also produced.<sup>153</sup>

In the Kola peninsula, Norilsk mines two orebodies, the Zhdanovskoye and Zapolyarnoe deposits; the ore there is a disseminated ore (see above for tonnage and grades). Four mines operate on these orebodies and all are underground mines except for one open pit. The four mines feed a single mill. Concentrate from the mill feeds a single smelter at Nikel. The matte is sent to Severonickel for refining.<sup>154</sup>

Severonickel refineries process the matte from the other two divisions plus imported and domestic scrap. Products include nickel and copper cathodes, precious metals concentrates and sulphuric acid.<sup>155</sup> In earlier years, it was noted that Severonickel produced a few thousand tonnes of nickel carbonyl annually and that Norilsk sells carbonyl powders.<sup>156</sup>

## Sourcing Canadian Nickel or Cobalt From Canadian Producers

Frequently, requests are received for contact details and product specifications for primary nickel or cobalt sold by Canadian producers. There are also inquiries about nickel and cobalt in scrap. The reader should visit the web sites of the Canadian producers for the contacts. As of mid-2004, the web pages to view were:

### Falconbridge

- [www.falconbridge.com](http://www.falconbridge.com) (no absolute addresses possible on Falconbridge site, search under "Our Products" on home page)

### Inco

- [www.inco.com/sales.asp](http://www.inco.com/sales.asp) for sales offices
- [www.inco.com/Products/default.asp](http://www.inco.com/Products/default.asp) for links to product information

### Sherritt

- [www.sherritt.com/sites/frames/topframe\\_metal.html](http://www.sherritt.com/sites/frames/topframe_metal.html) for contacts and product specifications

The Canadian industry also provides nickel in scrap and other recyclable forms. Some of the nickel is contained in stainless steels, which is the major market for primary and scrap nickel. There is an association of recycling companies called the Canadian Association of Recycling Industries (CARI),<sup>157</sup> which represents some of the companies that recycle nickel and other nonferrous metals. To obtain information about nickel recyclers in Canada, the reader may send an e-mail to len.shaw-cari@on.aibn.com. Alternatively, the reader may use a search engine on the Internet or may refer to telephone directories for the locations of interest.

## WORLD NICKEL PRODUCTION

Table 5 shows a list of world nickel producers and their web sites, where available. Table 6 provides information about world nickel producers for 2003. Table 8 shows mine production for major producing countries and Table 9 shows primary production for major producing countries.

Canada is the third largest nickel producer, having been overtaken by Australia in 2001. Canada also ranks as the fourth largest producer of primary nickel, having been overtaken by Australia in 2003 due to a strike in Inco's Sudbury facilities.

## WORLD COBALT PRODUCTION

Table 13 presents CDI information about cobalt availability by company for the period 1997-2003.

## NICKEL USE

Stainless steel is the single largest market for primary nickel.<sup>158</sup> The largest competitor and substitute for primary nickel use in stainless steel is nickel contained in scrap; worldwide, stainless producers source slightly more than half of their nickel feed from primary sources and the remainder from scrap. This ratio changes by region and as the price of nickel contained in scrap relative to primary nickel prices changes. According to Inco, the scrap ratio or percentage of nickel sourced from scrap was 47% in 2001, 45% in 2002 and 44% in 2003.<sup>159</sup>

Eramet presented data for nickel use in 2003 as:<sup>160</sup>

- Stainless steels, 69%;
- Nickel alloys, 9%;
- Plating, 8%;
- Ferrous metallurgy, 7%;
- Batteries, 3%; and
- Coinage, 2%.

Eramet presented further detail in the same source about the use as subdivisions of stainless steel usage in 2003:

- Industrial processes, 43%;
- Household and catering equipment, 30%;
- Transportation, 13%;
- Construction, 11%; and
- Others, 3%.

(Note that household and catering equipment included cutlery, kitchenware, sinks, appliances, etc., and transportation included vehicles such as ships, aerospace, cars and trucks.)

Stainless steel producers can source nickel in various forms such as LME-grade refined nickel<sup>161</sup> (in forms such as cathodes, pellets, briquettes), nickel in ferronickel (grades vary mainly from 20% to 35%, but can vary from a low of 6% in the Ukraine to 43% Ni at Severonickel), nickel oxide sinter (75% in Sudbury to 90% Ni+Co in Cuba), granules, ingots, or other forms such as Utility Nickel<sup>TM</sup>.<sup>162</sup> Some applications, for example, nickel plating, may use only a few of the many forms in which nickel is produced.

Eramet presented data on its web site about the forms in which primary nickel is produced. According to Eramet,<sup>163</sup> the distribution of nickel production in 2003 was:

- Electrolytic nickel, 52%;
- Ferronickel, 22%;
- Briquettes, 12%;
- Sinter and oxides, 11%; and
- Powders, 3%.

The nickel in scrap comes in the form of worn-out industrial and consumer products (old scrap) as well as in the form of cuttings, clips, etc., from the fabrication of stainless steel items. Some nickel in stainless is "lost" when it is not separated from lower-priced ferrous scrap; that nickel can be captured in non-stainless steel production, albeit unintentionally. "Scrap" can be "made" by combining either primary nickel or nickel in non-stainless recyclables with iron and chromium blended at a ratio acceptable to consumers. Some nickel is recycled by primary producers of nickel and cobalt and may be reported as "primary" nickel production; it is thought that this amount is a small percentage of the annual reported primary nickel production.

In addition to the 1.2 Mt of primary nickel used in 2003, there was approximately 650 000 t of nickel contained in stainless steel scrap used by stainless steel mills in 2003. This recycled nickel competes directly with primary nickel.

With the continuation of high nickel prices, stainless steel producers increased production of the 200 and 400-grade stainless steels. These grades are cheaper, due largely to the lower nickel content. As an example, prices in China for cold-rolled stainless in January 2004 were US\$1500/t f.o.b. for stainless with 4% nickel content and US\$1350/t f.o.b. for product with 1% nickel content. Hot-rolled stainless prices were US\$2050/t for nickel-based product compared to US\$850/t f.o.b. for chrome-based product.<sup>164</sup> It will be important to see the degree to which the stainless industry can minimize the use of nickel for markets in which price is very significant. If fabricators and users decide that some applications do not require as much nickel as had been previously used, the rate of increase of nickel demand by stainless usage will be moderated. In other applications, such as plating, the higher price of nickel caused relatively quicker adjustments that cut demand growth.

## COBALT USE

Canadian cobalt use is reported in Table 2c. General information about cobalt uses can be obtained from The Cobalt Development Institute's web site at [www.thecdi.com](http://www.thecdi.com) (click on "about cobalt"), from the U.S. Geological Survey's Internet site at <http://minerals.usgs.gov/minerals/pubs/commodity/cobalt>, or from the OM Group Inc.'s Internet site at [www.omgi.com](http://www.omgi.com). On the OM Group site at [www.omgi.com/industries/default.htm](http://www.omgi.com/industries/default.htm), there was also a list of applications; each title can be clicked on for more information about the specific application of cobalt and nickel as well as other OMG products.

## RECYCLING

To calculate a recycling rate, one needs to know the product life for the materials used in goods. Stainless steel is used in relatively long-life applications due to its higher initial cost and lower maintenance costs over its years in service. This means that there is a long period of time between production of the nickel-containing stainless steel and its recycling. But, during that time, demand and production grow. At a 6% growth rate, stainless steel demand more than quadruples in 25 years. If all the nickel in the stainless steels produced in one year were to be recycled after 25 years, the recycling of 100% of that material would only represent 25% of the nickel being used to make stainless steel. Therefore, in this case, 100% recycling would translate into a feed ratio of only 25% recycled material if all scrap were sourced only from used consumer and industrial goods (i.e., "old" scrap). Thus, one can conclude that recycling rates are higher than the ratio of recycled feed to total feed; calculating the true recycling

rate is difficult because of the varying product lives that contain nickel.

Information from the Nickel Institute about nickel risk assessment in Europe is available on the Internet at [www.nickelforum-eura.org/index.cfm/ci\\_id/11276/la\\_id/1.htm](http://www.nickelforum-eura.org/index.cfm/ci_id/11276/la_id/1.htm).

## PRICES AND INVENTORIES

Figure 2 shows prices in 2003 and for the period 1986-2003. LME inventories began the year at just under 22 000 t and ended the year at over 24 000 t. During 2003, Norilsk released 70 000 t of stockpiled nickel,<sup>165</sup> thereby moderating price increases.

Limited historical price and inventory information is available at no charge. Inco has daily price and inventory data back to 2002; this can be obtained from Inco's web site at [www.inco.com/customercentre/dailyprice/archive/default.asp](http://www.inco.com/customercentre/dailyprice/archive/default.asp).

The International Nickel Study Group publishes a monthly bulletin that includes data about prices. Details about the bulletin were available at [www.insg.org/publics.htm](http://www.insg.org/publics.htm).

The London Metal Exchange shows data for the current year on its web site at [www.lme.co.uk](http://www.lme.co.uk). One needs to choose the link to "current calendar year." There is a charge for earlier data.

Another source is [Metalprices.com](http://Metalprices.com), which charges an annual subscription fee for access to prices and information about nickel and precious, nonferrous and other metals.

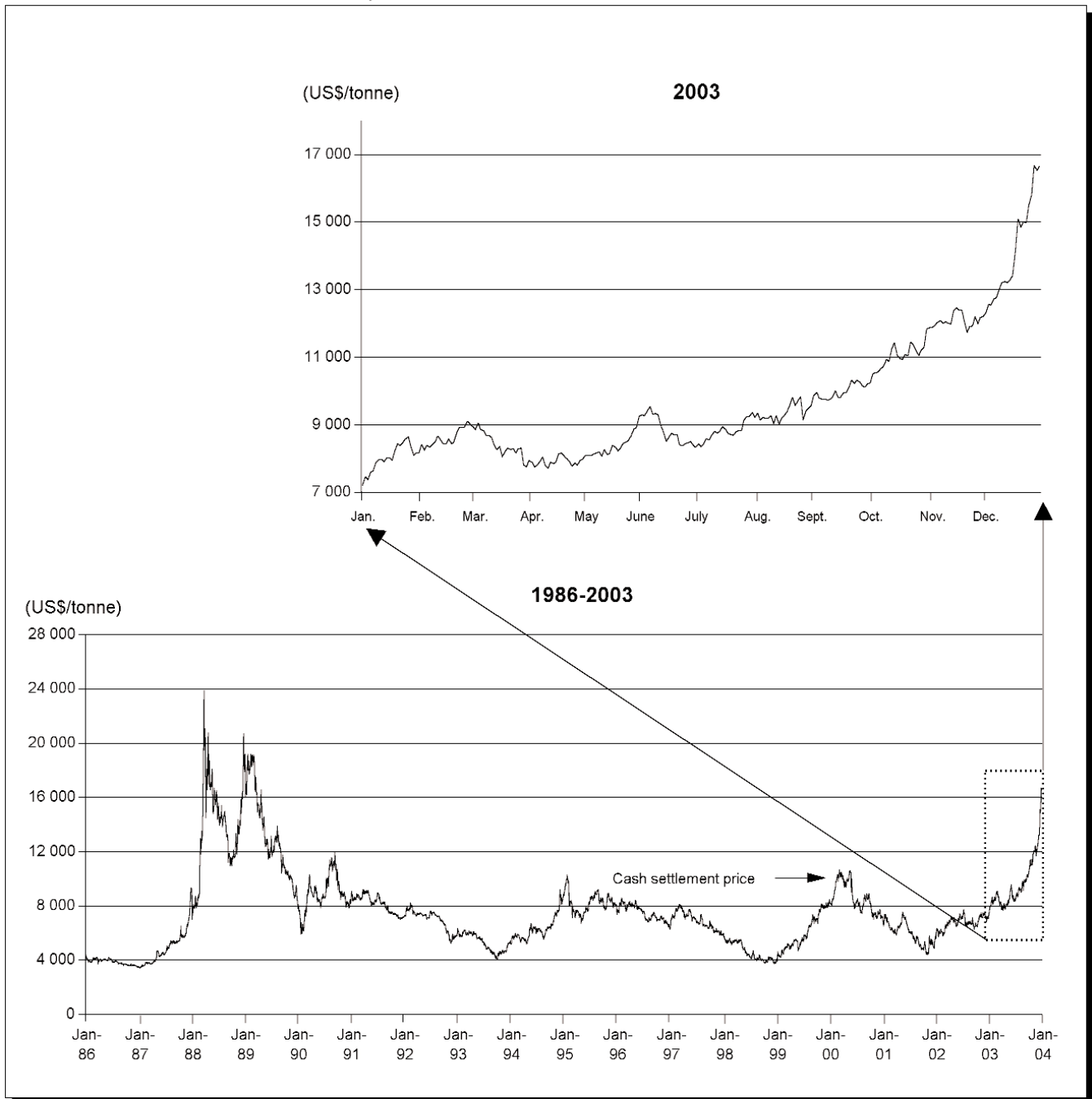
As well, *Metal Bulletin* has LME and other price data including proprietary prices, which include stainless steel; prices are available with a subscription.

## Cobalt

No terminal markets such as the LME exist for cobalt, although WMC Resources reports prices and sales data on sales on its Internet site at [www.wmc-cobalt.com/sales.asp](http://www.wmc-cobalt.com/sales.asp).

A graph comparing prices reported by WMC Resources and by *Metal Bulletin* was available at [www.wmc-cobalt.com/graphs/mbprice.pdf](http://www.wmc-cobalt.com/graphs/mbprice.pdf), and a graph comparing prices reported by WMC Resources and Ryan's Notes was available at [www.wmc-cobalt.com/graphs/ryprice.pdf](http://www.wmc-cobalt.com/graphs/ryprice.pdf).

**Figure 2**  
**LME Cash Settlement Nickel Prices, 1986-2003**



Sources: International Nickel Study Group; Reuters; World Bureau of Metal Statistics.  
 Conversions: \$2.50/lb = \$5512/t; \$3.00/lb = \$6614/t; \$3.50/lb = \$7716/t; \$4.00/lb = \$8818/t.



## OUTLOOK

In April 2004, the members of the International Nickel Study Group forecast<sup>166</sup> the following for 2004:

- primary nickel production, 1.28 Mt (up 0.08 Mt from 1.20 Mt in 2003); and
- primary nickel usage, 1.30 Mt (up 0.06 Mt from 1.24 Mt in 2003).

Project delays were commonplace in 2002; in 2003, there was mixed progress in advancing projects. Inco continued to review its New Caledonian Goro project, which was halted in December 2002 due to projected cost over-runs of 30-45% over the original target of US\$1.45 billion. (This followed an earlier announcement in October that the project costs could run 15% over the US\$1.45 billion estimate.) BHP Billiton plc continued to study its 50 000-t/y Ravensthorpe project in Western Australia and the associated expansion at Yabulu in Queensland.

As nickel prices are bid higher and higher as inventory declines, changes in some product lines will take place. These include:

- substitution of nickel by other alloying elements;
- substitution of nickel-bearing stainless steel by other materials; and
- a reduction in the amount of nickel used in some stainless steel applications.

In some markets, stainless steel usage may be relatively insensitive to increased prices for nickel. But the prospect of years of high stainless prices caused by high nickel prices due to insufficient supply will sow the seeds of the next market correction for nickel. Stainless steel may acquire the reputation of an “expensive” material, moderating future demand growth in the medium term. Concurrently, continued high prices may permit a new wave of laterite investments. This could be exacerbated by a rush to be among the “first into production” and benefit from the high prices of nickel. (One recalls the race to “beat Voisey’s Bay” into production in the late 1990s and its consequences.)

There appeared to be a general expectation that potential demand would outpace supply and that nickel prices would remain substantially above historical levels until perhaps 2006. It is notable that the prices used by Canadian companies to evaluate ore reserves<sup>167</sup> at the end of 2003 were far lower than the then current prices. Falconbridge used a long-term price for nickel of US\$3.25/lb (US\$7165/t) to evaluate ore reserves at the end of 2003.<sup>168</sup> Inco used a long-term nickel price of US\$3.20/lb subject to an unstated “volatility premium.”<sup>169</sup>

The continued high prices will continue to have an impact on potential demand growth. A significant unknown is the

degree to which substitution by low or no nickel alternatives for stainless steels will continue once prices fall. The question of substitution often appears to have a high degree of “inertia”; that is, it may take an extended period of high prices before a change takes place, but this change is not easily reversed once prices decline. Not all uses are substitutable in the same way – nickel used in high-nickel alloys for aerospace applications are expected to be less resistant to substitution than say plating or some architectural applications for stainless steels.

## New Projects

Two tables produced by the USGS are presented (see Tables 14 and 15) that summarize the nickel sulphide and the nickel laterite projects as of the end of 2002.

## Intermediates

The potential noted in 2002 for greater arm’s-length trade in nickel intermediates continued in 2003. Projects that could have an impact on this trade include Ramu, Weda Bay, Jaguar Nickel, and Canico, in addition to the concentrate sales from projects at Sally Malay and Aguablanca.

China continued to stoke demand for stainless steels and therefore for nickel. Chinese stainless production was forecast to continue to grow at 1 Mt/y; production of crude stainless grew from 1.1 Mt in 2002 to 2 Mt in 2003 and is forecast to reach 3 Mt in 2004 and 4 Mt in 2005.<sup>170</sup> The 200 series stainless was estimated to have accounted for 20% of total stainless demand of 2.8 Mt in 2003.<sup>171</sup>

The outlook for nickel demand is a function of the industrial activity of the major countries in the world. The largest user of nickel, both primary and recycled, is the stainless steel industry, whose use is strongly correlated with indices of industrial production (see the Nickel chapter of the 1999 *Canadian Minerals Yearbook*, Figure 5, for a graph illustrating the relationship).

The Eramet Group presented nickel consumption growth from 1950 to 2003, including a forecast for 2004, fitting a curve compounding at a 4% growth rate annually.<sup>172</sup>

The author projects that the demand for primary nickel will continue to grow at that rate, but will rather increase at an average trend rate of 3%/y or less during the next decade. The actual demand in any year will vary about the trend due primarily to changes in world industrial activity, which cause changes in stainless steel demand. The high growth rates for austenitic stainless steel (containing 8% nickel or more) has fueled the increased nickel prices, but a sustained period of prices in the range of US\$9000/t (reflecting lower-valued U.S. currency) would decrease the competitiveness of a significant portion of austenitic stainless steel production. Not all uses of austenitic stainless steels are equally at risk of substitution; some

applications are thought to be quite insensitive to substitution. Unless new lower-cost production came on stream, the higher nickel prices would lead to decreased demand growth for nickel. It appears that prices will remain at historically high levels in the short term because new projects have been delayed and because the stainless steel industry continues its massive capacity increase.

The December 1998-November 2001 price cycle that peaked in March 2000 at US\$10 660/t did not result in new nickel production capacity-building following this peak, as had occurred when prices improved in earlier price cycles. Part of the reason for the lack of enthusiasm by potential new entrants to the nickel industry in times of high prices was due to the legacy of the laterite debts. Lenders and bond holders for the three Australian projects (Cawse, Bulong and Anaconda [now Minara]) all suffered losses because the projects were unable to service all their debt.

In general, the amount of new nickel production capacity scheduled to come on stream in the next four years is regarded as insufficient to meet the expected growth rate in stainless steel production. This implies that growth in stainless steel production will not be as high as expected with higher nickel prices retarding stainless steel demand.

It seems increasingly likely that the U.S. currency value will continue to decline relative to other major currencies, so the nominal prices in U.S. dollars may increase more than the prices in Euros, as an example. If the Canadian dollar appreciates relative to the U.S. dollar, this will pose a challenge to Canadian producers who have many of their costs denominated in Canadian currency, especially when

the nickel price declines. Nickel prices are not expected to vary with the rates of inflation expected; technological advances are expected to more than overcome inflationary pressures.

## Cobalt

Cobalt prices (Figure 3) strengthened throughout the year, accelerating in the last two months. For 99.8% Co, the average monthly prices rose from US\$7.68/lb in January to US\$9.25/lb in March to US\$10.58/lb in June and then maintained a price between US\$10 and \$11/lb through October, after which it rose rapidly to US\$14.50/lb in November and then to US\$18.18/lb in December. For the lower-grade 99.3% Co, the average monthly prices rose from US\$7.28/lb in January progressively to US\$9.90/lb in October and then accelerated to US\$12.48/lb in November and US\$16.61/lb in December.

## ADDITIONAL SOURCES OF INFORMATION

Readers may access various additional sources of information on the Internet to obtain more details about nickel in general. Various search engines for the Internet exist.

### Natural Resources Canada

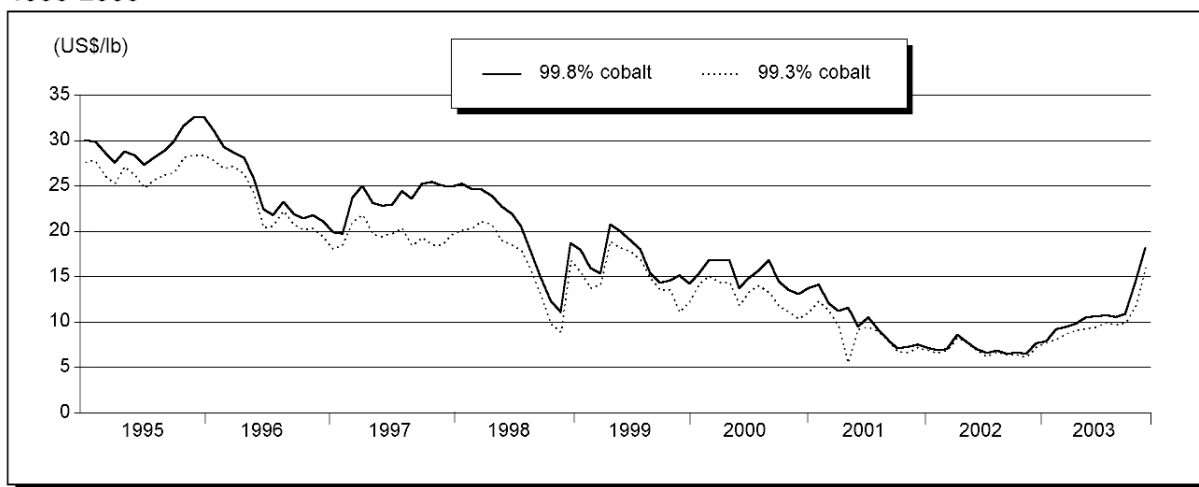
Canadian Minerals Yearbook:

[www.nrcan.gc.ca/mms/cmypref\\_e.htm](http://www.nrcan.gc.ca/mms/cmypref_e.htm)

Metal and mineral statistics:

[http://mmsd1.mms.nrcan.gc.ca/mmsd/minstatistics\\_e.asp](http://mmsd1.mms.nrcan.gc.ca/mmsd/minstatistics_e.asp)

**Figure 3**  
**Cobalt Prices, Average of Metal Bulletin Monthly Average High and Low Prices, 1995-2003**



Source: *Metal Bulletin*.

Nickel production by month:

[http://mmsd1.mms.nrcan.gc.ca/mmsd/data/default\\_e.asp](http://mmsd1.mms.nrcan.gc.ca/mmsd/data/default_e.asp)

Production by province and territory:

[http://mmsd1.mms.nrcan.gc.ca/mmsd/production/production\\_e.asp](http://mmsd1.mms.nrcan.gc.ca/mmsd/production/production_e.asp)

### Physical/Chemical Properties of Nickel

[www.webelements.com/webelements/elements/text/Ni/key.html](http://www.webelements.com/webelements/elements/text/Ni/key.html)

### Physical/Chemical Properties of Cobalt

[www.webelements.com/webelements/elements/text/Co/key.html](http://www.webelements.com/webelements/elements/text/Co/key.html)

### International Nickel Study Group

[www.insg.org](http://www.insg.org)

### U.S. Geological Survey

Comprehensive commodity reviews, monthly reports, historical information:

<http://minerals.usgs.gov/minerals/pubs/commodity>

Nickel is at:

<http://minerals.er.usgs.gov/minerals/pubs/commodity/nickel/>

Cobalt is at:

<http://minerals.er.usgs.gov/minerals/pubs/commodity/cobalt/>

## Other Country-Specific Information

### Australia

Western Australia - 2003 statistics and write-up is at [www.doir.wa.gov.au/documents/mineralsandpetroleum/statsdigest2003.pdf](http://www.doir.wa.gov.au/documents/mineralsandpetroleum/statsdigest2003.pdf).

At the port of Townsville in Queensland, Australia, port reports show imports by port of embarkation for tonnes of nickel ore imported to BHP Billiton's refinery at Yabulu. These records are obtainable from a link at <http://203.52.104.70/commerce/statsdefault.htm>.

### New Caledonia

Monthly production data are available (in French only) in a spreadsheet showing tonnes of limonitic ore mined, tonnes of saprolitic ore mined, tonnes of Ni in FeNi produced, and tonnes of Ni in matte produced on a web site located at [www.itsee.nc/pe/telechargement/minemeta.xls](http://www.itsee.nc/pe/telechargement/minemeta.xls).

A monthly commentary is available (in French only) at [www.itsee.nc/pe/pem/pemminesmeta.html](http://www.itsee.nc/pe/pem/pemminesmeta.html).

A review of events in the nickel industry in the previous year is available (in French only) at [www.itsee.nc/pe/bilan.pdf](http://www.itsee.nc/pe/bilan.pdf)/minesmetalbilan.pdf.

## ENDNOTES

<sup>1</sup> Actually 52%. This figure and the data for production of nickel by type is from the Eramet Group web site at [www.eramet.fr/us/nickel/marches/marches.php](http://www.eramet.fr/us/nickel/marches/marches.php).

<sup>2</sup> INSG *World Nickel Statistics*, June 2004. While statistics are collected and published by countries and the International Nickel Study Group (INSG) to four or more significant figures, it is very doubtful if the data are in fact consistently accurate to four or even three significant figures. The data for world primary production and world consumption are also from the June 2004 issue.

<sup>3</sup> The INSG defines Class I nickel as having a Ni content of 99% or more; Class II nickel includes products with less than 99% Ni content and includes FeNi, nickel oxide sinter, nickel in chemicals, etc.

<sup>4</sup> The London Metal Exchange (LME) prices serve as a basis for most transactions. The contract specifications are available on the Internet at [www.lme.co.uk/nickel\\_contractspec.asp](http://www.lme.co.uk/nickel_contractspec.asp) and a list of registered brands is available at [www.lme.co.uk/nickel\\_brands.asp](http://www.lme.co.uk/nickel_brands.asp). There is more than one type of nickel contract traded on the LME; the prices noted above are daily settlement prices.

<sup>5</sup> Available as a link shown on the Internet page at [www.eramet.fr/us/actionnaires/pres\\_finan.php#](http://www.eramet.fr/us/actionnaires/pres_finan.php#). For an explanation of the geological model for lateritic nickel deposits, visit <http://pubs.usgs.gov/bul/b1693/Md38a.pdf>. See also [www.portergeo.com.au/tours/nickel2000/m1b.asp](http://www.portergeo.com.au/tours/nickel2000/m1b.asp).

<sup>6</sup> CDI historical statistics are available on the Internet at [www.thecdi.com/statistics/index.html](http://www.thecdi.com/statistics/index.html).

<sup>7</sup> *Production of Canada's Leading Minerals*, December 2003, Table 7, available at <http://mmsd1.mms.nrcan.gc.ca/mmsd/data/2003/03mtly12.pdf>.

<sup>8</sup> Slater Steel Inc. press release, June 2, 2003, and Canadian legal documents filed on its web site at [www.slater.com/restructure/court\\_ontario\\_principal.htm](http://www.slater.com/restructure/court_ontario_principal.htm).

<sup>9</sup> Royal Canadian Mint ([www.mint.ca/en/business\\_services/plating/patented\\_process.htm?cookie%5Ftest=1](http://www.mint.ca/en/business_services/plating/patented_process.htm?cookie%5Ftest=1)).

<sup>10</sup> Royal Canadian Mint ([www.mint.ca/en/about\\_the\\_mint/Circulation+Coins/index\\_circ.htm?cookie%5Ftest=1](http://www.mint.ca/en/about_the_mint/Circulation+Coins/index_circ.htm?cookie%5Ftest=1)).

<sup>11</sup> *Production of Canada's Leading Minerals*, December 2003, Table 7, ISSN 0709-292 X; as noted earlier, data may not be as accurate as the number of significant figures shown.

<sup>12</sup> Estimate by NRCAN, based upon inputs by some producers.

<sup>13</sup> Cosec, M., Gaudreau, J.M., Selway, J.B. and Beauchamp, S.A., 2004. *Report of Activities 2003*, Resident Geologist Program, Kirkland Lake Regional Resident Geologist Report: Sudbury District; Ontario Geological Survey, Open File Report 6139, 33 pp., available on the Internet at [www.mndm.gov.on.ca/mndm/mines/ims/pub/roa/roapdfs/ofr6139.pdf](http://www.mndm.gov.on.ca/mndm/mines/ims/pub/roa/roapdfs/ofr6139.pdf).

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(1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 64. (2) Most information in this review was current as of July 2004. (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 [www.nrcan.gc.ca/mms/cmy/com\\_e.html](http://www.nrcan.gc.ca/mms/cmy/com_e.html).

#### NOTE TO READER

**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 | European Union        | Japan                  |
|----------|---|---------|------|------|---------------|-----------------------|------------------------|
|          |   | MFN     | GPT  | USA  | Canada        | Conventional Rate (1) | WTO (2)                |
| 2604.00  | Nickel ores and concentrates  | Free    | Free | Free | Free          | Free                  | Free                   |
| 2825.40  | Nickel oxides and hydroxides  | Free    | Free | Free | Free          | Free                  | 4.8%                   |
| 7202.60  | Ferro-nickel  | 6.5%    | Free | Free | Free          | Free                  | 3.3%                   |
| 7501.10  | Nickel mattes   | Free    | Free | Free | Free          | Free                  | Free                   |
| 7501.20  | Nickel oxide sinters and other intermediate products of nickel metallurgy | Free    | Free | Free | Free          | Free                  | Free-<br>(3) 44 yen/kg |
| 7502.10  | Unwrought nickel, not alloyed   | Free    | Free | Free | Free          | Free                  | 44 yen/kg              |
| 7502.20  | Unwrought nickel alloys   | Free    | Free | Free | Free          | Free                  | (4) Free-3%            |
| 7503.00  | Nickel waste and scrap  | Free    | Free | Free | Free          | Free                  | Free                   |
| 7504.00  | Nickel powders and flakes   | Free    | Free | Free | Free          | Free                  | Free-<br>41 yen/kg-3%  |
| 7505.11  | Bars, rods and profiles of nickel, not alloyed                            | Free    | Free | Free | Free          | Free                  | 3%                     |
| 7505.12  | Bars, rods and profiles of nickel alloys                                  | Free    | Free | Free | Free          | 2.9%                  | 3%                     |
| 7505.21  | Nickel wire, not alloyed  | Free    | Free | Free | Free          | Free                  | 3%                     |
| 7505.22  | Wire of nickel alloys   | Free    | Free | Free | Free          | 2.9%                  | 3%                     |
| 7506.00  | Nickel plates, sheets, strip and foil                                     | Free    | Free | Free | Free          | Free-3.3%             | Free-3%                |
| 7507.00  | Nickel tubes, pipes, and tube or pipe fittings                            | Free    | Free | Free | Free          | Free-2.5%             | Free-3%                |
| 7508.00  | Other articles of nickel  | Free-3% | Free | Free | Free          | Free                  | 3%                     |

Sources: Canadian *Customs Tariff*, effective January 2004, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States, 2004*; *Official Journal of the European Union* (October 30, 2003 Edition); *Customs Tariff Schedules of Japan, 2003*.

(1) The customs duties applicable to imported goods originating in countries that are Contracting Parties to the General Agreement on Tariffs and Trade or with which the European Community has concluded agreements containing the most-favoured nation tariff clause shall be conventional duties shown in column 3 of the Schedule of Duties. (2) WTO rate is shown; lower tariff rates may apply circumstantially. (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 |
|---------------|--|--------|------|------|--------|
|               |  | 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 therefor 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  | 5.5%   | 3%   | Free | Free   |
| 8105.00       | Cobalt mattes and other intermediate products of cobalt metallurgy; cobalt and articles thereof, including waste and scrap; unwrought cobalt; powders  |        |      |      |        |
| 8105.20.10    | Powders; unwrought cobalt, not alloyed   | Free   | Free | Free | Free   |
| 8105.20.90    | 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: Canadian *Customs Tariff*, effective January 2004, Canada Border services Agency; *Harmonized Tariff Schedule of the United States*, 2004.

n.e.s. Not elsewhere specified.



TABLE 1a. CANADA, NICKEL EXPORTS, 2002 AND 2003

|            |   | 2002     |           | 2003     |           |
|------------|---|----------|-----------|----------|-----------|
|            |   | (tonnes) | (\$000)   | (tonnes) | (\$000)   |
| 2604.00.40 | Nickel ores and concentrates (nickel content)   | ...      | 4         | 22       | 118       |
| 2825.40    | Nickel oxides and hydroxides (weight of material, not nickel content)   |          |           |          |           |
|            | Hong Kong   | 234      | 2 193     | 715      | 7 668     |
|            | China   | 126      | 1 203     | 206      | 2 094     |
|            | Germany   | -        | -         | 266      | 2 072     |
|            | Malaysia  | 8        | 80        | 108      | 1 210     |
|            | Japan   | 62       | 250       | 99       | 900       |
|            | United States   | 164      | 1 052     | ...      | 4         |
|            | Singapore   | 64       | 587       | 30       | 339       |
|            | Other   | 89       | 369       | 2        | 17        |
|            | Total   | 747      | 5 734     | 1 426    | 14 304    |
| 2827.35    | Nickel chlorides (weight of material, not nickel content)   |          |           |          |           |
|            | Norway  | -        | -         | 19       | 69        |
| 2833.24    | Nickel sulphates (weight of material, not nickel content)   |          |           |          |           |
|            | United Kingdom  | 356      | 8 203     | 293      | 2 145     |
| 3815.11    | Catalysts and other reaction initiators, reaction accelerators and catalytic preparations with nickel or nickel compounds as the substance (weight of material, not nickel content) |          |           |          |           |
|            | United States   | 1 514    | 607       | 258      | 138       |
|            | Other   | -        | -         | 30       | 4         |
|            | Total   | 1 514    | 607       | 288      | 142       |
| 7204.21    | Stainless steel waste and scrap (weight of material, not nickel content)  |          |           |          |           |
|            | United States   | 55 964   | 53 067    | 56 194   | 59 445    |
|            | Taiwan  | 942      | 900       | 1 221    | 1 466     |
|            | South Korea   | 40       | 56        | 763      | 1 053     |
|            | India   | 523      | 635       | 893      | 938       |
|            | China   | 4 870    | 3 626     | 680      | 736       |
|            | Netherlands   | 314      | 77        | 477      | 540       |
|            | Japan   | 202      | 314       | 254      | 365       |
|            | Germany   | 51       | 130       | 133      | 152       |
|            | United Kingdom  | -        | -         | 97       | 149       |
|            | Other   | 34       | 23        | 152      | 105       |
|            | Total   | 62 940   | 58 828    | 60 864   | 64 949    |
| 7501.10    | Nickel mattes (Nickel content)  |          |           |          |           |
|            | Norway  | 53 135   | 614 008   | 49 185   | 652 154   |
| 7501.20    | Nickel oxide sinters and other intermediate products of nickel metallurgy (weight of material, not nickel content)  |          |           |          |           |
|            | United Kingdom  | 37 492   | 382 630   | 32 806   | 393 715   |
|            | South Korea   | 8 761    | 85 511    | 5 670    | 64 092    |
|            | Belgium   | 689      | 8 172     | 905      | 12 881    |
|            | Taiwan  | 2 145    | 24 001    | 302      | 3 593     |
|            | United States   | 1 547    | 12 323    | 85       | 827       |
|            | Total   | 50 634   | 512 637   | 39 768   | 475 108   |
| 7502.10    | Nickel unwrought, not alloyed (nickel content)  |          |           |          |           |
|            | United States   | 48 193   | 507 010   | 35 537   | 417 012   |
|            | Belgium   | 8 711    | 91 318    | 11 924   | 154 977   |
|            | Hong Kong   | 8 168    | 88 010    | 8 852    | 123 227   |
|            | Taiwan  | 4 902    | 55 171    | 5 511    | 79 256    |
|            | United Kingdom  | 3 877    | 41 604    | 5 573    | 73 811    |
|            | Netherlands   | 5 627    | 59 850    | 5 485    | 73 256    |
|            | China   | 1 836    | 20 599    | 4 709    | 69 356    |
|            | Japan   | 2 827    | 29 491    | 3 460    | 45 951    |
|            | South Korea   | 1 750    | 18 848    | 2 983    | 42 148    |
|            | Spain   | 1 628    | 17 608    | 1 920    | 24 750    |
|            | Italy   | 2 836    | 30 866    | 1 306    | 18 210    |
|            | Singapore   | 2 646    | 28 081    | 1 131    | 14 943    |
|            | Thailand  | 797      | 8 775     | 1 004    | 13 796    |
|            | France  | 291      | 3 157     | 708      | 9 962     |
|            | Switzerland   | 36       | 387       | 660      | 8 346     |
|            | India   | 558      | 6 380     | 431      | 6 573     |
|            | Australia   | 401      | 3 999     | 426      | 5 585     |
|            | Sweden  | 96       | 1 022     | 384      | 5 216     |
|            | Gibraltar   | -        | -         | 216      | 2 600     |
|            | Indonesia   | 99       | 1 099     | 77       | 1 103     |
|            | Philippines   | 98       | 1 133     | 48       | 679       |
|            | Luxembourg  | 240      | 2 480     | 48       | 625       |
|            | Other   | 45       | 478       | 53       | 793       |
|            | Total   | 95 662   | 1 017 366 | 92 446   | 1 192 175 |

TABLE 1a (cont'd)

|         | 2002  |         | 2003      |         |           |
|---------|---|---------|-----------|---------|-----------|
|         | (tonnes)  | (\$000) | (tonnes)  | (\$000) |           |
| 7502.20 | Nickel unwrought, alloyed (weight of material, not nickel content)                                    |         |           |         |           |
|         | China   | 2 918   | 33 928    | 1 607   | 21 175    |
|         | Hong Kong   | 1 867   | 19 751    | 605     | 7 811     |
|         | India   | 201     | 2 139     | 383     | 5 085     |
|         | South Korea   | 1 040   | 11 664    | 200     | 2 565     |
|         | Other   | 172     | 1 623     | ...     | 8         |
|         | Total   | 6 198   | 69 105    | 2 795   | 36 644    |
| 7503.00 | Nickel waste and scrap (weight of material, not nickel content)                                       |         |           |         |           |
|         | United States   | 1 888   | 5 919     | 2 502   | 9 643     |
|         | Germany   | -       | -         | 180     | 1 055     |
|         | Japan   | 20      | 204       | -       | -         |
|         | Netherlands   | 103     | 234       | -       | -         |
|         | Other   | 76      | 76        | 76      | 76        |
|         | Total   | 2 087   | 6 699     | 2 711   | 10 813    |
| 7504.00 | Nickel powders and flakes, alloyed and unalloyed (weight of material, not nickel content)             |         |           |         |           |
|         | United States   | 4 416   | 70 633    | 3 704   | 61 210    |
|         | Japan   | 2 186   | 25 172    | 1 754   | 26 156    |
|         | Belgium   | 258     | 2 304     | 874     | 11 718    |
|         | South Korea   | 357     | 3 902     | 292     | 4 038     |
|         | United Kingdom  | 25      | 2 436     | 115     | 2 476     |
|         | Taiwan  | 207     | 2 118     | 157     | 2 286     |
|         | China   | 42      | 448       | 89      | 1 401     |
|         | Luxembourg  | 273     | 2 892     | 63      | 816       |
|         | Australia   | 102     | 986       | 53      | 742       |
|         | Germany   | 83      | 1 047     | 33      | 475       |
|         | Netherlands   | 149     | 1 640     | 3       | 51        |
|         | Other   | 50      | 841       | 32      | 632       |
|         | Total   | 8 148   | 114 419   | 7 169   | 112 001   |
| 7505.11 | Bars, rods and profiles of nickel, not alloyed (nickel content)                                       |         |           |         |           |
|         |   | ...     | ...       | 14      | 135       |
| 7505.12 | Bars, rods and profiles of nickel alloy (weight of material, not nickel content)                      |         |           |         |           |
|         |   | 3       | 112       | 7       | 143       |
| 7505.21 | Nickel wire, not alloyed (weight of nickel wire plus coating if any, not nickel content)              |         |           |         |           |
|         | United States   | -       | -         | 15      | 360       |
| 7505.22 | Wire, nickel alloy (weight of alloy plus coating, if any; not nickel content)                         |         |           |         |           |
|         | United States   | 5       | 168       | 87      | 1 565     |
|         | Other   | -       | 7         | 17      | 132       |
|         | Total   | 5       | 175       | 104     | 1 697     |
| 7506.00 | Nickel plates, sheets, strip and foil   |         |           |         |           |
|         |   | 25      | 866       | 12      | 159       |
| 7507.00 | Tubes, pipes and tube or pipe fittings alloyed and unalloyed (weight of material, not nickel content) |         |           |         |           |
|         | United States   | ..      | 1 779     | ..      | 2 535     |
|         | Other   | ..      | 1 102     | ..      | 1 571     |
|         | Total   | ..      | 2 881     | ..      | 4 106     |
| 7508.00 | Other articles of nickel (weight of material, not nickel content)                                     |         |           |         |           |
|         | United States   | ..      | 14 026    | ..      | 10 480    |
|         | United Kingdom  | ..      | 33        | ..      | 1 145     |
|         | Other   | ..      | 1 328     | ..      | 668       |
|         | Total   | ..      | 15 387    | ..      | 12 293    |
|         | Total exports   | ..      | 2 427 031 | ..      | 2 579 515 |

Sources: Natural Resources Canada; Statistics Canada.

- Nil; .. Not available; ... Amount too small to be expressed.

Note: Numbers may not add to totals due to rounding

TABLE 1b. CANADA, NICKEL IMPORTS, 2002 AND 2003

|              |   | 2002     |         | 2003     |         |
|--------------|---|----------|---------|----------|---------|
|              |   | (tonnes) | (\$000) | (tonnes) | (\$000) |
| 2604.0000.20 | Nickel ores and concentrates (Nickel content)   |          |         |          |         |
|              | Australia (1)   | 73 365   | 109 487 | 20 190   | 173 619 |
|              | Germany (1)   | 6 179    | 12 177  | 5 808    | 13 483  |
|              | United States (1)   | 10 774   | 6 281   | 10 316   | 7 121   |
|              | Other   | 21       | 71      | 541      | 4 959   |
|              | Total   | 90 339   | 128 016 | 36 855   | 199 182 |
|              | (NOTE: Trade data for 2604.00.00.20 imports are believed to be incorrect in 2002 and 2003. Reader should refer to footnote (1) and page 4 of text.)                                 |          |         |          |         |
| 2620.90      | Ash and residues (weight of material, not nickel content; material also includes significant cobalt value) (2)  |          |         |          |         |
|              | Cuba  | 62 005   | 272 743 | 70 726   | 345 162 |
| 2825.40      | Nickel oxides and hydroxides (weight of material, not nickel content)   |          |         |          |         |
|              | Finland   | 177      | 2 046   | 41       | 535     |
|              | United States   | 1 713    | 899     | 1 104    | 238     |
|              | Belgium   | 1        | 7       | 112      | 209     |
|              | Total   | 1 891    | 2 952   | 1 257    | 982     |
| 2827.35      | Nickel chlorides (weight of material, not nickel content)   |          |         |          |         |
|              | United States   | 70       | 441     | 580      | 3 742   |
|              | France  | 102      | 680     | 140      | 691     |
|              | Other   | ...      | 3       | ...      | 2       |
|              | Total   | 172      | 1 124   | 720      | 4 435   |
| 2833.24      | Nickel sulphates (weight of material, not nickel content)   |          |         |          |         |
|              | United States   | 2 382    | 5 284   | 9 209    | 19 613  |
|              | Belgium   | 172      | 579     | 324      | 1 091   |
|              | Finland   | 303      | 787     | 176      | 529     |
|              | Other   | 40       | 118     | 14       | 46      |
|              | Total   | 2 897    | 6 768   | 9 723    | 21 279  |
| 3815.11      | Catalysts and other reaction initiators, reaction accelerators and catalytic preparations with nickel or nickel compounds as the substance (weight of material, not nickel content) |          |         |          |         |
|              | United States   | 337      | 4 458   | 369      | 7 651   |
|              | Belgium   | 2        | 15      | 67       | 2 324   |
|              | Germany   | 176      | 2 068   | 155      | 2 132   |
|              | Denmark   | 61       | 1 801   | 20       | 569     |
|              | Japan   | 1        | 18      | 36       | 394     |
|              | United Kingdom  | 61       | 947     | 20       | 331     |
|              | Other   | 205      | 7 136   | 36       | 415     |
|              | Total   | 843      | 16 443  | 703      | 13 816  |
| 7202.60      | Ferronickel (weight of material, not nickel content)  | 15       | 77      | -        | -       |
| 7204.21      | Stainless steel scrap (weight of material, not nickel content)  |          |         |          |         |
|              | United States   | 34 434   | 32 583  | 36 529   | 38 548  |
|              | China   | 291      | 312     | 286      | 304     |
|              | Other   | 71       | 56      | 24       | 19      |
|              | Total   | 34 796   | 32 951  | 36 839   | 38 871  |
| 7501.10      | Nickel mattes (nickel content)  |          |         |          |         |
|              | Botswana  | -        | -       | 1 075    | 13 387  |
|              | Australia   | 513      | 2 537   | -        | -       |
|              | South Africa  | 375      | 2 206   | -        | -       |
|              | Other   | 40       | 178     | ...      | 1       |
|              | Total   | 928      | 4 921   | 1 075    | 13 388  |
| 7501.20      | Nickel oxide sinters and other intermediate products of nickel metallurgy (weight of material, not nickel content)  |          |         |          |         |
|              | Belgium   | -        | -       | 598      | 1 135   |
|              | United States   | 802      | 2 495   | 137      | 743     |
|              | Other   | -        | -       | 18       | 104     |
|              | Total   | 802      | 2 495   | 753      | 1 982   |

TABLE 1b (cont'd)

|         |   | 2002     |         | 2003     |         |
|---------|---|----------|---------|----------|---------|
|         |   | (tonnes) | (\$000) | (tonnes) | (\$000) |
| 7502.10 | Nickel unwrought, not alloyed (nickel content)  |          |         |          |         |
|         | Norway  | 970      | 10 009  | 495      | 6 661   |
|         | Finland   | 261      | 2 442   | 249      | 3 331   |
|         | United Kingdom  | 94       | 1 131   | 130      | 1 541   |
|         | United States   | 195      | 1 955   | 84       | 1 314   |
|         | Russia  | 39       | 430     | 54       | 718     |
|         | Other   | 46       | 534     | 20       | 272     |
|         | Total   | 1 605    | 16 501  | 1 032    | 13 837  |
| 7502.20 | Nickel unwrought, alloyed (weight of material, not nickel content)                        |          |         |          |         |
|         | Russia  | 665      | 3 915   | 1 079    | 5 987   |
|         | United States   | 253      | 2 196   | 110      | 1 445   |
|         | Finland   | —        | —       | 69       | 794     |
|         | United Kingdom  | 12       | 248     | 36       | 482     |
|         | Norway  | ...      | 1       | 28       | 279     |
|         | Germany   | 4        | 52      | 38       | 164     |
|         | Other   | 20       | 102     | 6        | 105     |
|         | Total   | 954      | 6 514   | 1 366    | 9 256   |
| 7503.00 | Nickel waste and scrap (weight of material, not nickel content)                           |          |         |          |         |
|         | United States   | 20 986   | 48 350  | 14 576   | 40 587  |
|         | Norway  | 70       | 457     | 225      | 1 413   |
|         | France  | 57       | 345     | 259      | 1 376   |
|         | United Kingdom  | 307      | 2 119   | 199      | 1 349   |
|         | Japan   | 7        | 53      | 511      | 1 021   |
|         | Russia  | —        | —       | 67       | 608     |
|         | Finland   | ...      | ...     | 69       | 480     |
|         | Belgium   | —        | —       | 175      | 278     |
|         | Bermuda   | —        | —       | 42       | 210     |
|         | Latvia  | 41       | 137     | —        | —       |
|         | Netherlands   | 37       | 166     | —        | —       |
|         | Other   | 54       | 186     | 139      | 413     |
|         | Total   | 21 559   | 51 813  | 16 262   | 47 735  |
| 7504.00 | Nickel powders and flakes, alloyed and unalloyed (weight of material, not nickel content) |          |         |          |         |
|         | Australia   | 673      | 6 478   | 469      | 6 023   |
|         | United States   | 360      | 4 350   | 256      | 4 210   |
|         | United Kingdom  | 69       | 774     | 183      | 2 152   |
|         | Russia  | 27       | 366     | 105      | 1 402   |
|         | Germany   | 211      | 2 853   | 69       | 564     |
|         | Finland   | 2        | 37      | 23       | 364     |
|         | Ireland   | 37       | 770     | 5        | 178     |
|         | Belgium   | 4        | 61      | 8        | 136     |
|         | Other   | 7        | 116     | 16       | 267     |
|         | Total   | 1 390    | 15 805  | 1 134    | 15 296  |
| 7505.11 | Bars, rods and profiles of nickel, not alloyed (nickel content)                           |          |         |          |         |
|         | United States   | 15       | 294     | 12       | 213     |
|         | Other   | —        | 9       | —        | 4       |
|         | Total   | 15       | 303     | 12       | 217     |
| 7505.12 | Bars, rods and profiles of nickel alloy (weight of material, not nickel content)          |          |         |          |         |
|         | United States   | 630      | 14 563  | 546      | 10 360  |
|         | Germany   | 52       | 895     | 31       | 629     |
|         | Russia  | ...      | 1       | 36       | 466     |
|         | Italy   | 20       | 498     | 12       | 225     |
|         | United Kingdom  | 6        | 130     | 11       | 203     |
|         | France  | 11       | 161     | 7        | 106     |
|         | Other   | 10       | 214     | 15       | 115     |
|         | Total   | 729      | 16 462  | 658      | 12 104  |
| 7505.21 | Nickel wire, not alloyed (weight of nickel wire plus coating if any, not nickel content)  |          |         |          |         |
|         | United States   | 43       | 521     | 36       | 489     |
|         | Japan   | 12       | 133     | 6        | 68      |
|         | Other   | 1        | 11      | 1        | 13      |
|         | Total   | 56       | 665     | 43       | 570     |

TABLE 1b (cont'd)

|         | 2002  |         | 2003     |         |         |
|---------|---|---------|----------|---------|---------|
|         | (tonnes)  | (\$000) | (tonnes) | (\$000) |         |
| 7505.22 | Wire, nickel alloy (weight of alloy plus coating, if any; not nickel content)                         |         |          |         |         |
|         | United States   | 430     | 5 789    | 349     | 7 053   |
|         | Germany   | 75      | 1 246    | 141     | 2 341   |
|         | Sweden  | 87      | 1 609    | 92      | 1 697   |
|         | United Kingdom  | 88      | 1 345    | 51      | 816     |
|         | Austria   | 6       | 108      | 35      | 540     |
|         | Other   | 61      | 951      | 11      | 211     |
|         | Total   | 747     | 11 048   | 679     | 12 658  |
| 7506.00 | Nickel plates, sheets, strip and foil (weight of material, not nickel content)                        |         |          |         |         |
|         | United States   | 592     | 12 635   | 436     | 9 333   |
|         | Germany   | 259     | 5 080    | 183     | 3 334   |
|         | Japan   | 18      | 360      | 28      | 595     |
|         | Other   | 15      | 398      | 8       | 217     |
|         | Total   | 884     | 18 473   | 655     | 13 479  |
| 7507.00 | Tubes, pipes and tube or pipe fittings alloyed and unalloyed (weight of material, not nickel content) |         |          |         |         |
|         | United States   | 551     | 13 012   | 710     | 15 571  |
|         | Norway  | 444     | 5 440    | 559     | 7 352   |
|         | Germany   | 101     | 1 824    | 102     | 2 027   |
|         | Japan   | 514     | 17 805   | 33      | 1 208   |
|         | Sweden  | 15      | 228      | 86      | 1 096   |
|         | France  | 63      | 2 103    | 12      | 544     |
|         | Other   | 59      | 1 441    | 68      | 1 035   |
|         | Total   | 1 747   | 41 853   | 1 570   | 28 833  |
| 7508.00 | Other articles of nickel (weight of material, not nickel content)                                     |         |          |         |         |
|         | United States   | 710     | 11 445   | 608     | 10 215  |
|         | France  | 33      | 458      | 50      | 830     |
|         | China   | 78      | 780      | 71      | 699     |
|         | United Kingdom  | 31      | 573      | 28      | 534     |
|         | Switzerland   | 100     | 667      | 84      | 523     |
|         | Other   | 116     | 1 821    | 122     | 1 433   |
|         | Total   | 1 068   | 15 744   | 963     | 14 234  |
|         | Total imports   | 244 462 | 724 242  | 206 346 | 872 097 |

Sources: Natural Resources Canada; Statistics Canada.

– Nil; . . Not available; . . . Amount too small to be expressed.

(1) Australian exports to Canada for 2002 and 2003 were reported as 18 600 t and 20 900 t, respectively (INSG *World Metal Statistics* - June 2004, p. 25) and the author believes that the Australian data for 2002 are more representative of the nickel contained in concentrates imported by Canada from Australia than are the Canadian trade data. Further, there are errors in the reporting of "nickel concentrates" from the United States and Germany as neither country has primary nickel production; either the classification or the country of origin is incorrect and thus it is uncertain whether the tonnage is gross or contained nickel. This has been an ongoing inaccuracy. (2) Nickel and cobalt are in an artificial nickel-cobalt sulphide made at an acid leach plant in Cuba using nickel-cobalt oxide as feed. The values reflect both the nickel and cobalt contents.

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

**TABLE 1c. CANADA, NICKEL PRODUCTION AND USE, 1970, 1975, 1980 AND 1985-2003**

|          | Production (1)<br>(Mine Output) | Use (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                         | (a) 13 322 |
| 1992     | 186 384                         | 15 528     |
| 1993     | 188 080                         | (a) 17 384 |
| 1994     | 149 886                         | 20 746     |
| 1995     | 181 820                         | 20 973     |
| 1996     | 192 649                         | 24 504     |
| 1997     | (r) 190 502                     | 19 447     |
| 1998     | (r) 208 301                     | 19 787     |
| 1999     | (r) 186 236                     | 22 527     |
| 2000     | 190 793                         | 24 976     |
| 2001     | 194 058                         | 17 735     |
| 2002     | 189 297                         | 18 955     |
| 2003 (p) | 162 756                         | 13 018     |

Source: Natural Resources Canada.

(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 1987-2003 are nickel contained in concentrates produced.

(2) Use 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 users on the Natural Resources Canada survey "Nickel Use."

Note: Metals are used in industrial and consumer applications; unlike fuel oil or agricultural commodities, metals are not "used up" or "consumed"; instead, they are recycled. For this reason, the word "use" has replaced "consumption" in this chapter, where appropriate.

**TABLE 1d. CUPRONICKEL, NICKEL-SILVER, STAINLESS STEELS, AND NICKEL-CADMIUM AND NICKEL-IRON BATTERIES, 2002 AND 2003**

|  | 2002     |         | 2003     |         |
|--|----------|---------|----------|---------|
|  | (tonnes) | (\$000) | (tonnes) | (\$000) |
| <b>STAINLESS STEEL SEMI-FABRICATED ITEMS</b><br>(excludes scrap)   |          |         |          |         |
| <b>Exports – Total For Each HS Class</b>   |          |         |          |         |
| 7204.29  | 117 663  | 28 377  | 111 622  | 31 836  |
| 7210.90  | 12 112   | 11 973  | 10 759   | 7 792   |
| 7220.20  | 5 739    | 19 349  | 4 083    | 14 565  |
| 7222.11  | 2 902    | 6 341   | 2 024    | 4 584   |
| 7222.19  | 285      | 1 328   | 353      | 1 262   |
| 7222.20  | 5 767    | 30 415  | 3 398    | 15 989  |
| 7222.30  | 3 706    | 18 310  | 3 361    | 13 356  |
| Total exports  | 148 174  | 116 092 | 135 599  | 89 384  |
| <b>Imports – Total For Each HS Class</b>   |          |         |          |         |
| 7204.29  | 156 400  | 50 273  | 161 543  | 44 582  |
| 7210.90  | 9 185    | 20 940  | 9 785    | 19 794  |
| 7212.50.90.13  | 3 508    | 9 356   | 3 218    | 8 895   |
| 7222.11  | 2 253    | 9 338   | 2 437    | 9 121   |
| 7222.19  | 3 844    | 15 645  | 2 445    | 9 431   |
| 7222.20.10   | 94       | 578     | 77       | 373     |
| 7222.20.90   | 9 358    | 35 830  | 9 496    | 34 371  |
| 7222.30.00.11  | 58       | 274     | 99       | 516     |
| 7222.30.00.19  | 2        | 10      | 290      | 1 121   |
| Total imports  | 184 702  | 142 244 | 189 390  | 128 203 |
| Net exports of stainless steels  | -36 527  | -26 152 | -53 791  | -38 818 |
| <b>CUPRO-NICKEL AND NICKEL-SILVER SEMI-FABRICATED GOODS</b><br>(nickel-silver is a copper-nickel-zinc alloy) |          |         |          |         |
| <b>Exports – Total For Each HS Class</b>   |          |         |          |         |
| 7403.23  | –        | –       | 1        | 10      |
| 7407.22  | 239      | 1 563   | 311      | 2 159   |
| 7408.22  | 65       | 747     | 14       | 235     |
| 7409.40  | 615      | 2 569   | 74       | 157     |
| 7411.22  | 5 602    | 44 905  | 5 189    | 39 222  |
| Total exports  | 6 520    | 49 784  | 5 590    | 41 783  |
| <b>Imports – Total For Each HS Class</b>   |          |         |          |         |
| 7403.23.00.10 to 7403.23.00.40   | 49       | 189     | 17       | 60      |
| 7407.22.11 to 7407.22.29.10  | 147      | 689     | 199      | 847     |
| 7408.22.10 to 7408.22.90.30  | 164      | 594     | 99       | 329     |
| 7409.40.00.11 to 7409.40.00.40   | 112      | 578     | 85       | 495     |
| 7411.22.00.10 to 7411.22.00.30   | 406      | 2 853   | 615      | 4 021   |
| Total imports  | 878      | 4 903   | 1 016    | 5 752   |
| Net exports of cupro-nickel and nickel-silver  | 5 642    | 44 881  | 4 574    | 36 031  |
| <b>ELECTRIC ACCUMULATORS</b><br>(nickel-cadmium and nickel-iron batteries)                                   |          |         |          |         |
| <b>Exports – Total For Each HS Class</b>   |          |         |          |         |
| 8507.30 Ni-Cd batteries  | ..       | 3 463   | ..       | 4 572   |
| 8507.40 Ni-Fe batteries  | ..       | 67      | ..       | 126     |
| Total exports  | ..       | 3 530   | ..       | 4 698   |
| <b>Imports – Total For Each HS Class</b>   |          |         |          |         |
| 8507.30 Ni-Cd batteries  | ..       | 44 701  | ..       | 40 097  |
| 8507.40 Ni-Fe batteries  | ..       | 1 360   | ..       | 880     |
| Total imports  | ..       | 46 061  | ..       | 40 977  |
| Net exports of Ni-Cd and Ni-Fe batteries   | ..       | -42 531 | ..       | -36 279 |

Source: Natural Resources Canada.

– Nil; .. Not available.

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

**TABLE 2a. CANADA, COBALT EXPORTS, 2002 AND 2003**

|         | 2002   |           | 2003        |           |         |
|---------|--|-----------|-------------|-----------|---------|
|         | (kilograms)  | (\$000)   | (kilograms) | (\$000)   |         |
| 2822.00 | Oxides and hydroxides; commercial cobalt oxides (weight of material, not cobalt content) |           |             |           |         |
|         | United Kingdom   | 287 374   | 7 232       | 300 479   | 6 485   |
| 2915.23 | Cobalt acetates (weight of material not cobalt content)                                  |           |             |           |         |
|         |  | –         | –           | 4         | –       |
| 8105.20 | Cobalt mattes and other intermediate products; powders                                   |           |             |           |         |
|         | Japan  | 1 704 195 | 41 804      | 1 488 904 | 47 208  |
|         | Norway   | 1 703 295 | 37 706      | 1 795 698 | 42 182  |
|         | Singapore  | 533 550   | 12 644      | 674 000   | 20 511  |
|         | Netherlands  | 620 200   | 14 723      | 542 000   | 17 657  |
|         | Belgium  | 382 771   | 11 943      | 442 642   | 14 447  |
|         | United States  | 889 704   | 25 061      | 492 862   | 13 015  |
|         | Taiwan   | 190 470   | 4 725       | 180 205   | 5 801   |
|         | China  | 19 173    | 994         | 80 694    | 1 998   |
|         | Hong Kong  | 150 000   | 3 464       | 23 000    | 503     |
|         | United Kingdom   | 80 000    | 2 038       | 16 000    | 367     |
|         | Other  | 27 949    | 1 022       | 4 428     | 184     |
|         | Total  | 6 301 307 | 156 124     | 5 740 433 | 163 873 |
| 8105.30 | Cobalt waste and scrap   |           |             |           |         |
|         | United States  | 41 800    | 311         | 25 337    | 307     |
| 8105.90 | Cobalt and articles thereof, n.e.s.  |           |             |           |         |
|         | United States  | 19 922    | 5 355       | 23 759    | 5 423   |
|         | Japan  | 10 041    | 120         | 120 000   | 3 533   |
|         | Germany  | 8 584     | 1 536       | 6 239     | 1 062   |
|         | Netherlands  | –         | –           | 21 000    | 622     |
|         | Other  | 4 384     | 352         | 12 996    | 610     |
|         | Total  | 42 931    | 7 363       | 183 994   | 11 250  |
|         | Total exports  | 6 673 412 | 171 030     | 6 250 247 | 181 915 |

Sources: Natural Resources Canada; Statistics Canada.

– Nil.

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



TABLE 2b. CANADA, COBALT IMPORTS, 2002 AND 2003

|               |   | 2002        |         | 2003        |         |
|---------------|---|-------------|---------|-------------|---------|
|               |   | (kilograms) | (\$000) | (kilograms) | (\$000) |
| 2605.00       | Cobalt ores and concentrates (cobalt content)                     |             |         |             |         |
|               | Congo   | –           | –       | 523 719     | 765     |
|               | Norway  | 20 167      | 1 061   | 407 684     | 584     |
|               | Other   | 40 595      | 705     | 48 659      | 859     |
|               | Total   | 60 762      | 1 766   | 980 062     | 2 208   |
| 2822.00.00.10 | Cobalt hydroxides (weight of material, not cobalt content)        |             |         |             |         |
|               | United States   | 5 697       | 336     | 25 196      | 830     |
|               | Other   | 824         | 38      | 1 100       | 62      |
|               | Total   | 6 521       | 374     | 26 296      | 892     |
| 2822.00.00.20 | Cobalt oxides (weight of material, not cobalt content)            | 16 936      | 936     | 2 538       | 81      |
| 2822.00.00.30 | Commercial cobalt oxides (weight of material, not cobalt content) |             |         |             |         |
|               | United Kingdom  | 491         | 9       | 1 606       | 33      |
|               | Other   | 317         | 6       | 763         | 14      |
|               | Total   | 808         | 15      | 2 369       | 47      |
| 2827.34       | Cobalt chlorides (weight of material, not cobalt content)         |             |         |             |         |
|               | United States   | 20 605      | 318     | 57 546      | 898     |
|               | Other   | 428         | 5       | 1 900       | 27      |
|               | Total   | 21 033      | 323     | 59 446      | 925     |
| 2833.29.00.40 | Cobalt sulphate (weight of material, not cobalt content)          | 67 887      | 906     | 27 957      | 372     |
| 2836.99.10.30 | Cobalt carbonates (weight of material, not cobalt content)        | ..          | 225     | ..          | 382     |
| 2836.99.90.20 | Other cobalt carbonates (weight of material, not cobalt content)  | 10 726      | 230     | 6 106       | 135     |
| 2915.23       | Cobalt acetates (weight of material not cobalt content)           | 13 516      | 153     | 33 834      | 375     |
| 8105.20.10.10 | Cobalt powders  |             |         |             |         |
|               | Australia   | 441 328     | 8 023   | 370 000     | 8 448   |
|               | United States   | 50 289      | 2 402   | 37 739      | 1 786   |
|               | Belgium   | 1 309       | 70      | 24 208      | 941     |
|               | South Africa  | 6 000       | 163     | 120 172     | 805     |
|               | Other   | 35 552      | 1 150   | 47 998      | 1 285   |
|               | Total   | 534 478     | 11 808  | 600 117     | 13 265  |
| 8105.20.10.20 | Unwrought cobalt, not alloyed                                     |             |         |             |         |
|               | Russia  | 4 094       | 95      | 53 491      | 1 332   |
|               | Other   | 43 005      | 1 244   | 5 468       | 276     |
|               | Total   | 47 099      | 1 339   | 58 959      | 1 608   |
| 8105.20.90    | Other   |             |         |             |         |
|               | Botswana  | –           | –       | 37 380      | 1 129   |
|               | Other   | 2 797       | 125     | 1 851       | 99      |
|               | Total   | 2 797       | 125     | 39 231      | 1 228   |
| 8105.30       | Cobalt waste and scrap  |             |         |             |         |
|               | United States   | 190 784     | 784     | 329 896     | 907     |
|               | Germany   | 590 595     | 663     | 21 982      | 175     |
|               | Other   | 15 540      | 27      | 185 927     | 472     |
|               | Total   | 796 919     | 1 474   | 537 805     | 1 554   |
| 8105.90.00.10 | Cobalt bars and rods, not alloyed                                 |             |         |             |         |
|               | United States   | 8 363       | 654     | 17 913      | 1 567   |
|               | Other   | 201         | 13      | 301         | 16      |
|               | Total   | 8 564       | 667     | 18 214      | 1 583   |
| 8105.90.00.90 | Cobalt and articles thereof, n.e.s.                               |             |         |             |         |
|               | United States   | 33 766      | 4 064   | 33 507      | 3 652   |
|               | Other   | 1 901       | 103     | 5 705       | 289     |
|               | Total   | 35 667      | 4 167   | 39 212      | 3 941   |
|               | Total imports   | 1 623 713   | 24 508  | 2 432 146   | 28 596  |

Sources: Natural Resources Canada; Statistics Canada.

– Nil; .. Not available.

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

**TABLE 2c. CANADA, COBALT PRODUCTION, TRADE AND USE, 1975 AND 1980-2003**

|          | Concentrate Shipments (1) | Processed Cobalt Exports (2) | Cobalt Oxide and Hydroxide Exports | Cobalt Ore and Concentrate Exports (3) | Cobalt Oxide and Hydroxide Imports (4) | Use (5) |
|----------|---------------------------|------------------------------|------------------------------------|--|--|---------|
| (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                     | (r) 4 488                    | 632                                | —                                      | 33                                     | 147     |
| 1997     | 2 168                     | 5 829                        | 526                                | —                                      | 39                                     | 136     |
| 1998     | 2 262                     | 6 592                        | 457                                | —                                      | 45                                     | 146     |
| 1999     | 2 014                     | 6 307                        | 224                                | 10                                     | 114                                    | 130     |
| 2000     | 2 022                     | 4 987                        | 335                                | —                                      | 103                                    | 127     |
| 2001     | 2 112                     | 5 009                        | 355                                | —                                      | 126                                    | 94      |
| 2002     | 2 065                     | 6 386                        | 287                                | —                                      | 24                                     | 92      |
| 2003 (p) | 1 743                     | 5 950                        | 300                                | —                                      | 31                                     | 88      |

Sources: Natural Resources Canada; Statistics Canada.

— Nil; .. Not available; (p) Preliminary; (r) Revised.

(1) Production includes recoverable cobalt in concentrates shipped. Beginning in 1988, exports and imports are based on the new Harmonized System and may not be in complete accordance with previous method of reporting. (2) Processed cobalt includes all forms classified in HS code 8105.10 (intermediate forms such as cobalt in matte, unwrought cobalt, alloyed cobalt, waste or scrap of cobalt, cobalt powders) plus all forms classified in HS code 8105.90 (cobalt and articles thereof, not elsewhere specified). (3) Cobalt content. From 1975 to 1988, cobalt recovered in Canada from domestic concentrate plus exports of payable cobalt in concentrate. Starting in 1989 to date, recoverable cobalt in concentrates shipped. (4) Gross weight. Producers' domestic shipments of refined cobalt plus imports of refined shapes. (5) Use of cobalt in metal, oxides and salts; available data as reported by user.

**TABLE 3. CANADIAN NICKEL PRODUCERS**

| Full Corporate Name                     | Web Site   |
|---|--|
| Dynatec Corporation                     | <a href="http://www.dynatec.ca">www.dynatec.ca</a>             |
| Falconbridge Limited                    | <a href="http://www.falconbridge.com">www.falconbridge.com</a> |
| FNX Mining Company Inc.                 | <a href="http://www.fnxmining.com">www.fnxmining.com</a>       |
| Inco Limited                            | <a href="http://www.inco.com">www.inco.com</a>                 |
| LionOre Mining International Ltd. (1)   | <a href="http://www.lionore.com">www.lionore.com</a>           |
| North American Palladium Ltd.           | <a href="http://www.napalladium.com">www.napalladium.com</a>   |
| Sherritt International Corporation      | <a href="http://www.sherritt.com">www.sherritt.com</a>         |
| Voisey's Bay Nickel Company Limited (2) | <a href="http://www.vbnc.com">www.vbnc.com</a>                 |

(1) Production from Botswana and Australian operations. (2) A subsidiary of Inco Limited.

**TABLE 4. CANADIAN NICKEL PRODUCERS, SOURCES FOR MORE CORPORATE INFORMATION VIA THE INTERNET**

| Full Corporate Name                     | SEDAR Site   |
|---|--|
| Dynatec Corporation                     | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00008191">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00008191</a> |
| Falconbridge Limited                    | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00000376">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00000376</a> |
| FNX Mining Company Inc.                 | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00008610">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00008610</a> |
| Inco Limited                            | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00001084">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00001084</a> |
| LionOre Mining International Ltd. (1)   | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00000389">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00000389</a> |
| North American Palladium Ltd.           | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00003026">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00003026</a> |
| Sherritt International Corporation      | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00002460">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00002460</a> |
| Voisey's Bay Nickel Company Limited (2) | <a href="http://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00001084">www.sedar.com/DisplayCompanyDocuments.do?lang=EN&amp;issuerNo=00001084</a> |

(1) Production from Botswana and Australian operations. (2) A subsidiary of Inco Limited.

Note: SEDAR changed its web page addresses for company listings since 2002; it is possible to go to [www.sedar.com](http://www.sedar.com), then click on "English," then "Company Profiles," then the first letter of the company name.

**TABLE 5. LIST OF WORLD NICKEL PRODUCERS, 2003**

| Country   | Full Corporate Name or Identifier  | Web Site   |
|-----------|--|--|
| Albania   | Bitincka mine<br>European Nickel plc   | web site unknown<br>www.enickel.co.uk  |
| Australia | Adelaide Resources Limited<br>Albidon Limited<br>Allegiance Mining N.L.<br>Apex Minerals NL<br>Austminex Limited<br><br>Australian Mines Limited<br>Breakaway Resources Ltd.<br>Compass Resources NL<br>Consolidated Minerals Limited<br>Cougar Minerals NL<br><br>Cullen Resources Limited<br>Discovery Nickel Limited<br>Falcon Minerals Limited<br>Fox Resources Limited<br>GBF Pty. Ltd.<br><br>Greenvale Mining NL<br>Hallmark Consolidated Limited<br>Heron Resources Limited<br>Highlands Pacific Ltd.<br>Image Resources NL<br><br>Independence Group NL<br>Jervois Mining Limited<br>Jubilee Gold Mines N.L.<br>Jubilee Mines NL<br>LionOre Australia (Nickel) Ltd.<br><br>Metallica Minerals Limited<br>Mittel Joint Venture<br>Minara Resources Limited<br>Minara Resources Limited<br>Mincor Resources NL<br><br>Mithril Resources Ltd.<br>MPI Mines Ltd.<br>MPI Mines Ltd.<br>Nickel Australia Limited<br>OM Group, Inc<br><br>Outokumpu Mining Australia Pty. Ltd.<br>Pearce Matheson Group Pty Ltd.<br>Pioneer Nickel Limited<br>Preston Resources Limited<br>Preston Resources Limited<br><br>QNI Ltd.<br>Reliance Mining Limited<br>ReLode Limited<br>Resource Mining Corporation Limited<br>Rusina Mining N.L.<br><br>Sally Malay Mining Limited<br>Skryne Hill Pty Ltd.<br>Tectonic Mines NL<br>Tectonic Resources NL<br>Tenant Creek Gold Limited (ex Hallmark)<br><br>Thundelarra Exploration Limited<br>Titan Resources NL<br>View Resources Limited<br>Western Areas NL<br>Westonia Mines Limited<br>WMC Resources Ltd. | www.adelaideresources.com.au<br>www.albidon.com<br>www.allegiance-mining.com.au<br>www.apexminerals.com<br>www.austminex.com.au<br><br>www.australianmines.com.au<br>www1.breakawayresources.com.au<br>www.compassnl.com<br>www.consmineals.com.au<br>www.cougarmetals.com.au<br><br>www.cullenresources.com.au<br>www.discoverynickel.com.au<br>www.falcon.indigo.net.au<br>www.foxresources.com.au<br>web site unknown<br><br>web site unknown<br>www.hallmarkconsolidated.com<br>www.heronresources.com.au<br>www.highlandspacific.com<br>www.imageres.com.au<br><br>www.independencgold.com.au<br>www.jervoismining.com.au<br>www.jubileemines.com.au<br>www.jubileemines.com.au<br>www.lionore.com<br><br>www.metallicaminerals.com.au<br>www.mincor.com.au<br>www.anaconda.com.au<br>www.minara.com.au<br>www.mincor.com.au<br><br>www.mithrilresources.com.au<br>www.mpimines.com.au<br>www.mpimines.com.au<br>www.nickelaustralia.com.au<br>www.omgi.com<br><br>www.outokumpu.com<br>web site unknown<br>www.pioneernickel.com.au<br>www.prestonres.com.au<br>www.prestonres.com.au<br><br>www.qni.com.au<br>www.reliancemining.com.au<br>www.relode.com.au<br>web site unknown<br>web site unknown<br><br>www.sallymalay.com<br>web site unknown<br>www.tectonicres.com.au<br>www.tectonicres.com.au<br>www.tennantcreekgold.com.au<br><br>www.thundelarra.com<br>www.titanresources.com.au<br>www.viewresources.com.au<br>www.westernareas.com.au<br>www.westoniamines.com.au<br>www.wmc.com |
| Austria   | Treibacher Industrie AG  | www.treibacher.at/en/index.html  |
| Botswana  | Bamangwato Concessions Limited<br>Tati Nickel Mining Company (Proprietary) Limited   | web site unknown<br>www.lionore.com  |

TABLE 5 (cont'd)

| Country   | Full Corporate Name or Identifier               | Web Site                               |
|---|---|--|
| Brazil  | Barro Alto Mineração Limitada Project           | www.angloamerican.co.uk                |
|   | Canico Resource Corp.                           | www.canico.com                         |
|   | CODEMIN SA                                      | www.angloamerican.co.uk                |
|   | Companhia Níquel Tocantins                      | www.vmetais.com.br/english/homecnt.htm |
|   | Mineração Serra da Fortaleza Limitada           | www.riotinto.com                       |
|   | Mirabela Nickel Limited                         | www.mirabelanickel.com.au              |
| Canada  | Altius Minerals Corporation                     | www.altiusminerals.com                 |
|   | Aurora Platinum Corp.                           | www.auroraplatinum.com                 |
|   | Avalon Ventures Ltd.                            | www.avalonventures.com                 |
|   | Blackstone Ventures Inc.                        | www.blv.ca                             |
|   | Callinan Mines Limited                          | www.callinan.com                       |
|   | Canadian Arrow Mines Limited                    | www.canadianarrowminesltd.com          |
|   | Canadian Association of Recycling Industries    | www.cari-acir.org                      |
|   | Canadian Royalties Inc.                         | www.canadianroyalties.com/en           |
|   | Cornerstone Capital Resources Inc.              | www.cornerstoneresources.com           |
|   | Cream Minerals Ltd.                             | www.creamminerals.com                  |
|   | Crowflight Minerals Inc.                        | www.crowflight.com                     |
|   | Donner Minerals Ltd.                            | www.donner-minerals.com                |
|   | Dynatec Corporation                             | www.dynatec.ca                         |
|   | Falconbridge Limited                            | www.falconbridge.com                   |
|   | First Nickel Inc.                               | www.firstnickel.com                    |
|   | Flag Resources (1985) Limited                   | web site unknown                       |
|   | FNX Mining Company Inc.                         | www.fnxmining.com/docs/index.php       |
|   | Inco Limited                                    | www.inco.com                           |
|   | Knight Resources Ltd.                           | www.knightresources.ca/news.htm        |
|   | Liberty Mineral Exploration Inc.                | www.libertymineral.com                 |
|   | LionOre Mining International Ltd.               | www.lionore.com                        |
|   | MBMI Resources Inc.                             | www.mbmresources.com/news.asp          |
|   | Mustang Minerals Corp.                          | www.mustangminerals.com                |
|   | North American Palladium Ltd.                   | www.napalladium.com                    |
|   | North American Palladium Ltd.                   | www.napalladium.ca                     |
|   | Nuinsco Resources Limited                       | www.nuinsco.ca                         |
|   | PacRim Resources Ltd.                           | www.pacrim-resources.com               |
|   | Polymet Mining Corp                             | www.polymetmining.com/s/Home.asp       |
|   | Quinto Technology Inc.                          | www.quintotechnology.com               |
|   | Ressources Appalaches Inc.                      | www.ressourcesappalaches.com           |
|   | Rio Narcea Gold Mines, Ltd.                     | www.rionarcea.com/s/Home.asp           |
|   | Sherritt International Corporation              | www.sherritt.com                       |
| Sherritt International Corporation; The Cobalt Refinery Company Inc.; Metals Enterprise | www.sherritt.com                                |  |
| Starfield Resources Inc.  | web site unknown                                |  |
| Voisey's Bay Nickel Company Limited   | www.vbnc.com                                    |  |
| Wallbridge Mining Company Limited   | www.wallbridgeminig.com                         |  |
| China   | Jilin Nickel Industry Corporation               | www.jlnickel.com.cn                    |
|   | Jinchuan Nonferrous Metals Corporation          | www.jnmc.com                           |
|   | Jinco Nonferrous Metals Co., Ltd.               | www.inco.com; www.jnmc.com             |
|   | Sichuan Copper-Nickel, Co. Ltd.                 | web site unknown                       |
|   | Simson Metals (Holdings) Ltd.                   | web site unknown                       |
|   | Xinjiang Nonferrous Metals Industry Corporation | web site unknown                       |
| <i>corporate name unknown</i> Tonghua Ni Cu mine  | web site unknown                                |  |
| <i>corporate name unknown</i> Huili Ni mine   | web site unknown                                |  |
| Colombia  | Cerro Matoso S.A.                               | www.bhpbilliton.com                    |
| Cuba  | Moa Nickel S.A.                                 | www.sherritt.com                       |
|   | Union del Níquel                                | web site unknown                       |
| Dominican Rep.  | Falconbridge Dominicana, C. por A               | www.falconbridge.com                   |
| Finland   | Kokkola Chemicals Oy                            | www.omgi.com                           |
|   | OM Group, Inc.                                  | www.omgi.com                           |
|   | Mondo Minerals Oy                               | www.mondominerals.com                  |
|   | OMG Harjavalta Nickel Oy                        | www.omgi.com                           |
|   | Outokumpu Oyj                                   | www.outokumpu.com                      |

TABLE 5 (cont'd)

| Country                               | Full Corporate Name or Identifier   | Web Site  |
|---------------------------------------|---|---|
| France                                | Eramet Group<br>Bureau de Recherches Géologiques et Minières  | www.eramet.fr<br>www.brgm.fr  |
| Former Yugoslav Republic of Macedonia | Société Commercial de Métaux et Minerais (SCMM René Aumas)  | www.comecim.ch/Us/accueil.htm   |
| Greece                                | General Mining and Metallurgical Co., S.A.  | www.larco.gr/indexxen.html  |
| Guatemala                             | Geostar Metals Inc.<br>Jaguar Nickel Inc.<br>Skye Resources Inc.  | www.geostarmetals.com<br>www.jaguarnickel.com<br>www.skyeresources.com                            |
| Indonesia                             | Antam Tbk<br>PT International Nickel Indonesia Tbk<br>Weda Bay Minerals Inc.  | www.antam.com<br>www.inco.com<br>www.wedabay.com  |
| Japan                                 | Hyuga Smelting Co., Ltd.<br>Inco TNC Limited<br>Nippon Yakin Kogyo Co., Ltd.<br>Pacific Metals Co. Ltd.<br>Sumitomo Metal Mining Co., Ltd.              | www.smm.co.jp<br>www.inco.com<br>www.nyk.co.jp<br>web site unknown<br>www.smm.co.jp/main.html     |
| Kazakhstan                            | Kempirsai Mining Directorate<br>Oriël Resources plc   | web site unknown<br>www.orielresources.com  |
| New Caledonia                         | Goro Nickel S.A<br>Le Nickel-SLN<br>Société Minière de Sud Pacifique S.A.<br>Société Minière Georges Montagent S.A.<br>Société des Mines de la Tontouta | www.inco.com<br>www.eramet.fr<br>web site unknown<br>web site unknown<br>web site unknown         |
| Norway                                | Falconbridge Nikkelverk Aktieselskap<br>Titania A/S   | www.falconbridge.com<br>www.titania.no/eng/   |
| Philippines                           | Cagdianao Mining Corporation<br>Hinatuan Mining Corporation<br>Crew Gold Corporation<br>Rio Tuba Mining Corporation<br>Taganito Mining Corporation      | web site unknown<br>web site unknown<br>www.crewgroup.com<br>web site unknown<br>web site unknown |
| Russia                                | MMC Norilsk Nickel<br>Rezh Nickel Plant Joint Stock Company<br>Ufaleynikel Joint Stock Co.<br>Yuzhuralnikel Kombinat Joint Stock Co.                    | www.nornik.ru/en/<br>web site unknown<br>web site unknown<br>web site unknown                     |
| Serbia                                | Ferro-Nickel D.D. Glogovac  | web site unknown  |
| South Africa                          | Anglo American Platinum Corporation<br>Impala Platinum Limited<br>Lonmin plc<br>African Rainbow Minerals Limited  | www.angloplatinum.com<br>www.implats.za<br>www.lonmin.com<br>www.arm.co.za                        |
| South Korea                           | Korea Nickel Corporation  | www.inco.com  |
| Taiwan, China                         | Taiwan Nickel Refining Corporation  | web site unknown  |
| Turkey                                | European Nickel plc<br>Oriël Resources plc  | www.enickel.co.uk<br>www.orielresources.com   |
| Ukraine                               | Nikoméd Limited   | web site unknown  |
| United Kingdom                        | Inco Limited  | www.inco.com  |
| United States                         | Franconia Minerals Corporation<br>Teck Cominco American Incorporated<br>Kennecott Minerals Company  | www.franconiaminerals.com<br>www.teckcominco.com<br>www.kennecottminerals.com                     |
| Venezuela                             | Minera Loma de Niquel, C.A.   | www.angloamerican.co.uk   |
| Zimbabwe                              | Bindura Nickel Corporation Limited<br>Rio Tinto Zimbabwe Limited<br>Mimosa Mining Company (Pvt) Limited<br>Makwiro Platinum Mines (Private) Limited     | web site unknown<br>www.riotinto.com<br>www.aquariusplatinum.com<br>www.zimplats.com              |

Note: Information current as of December 2003.

**TABLE 6. WORLD NICKEL PRODUCERS, 2003**

| Country  | Company               | Operation                   | Nickel Output |           | Cobalt<br>2003 | Type of<br>Ni Output |
|--|-----------------------|-----------------------------|---------------|-----------|----------------|----------------------|
|  |                       |                             | 2002          | 2003      |                |                      |
| (tonnes)   |                       |                             |               |           |                |                      |
| <b>ALBANIA</b>   |                       |                             |               |           |                |                      |
|  | ?                     | Bitinckë mine               | - ?           | (e) 500   | -              | L                    |
| <p>Remarks: FENI-Mak operation in Former Yugoslav Republic of Macedonia supplemented own mine feed with imports from Albania, believed to be from the Bitinckë mine located close to the Greek border. This mine may have exported ore to LARCO in 2000 or 2001. European Nickel plc completed prefeasibility study, through its Albanian subsidiary, Adriatic Nickel Sh. p. k., of Bitinckë, an underground operation to evaluate exploitation by acid heap leaching. Resource estimated at 93 Mt @ 1.2% Ni, 0.06% Co, with potential to yield 20 000 t/y Ni. Further details about Albanian properties are available on European Nickel web site. (Contained Ni estimated by author by assuming 1.3% Ni grade.)</p> <p>Sources: Nickel Australasia, January 21, 2004, for tonnage; European Nickel (resource grade); Feni-Mak; author's estimates.</p> |                       |                             |               |           |                |                      |
| <b>AUSTRALIA</b>   |                       |                             |               |           |                |                      |
|  | GBF Pty. Ltd.         | Otter Juan and Cornet mines | (e) 5 500     | (e) 5 500 |                | SO                   |
| <p>Remarks: Long-term lease by WMC in 2001 to GBF Mining Pty Ltd., which operates Otter Juan mine through its subsidiary, Goldfield Mine Management. Ore is delivered to Kambalda mill under long-term agreement. Production averages about 150 000 t/y at a grade of 4.2% Ni. Reserves expected to last until mid-2007. Data on Coronet mine not found, but may be included in Otter Juan details.</p> <p>Sources: WMC Quarterly Reports, March 2001, June 2001; Abstract in Second International Symposium on Mining Techniques of Narrow-Vein Deposits, Canadian Institute of Mining, Metallurgy and Petroleum.</p>   |                       |                             |               |           |                |                      |
|  | Fox Resources Limited | Radio Hill mine, mill       | 3 387         | -         | -              | S                    |
| <p>Remarks: Radio Hill property, including disseminated material, sold to Fox Resources Limited in September 2002; Fox undertook drilling, purchased equipment for site, and at year-end was completing final drilling for bankable feasibility study expected to be completed in January 2004; company expected to put mine and plant into operation in early 2004 to produce nickel, copper, and cobalt concentrate. Production in 2002 reflects partial year of operation as mine shut in September 2002.</p> <p>Sources: Company press releases and quarterly reports.</p>   |                       |                             |               |           |                |                      |
|  | Independence Group NL | Long Nickel mine            | 600           | 5 830     | ?              | SO                   |
| <p>Remarks: Name changed in November 2003 from Independence Gold NL; Long shaft, Victor decline and leases sold by WMC Resources in September 2002; Lightning Nickel Pty Ltd., wholly owned subsidiary of Independence, started production in October 2002; delivers ore to WMC Resources' Kambalda mill under long-term agreement whereby Lightning to be paid for 63-65% of contained Ni and Cu in ore; mine started up with five years' reserve; agreement with St. Ives Gold Mining Co. Pty Ltd. to explore continuation of Victor South orebody; mining areas include Long Nickel mine, Gibb South, Victor South, Long Shoot; above production data show tonnage of nickel contained in ore shipped to mill.</p> <p>Sources: Company reports; company web site.</p>   |                       |                             |               |           |                |                      |
|  | Jubilee Mines NL      | Cosmos mine, mill           | 11 300        | 12 300    | ?              | S                    |
| <p>Remarks: Mine/mill run by wholly owned subsidiary, Sir Samuel Mines NL; underground mining commenced in June; open-pit mining completed August 1; operation produced 62 300 dry tonnes of concentrate grading 19.7% Ni; concentrate shipped to Inco's facilities in Canada for smelting and refining; quarterly smelting and refining costs averaged A\$1.40/lb or US91¢/lb (based upon average of Bank of Canada exchange rates); underground mine development expected to be completed by April 2004. A\$2 million predevelopment studies for open pit at "Anomaly 1" started in December 2004.</p> <p>Sources: Company reports; company web site.</p>  |                       |                             |               |           |                |                      |

|  |                                   |           |           |         |    |
|--|-----------------------------------|-----------|-----------|---------|----|
| LionOre Australia (Nickel) Ltd.  | Emily Ann mine, mill              | 5 745     | 7 682     | ?       | S  |
| Remarks: Plant processed over 280 000 t of ore (design capacity was 250 000 t/y ore); recovery averaged 87%; mill expansion under way to accommodate ore from Maggie Hays project (see below) starting up in 2004; all concentrate shipped to Inco's Canadian smelters for processing; concentrate grades about 14.7% Ni.<br>Sources: Company reports and web site.  |                                   |           |           |         |    |
| LionOre Australia (Nickel) Ltd.  | Maggie Hays mine                  | –         | –         | –       | SO |
| Remarks: Development of mine under way, but slowed by higher-than-expected groundwater inflows; production expected in Q4 of 2004; ore to be trucked to nearby Emily Anne mill; all output destined for Inco Limited's smelters in Canada.<br>Sources: Company reports and web site.   |                                   |           |           |         |    |
| Minara Resources   | Murrin Murrin mine, PAL, refinery | 30 009    | 27 644    | 2033    | I  |
| Remarks: Name changed to Minara Resources from Anaconda Nickel Limited in November; A\$100 million capital improvement plan undertaken to reach capacity of 40 000 t/y Ni by mid-2004 and to operate at cash cost of US\$2.00-\$2.40/lb Ni; new screening plant and ore preparation paste thickener; lower-grade ore affected production in Q1 and Q2; US\$466 million in senior debt extinguished in Q1 by restructuring and re-capitalization; mine grade expected to average 1.3% Ni until mid-2008, then to decline to 1.15% during subsequent 10 years. Change in reporting in March from metal "reduced" to metal "produced and ready for dispatch" – 2003 totals for "reduced" were 27 988 t of Ni and 2045 t of Co. (CDI statistics showed cobalt production of 2039 t in 2003.)<br>Sources: Minara Resources quarterly and annual reports and web site; CDI statistics from CDI web site.   |                                   |           |           |         |    |
| Mincor Resources NL  | Miitel and Wannaway mines         | 13 500    | 11 300    | 250     | SO |
| Remarks: Mincor bought outstanding 24% of Miitel JV effective October 1, 2003. Ni production considered to be "nickel sold" as reported; Co data reflect payable Co, so Co contained in concentrates is expected to be higher; ore also contains payable Cu. Mines supply ore to Kambalda mill owned by WMC Resources. Development of Redross mine under way in Q4 and expected to produce ore in September 2004. North Miitel orebody development under way in 2003. Mariners Nickel mine development decision announced; dewatering to commence in 2004 with first production expected in Q3 or Q4 of 2004 (Mariners was operated by WMC Resources between 1991 and 1999), production in 2003/04 fiscal year expected at 8300 t, 11 000 t in 2004/05 and 15 000 t in 2005/06.<br>Sources: Mincor reports, press releases and web site.   |                                   |           |           |         |    |
| MPI Nickel Pty Ltd.  | Black Swan mine, mill             | 14 350    | 11 300    | ?       | S  |
| Remarks: Black Swan processed 232 000 t @ 5.39% Ni. OM Group (OMG) is a 20% shareholder in MPI. Black Swan operations send concentrate to smelter at Harjavalta in Finland, then to OMG's nickel refinery at the same site. Smelting, refining and transport costs were A\$2.08/lb in 2003, with quarterly averages ranging from A\$1.71/lb to A\$2.33/lb. Development of Lower White Swan orebody expected to be completed in early 2004. Following a new concentrate treatment agreement with OMG, decision taken in December to proceed with Black Swan Disseminated (BSD) open pit, expected to produce 450 000 t/y ore to yield 2500 t/y Ni in concentrates; BSD expected to start production in July 2005. Feasibility study under way at year-end to increase mining rate at BSD to 1 Mt/y to yield about 5500 t/y Ni in concentrates. OMG-MPI study of low pressure acid leaching of ore from Honymoon Well project was feasible and study will continue. Leaching system could be built at OMG's Cawse refinery. Production in 2004 forecast to exceed 10 000 t Ni in concentrate.<br>Sources: MPI quarterly reports, open briefings, and web site. |                                   |           |           |         |    |
| OM Group, Inc. (OMG)   | Cawse mine, PAL, refinery         | (e) 8 000 | (e) 7 000 | (e) 900 | I  |
| Remarks: Company does not reveal data of Ni-Co intermediates shipped to Finland for refining; however, in transcripts of OMG's 2002 Fourth Quarter conference call, a reference was made to output at Cawse of about 9000 t of nickel. Financial data reporting for 2003 was delayed and unavailable at time of writing. In OMG's 10-K for 2002, reference was made to production of about 8000 t/y of Ni. Cobalt production is assumed to be 10% of nickel production. Cobalt from Cawse is eventually recovered at OMG's Kokkola facility. Author's production estimates based partially upon INSG trade data.<br>Sources: Company reports and web site; INSG World Nickel Statistics, July 2004.  |                                   |           |           |         |    |





|                       |               |        |        |   |   |
|-----------------------|---------------|--------|--------|---|---|
| WMC Resources Limited | Kambalda mill | 25 912 | 23 255 | ? | S |
|-----------------------|---------------|--------|--------|---|---|

Remarks: All ore processed by the Kambalda mill in 2003 came from third-party operating properties purchased from WMC Resources; sales of Kambalda mines and properties totaled US\$52 million to end of 2003. Capacity is 1.5 Mt/y ore. Third parties deliver ore to Kambalda mill under contract terms that include recovery factors, smelting and refining charges, etc. Nickel recovery estimated at 92% of Ni in ore.  
Sources: Company reports, press releases and web site.

|                       |                      |        |        |   |   |
|-----------------------|----------------------|--------|--------|---|---|
| WMC Resources Limited | Leinster mines, mill | 40 006 | 41 806 | ? | S |
|-----------------------|----------------------|--------|--------|---|---|

Remarks: Harmony open pit and Perseverance underground mine supplied 2.7 Mt ore to Leinster concentrator. Mt. Keith recovery of Ni in 2003 was 68%; program to increase mill recovery of nickel, similar to that at Mt. Keith, resulted in 5% increase in nickel recovery. Concentrate sent to company's Kalgoorlie smelter.  
Sources: Company reports, press releases and web site.

|                       |                     |        |        |   |   |
|-----------------------|---------------------|--------|--------|---|---|
| WMC Resources Limited | Mt. Keith pit, mill | 43 192 | 50 004 | ? | S |
|-----------------------|---------------------|--------|--------|---|---|

Remarks: Concentrator capacity is 11.2 Mt/y ore. Feasibility study to increase pit output by 25% to be finished in early 2003, which would raise mining/milling rate to 14 Mt/y at a cost of A\$200 million, with subsequent increase to 16 Mt/y; expansion does not depend upon mining of Yakabindie deposit (292 Mt @ 0.52% Ni), which WMC purchased from Rio Tinto in 2001. Recovery of nickel at mill increased from 60% to 71% in five years to 2003. While most Mt. Keith concentrates are sent to company's Kalgoorlie smelter, Mt Keith also supplied 14 000 t/y Ni in concentrate to OMG to be smelted at the Harjavalta smelter in Finland under a contract with OMG; this contract is expected to expire in Q1 of 2005. Smelter produced 529 000 t of acid, most of which was sold to laterite leach operations in Western Australia.  
Sources: Company reports, press releases and web site.

|                       |                    |        |        |     |   |
|-----------------------|--------------------|--------|--------|-----|---|
| WMC Resources Limited | Kalgoorlie smelter | 91 574 | 99 152 | 886 | M |
|-----------------------|--------------------|--------|--------|-----|---|

Remarks: Smelter takes feed from three WMC Resources concentrators plus other sources; about one-third of the matte is exported to OMG's refinery in Finland and to Sumitomo's refinery in Japan; cobalt in residues believed to be shipped to Falconbridge plant at Nikkelverk for toll refining; matte export contract signed in August with Jinchuan for 90 000 t Ni in matte (in addition to December 2002 contract for 30 000 t), which means that total of Ni in matte contracted to Jinchuan over the period 2005-10 will be 120 000 t. Record six-month production of 55 145 t Ni in matte in period of July-December 2003. Cobalt production per Tex Report consistent with approximate sales reported by WMC Resources on its COSS web site. Smelter recovery was 97%; 2004 production is forecast at 90 000-95 000 t due to lower scheduled mine grades in 2004. Western Australia government also reported the production of 477 kg of Pd and 133 kg of Pt as a by-product of nickel production; while the table makes no attribution of Pd/Pt production to a particular company, WMC Resources is the only nickel smelter in the state.  
Sources: WMC Resources Annual Report – Concise 2003, p. 60, company web site and press releases; Tex Report, February 13, 2004; Western Australian Mineral and Petroleum Statistics Digest, 2003.

|                       |                  |        |        |     |   |
|-----------------------|------------------|--------|--------|-----|---|
| WMC Resources Limited | Kwinana refinery | 65 055 | 61 417 | 886 | I |
|-----------------------|------------------|--------|--------|-----|---|

Remarks: Refinery uses Sherritt-Gordon ammonia leach process; de-bottlenecking program under way to take capacity to 70 000 t/y in 2004; intermediate mixed Ni-Co sulphide sent to third parties for recovery, likely to Falconbridge's Nikkelverk refinery for final recovery, then cobalt is returned to WMC Resources for sale. Refinery recovery for Ni is 98%; 2004 forecast production is 62 000 t Ni. Refinery produced by-product ammonium sulphate.  
Sources: Company reports; Tex Report, February 13, 2004.

## AUSTRIA

|                         |              |       |           |   |    |
|-------------------------|--------------|-------|-----------|---|----|
| Treibacher Industrie AG | FeNi smelter | 1 300 | (e) 1 500 | – | II |
|-------------------------|--------------|-------|-----------|---|----|

Remarks: Ni recovered from scrap and residues, including catalysts from food industry.

TABLE 6 (cont'd)

| Country   | Company                       | Operation                                | Nickel Output |        | Cobalt<br>2003 | Type of<br>Ni Output |
|---|-------------------------------|--|---------------|--------|----------------|----------------------|
|   |                               |  | 2002          | 2003   |                |                      |
| (tonnes)  |                               |  |               |        |                |                      |
| <b>BELGIUM</b>  |                               |  |               |        |                |                      |
| Umicore   | Umicore Group                 | Refinery                                 | ?             | ?      | 1 704          | I                    |
| Remarks: Umicore produces cobalt and nickel specialty products; arrangement with Norilsk for cobalt marketing; recovers undetermined amount of nickel from processing of cobalt feeds and recycling operations. Recovery of nickel from secondary sources estimated at less than 500 t/y. Cobalt from primary and secondary sources.<br>Source: Cobalt Development Institute web site.  |                               |  |               |        |                |                      |
| <b>BOTSWANA</b>   |                               |  |               |        |                |                      |
|   | BCL Limited                   | Mines, mill and smelter at Selebi Phikwe | 23 896        | 29 083 | 350            | M                    |
| Remarks: Processed 2.7 Mt @ 0.75% Ni, 0.80% Cu (2.9 Mt in 2002); smelter processes feed from own mines, supplemented by custom feed from expanded Tati operation (see next entry) and Nkomati. Smelter shut for six weeks in Q1 due to a failure in the uptake shaft. Matte sold through Centametal AG, which had arrangements with Nikkelverk refinery in Norway and Rio Tinto Zimbabwe's Empress refinery in Zimbabwe for refining. Schedule in 2004 calls for planned maintenance shut-down of 55 days in June-July 2004.<br>Sources: LionOre International quarterly and annual reports; Botswana Department of Mines Annual Report 2002; communication from Department of Mines to author. |                               |  |               |        |                |                      |
|   | Tati Nickel Mining Company    | Phoenix pit, mill                        | 9 539         | 16 303 | 71             | S                    |
| Remarks: Production reduced by six-week closure of BCL smelter (above), which smelts Tati concentrates; 2003 payable production was 11 509 t Ni, or 71% of the contained Ni (16 303 t). Feasibility study of Activox® process at Phoenix mine started in January and study ongoing at year-end. Demonstration Activox® plant to be assembled at Tati for evaluation of plan to produce 17 000 t/y Ni by leach process by 2007. Cobalt tonnage is payable amount; contained cobalt is likely higher.<br>Sources: LionOre company reports, press releases and web site.   |                               |  |               |        |                |                      |
| <b>BRAZIL</b>   |                               |  |               |        |                |                      |
|   | Barro Alto Mineração Limitada | Barro Alto project                       | –             | –      | –              | L                    |
| Remarks: Feasibility studies completed in 2001 led to conversion of resources to reserves; November decision to proceed with development of orebody as feed source for Codemin plant; ore reserves of 30.4 Mt @ 1.84% Ni.<br>Sources: Anglo American plc reports.   |                               |  |               |        |                |                      |
|   | Codemin SA                    | Niquelandia mine, smelter                | 6 010         | 6 408  | –              | II                   |
| Remarks: Production increased as power rationing ended; operation owned 90% by Anglo American; decision in November to proceed with development of Codemin expansion project using higher-grade Barro Alto ore as feed for Codemin plant; target is to commission and ramp up to 10 000-t/y Ni rate during 2005; Codemin ore reserves are 4 Mt @ 1.34% Ni (4.5 Mt @ 1.35% Ni).<br>Sources: Anglo American reports, press releases and web site; PRODUÇÃO BRASILEIRA DE METAIS PRIMÁRIOS POR EMPRESA found at <a href="http://www.mme.gov.br/SMM/informativo/fevereiro/Metais1.PDF">www.mme.gov.br/SMM/informativo/fevereiro/Metais1.PDF</a> .   |                               |  |               |        |                |                      |

|                                       |                               |       |       |   |   |
|---------------------------------------|-------------------------------|-------|-------|---|---|
| Mineração Serra da Fortaleza Limitada | Fortaleza mine, mill, smelter | 6 273 | 5 950 | ? | M |
|---------------------------------------|-------------------------------|-------|-------|---|---|

Remarks: Matte exported to Harjavalta refinery under long-term contract. Mine production interrupted from April to July in order to complete mine development and support work and modify mining methods. Rio Tinto announced that operation would be closed by mid-2006 due to insufficient reserves. Rio Tinto sold operation to Votorantim Metais (owner of Companhia Niquel Tocantins - see next) effective January 2004.

Sources: Company reports, press releases, and web site; Metal Bulletin, August 28, 2003; PRODUÇÃO BRASILEIRA DE METAIS PRIMÁRIOS POR EMPRESA found at [www.mme.gov.br/SMM/informativo/fevereiro/Metais1.PDF](http://www.mme.gov.br/SMM/informativo/fevereiro/Metais1.PDF).

|                            |  |        |        |       |   |
|----------------------------|--|--------|--------|-------|---|
| Companhia Niquel Tocantins | Tocantins mine and ammonia leach plant at Niquelandia; refinery at Sao Paulo | 17 675 | 18 155 | 1 097 | I |
|----------------------------|--|--------|--------|-------|---|

Remarks: Sole producer of nickel metal in Brazil; ongoing work on expansion to 20 500 t/y Ni and 1200 t/y Co by 2004; subsequent phase of expansion to 23 000 t/y Ni and 1400 t/y Co expected to be completed in 2005; purchased Fortaleza operation (see preceding entry) from Rio Tinto plc for about US\$90 million; nickel sulphide reserves at Niquelandia could provide feed to Fortaleza smelter at rate of 10 000 t/y for 14 years.

Sources: WMC Resources Cobalt News; Bnamericas.com; CDI cobalt production data; PRODUÇÃO BRASILEIRA DE METAIS PRIMÁRIOS POR EMPRESA found at [www.mme.gov.br/SMM/informativo/fevereiro/Metais1.PDF](http://www.mme.gov.br/SMM/informativo/fevereiro/Metais1.PDF).

## CANADA

|                               |                                    |   |         |         |    |
|-------------------------------|------------------------------------|---|---------|---------|----|
| Canmine Resources Corporation | Cobalt hydrometallurgical refinery | - | minimal | minimal | Ch |
|-------------------------------|------------------------------------|---|---------|---------|----|

Remarks: Company placed under protection of *Companies Creditors Arrangement Act* to allow opportunity for restructuring. No resolution by year-end; refinery stayed shut through year-end.

|                      |                   |        |        |     |   |
|----------------------|-------------------|--------|--------|-----|---|
| Falconbridge Limited | Raglan mine, mill | 24 636 | 25 110 | 381 | S |
|----------------------|-------------------|--------|--------|-----|---|

Remarks: Mill capacity increased from 0.8 to 1.0 Mt/y. All output shipped as Ni-Cu-Co concentrate from Deception Bay to Québec City and then railed to Falconbridge's smelter in Sudbury (see next entry) from mid-June to mid-March. Project started during year that will result in 100% recycling of mill water. Mine also produced 6628 t of Cu in concentrates in 2003.

Sources: Company reports, presentations, press releases and web site.

|                      |                                      |        |        |     |   |
|----------------------|--------------------------------------|--------|--------|-----|---|
| Falconbridge Limited | Sudbury - 4 u/g mines, mill, smelter | 27 833 | 24 143 | 611 | M |
|----------------------|--------------------------------------|--------|--------|-----|---|

Remarks: Four mines (Craig, Fraser, Lindsley, Lockerby) feed the Strathcona mill. Reduction in Ni due to lower grade (1.35% Ni vs. 1.58% in 2002). Strathcona mill processed 2.26 Mt to produce two concentrates: a copper concentrate sent to the company's Kidd copper smelter and refinery and a Ni-Cu-Co concentrate smelted in Sudbury. The smelter also recovered 6400 t Ni, 5000 t Cu and 1100 t Co from recyclables. Smelter may be the largest single Co recycling operation in the world. All matte from the smelter is sent to the company's refinery in Norway. Exploration activities centred on Nickel Rim South (see text). Acid plant produced 245 500 t in 2003.

Sources: Company reports, presentations, and web site; Noranda Annual Information Form, 2003.

|                      |                  |   |   |   |    |
|----------------------|------------------|---|---|---|----|
| Falconbridge Limited | Montcalm deposit | - | - | - | SO |
|----------------------|------------------|---|---|---|----|

Remarks: Decision taken to proceed with development of mine at Montcalm; construction began in November. Property to begin shipping ore 70 km to Kidd metallurgical site near Timmins, Ontario, where ore will be milled in a separate circuit; concentrate to be shipped to Sudbury to company's smelter. Mine output expected to provide 8000 t/y refined Ni. Montcalm targeted to achieve commercial production in Q1 of 2005. Projected capital expenditures in 2004 for Montcalm were US\$75 million, compared to US\$5 million in 2002.

Reserves of 5.1 Mt @ 1.46% Ni and 0.71% Cu sufficient for over seven years; additional measured and indicated resources of 7 Mt @ 1.36% Ni and 0.66% Cu.

Sources: Company reports, presentations and web site.



|                                  |   |        |        |       |   |
|----------------------------------|---|--------|--------|-------|---|
| The Cobalt Refinery Company Inc. | Hydrometallurgical nickel-cobalt refinery | 31 694 | 31 106 | 3 141 | I |
|----------------------------------|---|--------|--------|-------|---|

Remarks: Company owned 50% by Sherritt International Corporation and 50% by General Nickel Company S.A. (the latter a state-owned Cuban company). Operation processes Ni-Co residue from pressure leach operation located at Moa Bay in Cuba to recover Ni and Co in form of briquettes and powder. High-grade residue containing about 50% Ni and 5% Co shipped to eastern Canada and then railed to Fort Saskatchewan, Alberta, for processing along with small amounts of material from third parties. Sherritt is considering expansion of operations at Moa and Fort Saskatchewan. Produces about 250 000 t/y of fertilizer as a by-product.  
Sources: Company reports, press releases and web site.

## CHINA

Jinchuan Nickel is the largest miner, smelter and refiner of nickel in China. Much of the information about the other operations is fragmentary, proprietary or conflicting. The USGS reported in 2002 that refined nickel was produced at two locations: 60 000 t capacity at Jinchuan and 5000 t capacity at Chengdu Electro-Metallurgy Factory. The International Nickel Study Group sells a directory of nickel facilities in the world, which shows data about lesser-known Chinese producers (web site at [www.insg.org/publics.htm](http://www.insg.org/publics.htm)).

|                                   |                    |   |   |   |   |
|-----------------------------------|--------------------|---|---|---|---|
| Cu-Ni mine (company name unknown) | Tonghua Cu-Ni mine | ? | ? | ? | S |
|-----------------------------------|--------------------|---|---|---|---|

Remarks: Cu-Ni mine; capacity and output unknown.

|                                |                               |   |   |   |   |
|--------------------------------|-------------------------------|---|---|---|---|
| Ni mine (company name unknown) | Huili Nickel mine and smelter | ? | ? | ? | M |
|--------------------------------|-------------------------------|---|---|---|---|

Remarks: Reportedly a mine and smelter with capacity of about 1400 t/y Ni.

|                                   |                                 |   |   |   |    |
|-----------------------------------|---------------------------------|---|---|---|----|
| Jinco Nonferrous Metals Co., Ltd. | Converts nickel to nickel salts | ? | ? | ? | Ch |
|-----------------------------------|---------------------------------|---|---|---|----|

Remarks: JV of Inco (65%) and Jinchuan (35%) producing nickel salts (nickel sulphate and nickel chloride) for plating and other applications; product specifications available at [www.inco.com/products/MSDS/IncomondNickelSulphate-EUMSDS.pdf](http://www.inco.com/products/MSDS/IncomondNickelSulphate-EUMSDS.pdf) and [www.inco.com/products/MSDS/IncomondNickelChloride-EUMSDS.pdf](http://www.inco.com/products/MSDS/IncomondNickelChloride-EUMSDS.pdf).  
Sources: Inco reports and web site.

|                            |                              |   |   |   |      |
|----------------------------|------------------------------|---|---|---|------|
| Jilin JIEN Nickel Co.. Ltd | 3 mines, smelter, refineries | ? | ? | ? | M, I |
|----------------------------|------------------------------|---|---|---|------|

Remarks: Produces nickel salts (Ni chloride, sulphate, acetate, and fluoride) and cobalt chloride. Capacity stated as 29 000 t/y Ni salts, which author estimates at equivalent of between 6500 and 7200 t/y Ni in salts. Company states it also produces electrolytic Ni and Ni matte. The matte and electrolytic Ni may be feed to salts production. IPO in mid-2003 to raise US\$35 million for carbonyl Ni plant with reported capacity of 2000 t/y. Antaike reports Ni sulphate capacity of 15 000 t/y. Metal Bulletin reported production in 2003 as 5826 t of Ni sulphate, 16 600 t of Ni matte, and 1367 t of electrolytic Ni. INSG notes matte grade as 68% Ni.  
Sources: Jilin web site; Antaike Copper and Nickel Monthly, April 2004; Metal Bulletin, September 4, 2003.

|                        |                                |            |        |       |       |
|------------------------|--------------------------------|------------|--------|-------|-------|
| Jinchuan Group Limited | Mines, mill, smelter, refinery | (e) 48 000 | 60 588 | 1 509 | I, Ch |
|------------------------|--------------------------------|------------|--------|-------|-------|

Remarks: Company restructuring completed on December 1; development and exploration work began on East Mining Area of Longshou mine in Q4; Jinchuan's uncut cathode was registered on the LME in November; expansion of cobalt production undertaken, based in part on imports of Co in mixed sulphides from Guevara plant in Cuba. Additional feed material to arrive in 2004 with start-up of Sally Malay mine providing 8000 t/y Ni in concentrates. Expansion of sodium sulphite plant from 40 000 t/y to 190 000 t/y under way to capture more SO<sub>2</sub>; plant was scheduled to be operating at 120 000 t/y by end of 2003. Jinchuan continued to seek additional feed material to allow expansion to 100 000 t/y Ni production by 2006, which resulted in contract with Sally Malay as noted and in second matte supply contract with WMC Resources for 90 000 t Ni in matte (earlier contract for 30 000 t Ni in matte signed in December 2002; together they total 120 000 t Ni in matte over the period 2005 to 2010). Discussions with Titan to apply the Bio-Heap™ process to Jinchuan may have been retarded by the high magnesium content of ore.  
Sources: Company press releases and web site; Titan Resources web site and reports; Sally Malay reports, press releases and web site; WMC Resources reports, press releases and web site.

TABLE 6 (cont'd)

| Country  | Company   | Operation  | Nickel Output |            | Cobalt<br>2003 | Type of<br>Ni Output |
|--|---|--|---------------|------------|----------------|----------------------|
|  |   |  | 2002          | 2003       |                |                      |
|  | Sichuan Copper-Nickel Co.                       | Chengdu refinery   | 5 000         | ?          | ?              | I                    |
| (tonnes)   |   |  |               |            |                |                      |
| Remarks: Except for report of 5000 t of refined production in 2002 by the USGS, refinery capacity and output unknown.<br>Source: The Mineral Industry of China – 2002, USGS.   |   |  |               |            |                |                      |
|  | Simsen Metals (Holdings) Ltd.                   | Mine   | ?             | ?          | ?              | S                    |
| Remarks: Started up in 1999; ships concentrate to Jinchuan; forecast from 1999 that production would be 1500 t of contained Ni in 2000; no information found for 2002 or 2003.   |   |  |               |            |                |                      |
|  | Xinjiang Nonferrous Metals Industry Corporation | Kalatongke   | ?             | (e) 2 600  | ?              | M, I                 |
| Remarks: Ni-Cu mine, smelter, refinery; capacity and output unknown; estimate for 2003 based upon forecast for production rate in 2004 of 3000 t/y.<br>Sources: INSG; 2003 production estimate derived from information in China Metals (Interfax), July 6-12, 2004.   |   |  |               |            |                |                      |
|  | Ni mine (company name unknown)                  | Small mines, mill  | (e) 500       | (e) 500    | ?              | S                    |
| Remarks: Small mining operations in Hami area of China, 1850 km northwest of Beijing; 140 Mt @ 0.5% Ni in Huang Shan East and Huang Shan West orebodies plus undetermined amount of material in Xiang Shan orebody; mines believed to be sending concentrate to Jinchuan.<br>Sources: Titan Resources June 2003 Quarterly Report plus author's estimates.  |   |  |               |            |                |                      |
| <b>COLOMBIA</b>  |   |  |               |            |                |                      |
|  | Cerro Matoso S.A.                               | Cerro Matoso mine, FeNi smelter  | 44 000        | 48 000     | –              | II                   |
| Remarks: Expansion completed in January 2001 when second processing line started up; mine reserves grade 2.2% Ni; bulk of FeNi output shipped to Europe.<br>Sources: BHP Billiton plc reports, press releases and web site.  |   |  |               |            |                |                      |
| <b>CUBA</b>  |   |  |               |            |                |                      |
| Production data from the Union del Nickel operations is not commonly available by plant; various estimates exist for production. National Ni + Co production in 2003 was reported at 71 600 t compared to 75 116 t in 2002 (FOCAL, below). Co contained in Union del Niquel output thought unlikely to be recovered. Subtraction of Moa's Ni+Co output implies Union del Niquel production of about 39 500 t in 2003, of which perhaps about 31 000 t likely produced at Commandante Ernesto Che Guevara with remaining 8500 t from Commandante Rene Ramos Latour. Estimation approximate as INSG did not show Cuban nickel production data for 2003.  |   |  |               |            |                |                      |
|  | Union del Niquel                                | Commandante Ernesto Che Guevara Mining and Metallurgical Combine (Punta Gorda) mine and refinery | (r) 31 500    | (e) 31 000 | (e) 1 000      | II,S                 |
| Remarks: Program to reduce production costs by converting to domestic high-sulphur oil (imported oil costs represented 55% of operating costs); in addition to Ni oxide, plant increasing output of mixed Ni-Co sulphides production; plans to expand operation to range of 50 000-55 000 t/y, possibly drawing on some of resources of Las Camariacas; exports Co concentrate (possibly mixed Ni-Co sulphides) to China.<br>Sources: Canadian Foundation for the Americas (FOCAL) "Summary of News Items Reported on Cuba, January-December, 2003 at <a href="http://www.cubasource.org/chronicles/2003%20Summaries/Economy.pdf">www.cubasource.org/chronicles/2003%20Summaries/Economy.pdf</a> . |   |  |               |            |                |                      |

|                  |   |           |           |   |    |
|------------------|---|-----------|-----------|---|----|
| Union del Niquel | Commandante Rene Ramos Latour<br>Mining and Metallurgical Combine<br>(Nicaro) mine and refinery | (e) 9 000 | (e) 8 500 | ? | II |
|------------------|---|-----------|-----------|---|----|

Remarks: Older plant with high energy costs; output limited by depletion of nearby orebodies; 11-km conveyor system to new mining areas scheduled for completion by 2005, which could allow production to rise to 17 000 t Ni in NiO. Production likely in range of 7500 to 10 000 t/y Ni.

Sources: See sources for Commandante Ernesto Che Guevara.

|                 |                            |            |            |       |   |
|-----------------|----------------------------|------------|------------|-------|---|
| Moa Nickel S.A. | Pedro Sotto Alba mine, PAL | (e) 31 700 | (e) 29 400 | 2 675 | T |
|-----------------|----------------------------|------------|------------|-------|---|

Remarks: Sherritt International owns half of operation with remaining 50% owned by Cuban government. Mined 2.9 Mt @ 1.26% Ni and 0.14% Co in 2003. Output of leach plant was 37 100 t of Ni + Co in mixed sulphides, all of which are exported to Fort Saskatchewan refinery for recovery of Ni and Co. Sherritt studying expansion to 60 000 t/y Ni, which would be processed at Fort Saskatchewan plant; mixed Ni-Co sulphides (Ni and Co content in mixed sulphides thought to be 50% Ni and 5% Co based upon Dynatec conference call of August 2003 and is used to estimate the Ni and Co production for 2003 above - data are rounded and approximate).

Sources: Sherritt reports and conference calls; Dynatec conference call, August 2003.

#### DOMINICAN REPUBLIC

|                                    |                             |        |        |   |    |
|------------------------------------|-----------------------------|--------|--------|---|----|
| Falconbridge Dominicana, C. por A. | Falcondo mine, FeNi smelter | 23 300 | 27 300 | - | II |
|------------------------------------|-----------------------------|--------|--------|---|----|

Remarks: Plant capacity is 29 000 t/y Ni in FeNi. Power at 200-MW plant generated using fuel oil; hence, economics sensitive to relative fuel oil and nickel prices. Falconbridge owns 85%, government owns 10% and Redstone Resources Inc. owns remainder. Mine produced 3.8 Mt @ 1.19% Ni during 2003. Contract with unionized workers expires on November 30, 2005. FeNi product grades 38.5% Ni. Forecast production for 2004 = 27 000 t of Ni in FeNi.

Sources: Falconbridge reports, press releases and web site.

#### FINLAND

|                   |                                   |     |     |   |   |
|-------------------|-----------------------------------|-----|-----|---|---|
| Mondo Minerals Oy | Lahnaslampi mine, Horsmanaho mine | 940 | 620 | ? | S |
|-------------------|-----------------------------------|-----|-----|---|---|

Remarks: Talc operations produce flotation concentrate of pyrrhotite and pentlandite. Company has produced at least since 1990. Concentrate grades between 8% and 9% Ni. Source: Mondo Minerals.

|               |                   |       |       |   |   |
|---------------|-------------------|-------|-------|---|---|
| Outokumpu Oyj | Hituri mine, mill | 2 500 | 2 700 | ? | S |
|---------------|-------------------|-------|-------|---|---|

Remarks: OMG made agreement with Outokumpu in 2001 to maintain operation of mine for feed to OMG's refinery at Harjavalta smelter (see below) and refinery (see below). Mine scheduled to be depleted and closed in 2005.

Sources: Outokumpu 2003 Annual Report; see also references listed on Geological Survey of Finland web site as link on page at [http://info.gsf.fi/eng/explor/finnish\\_mines.html](http://info.gsf.fi/eng/explor/finnish_mines.html).

|               |                    |            |            |   |   |
|---------------|--------------------|------------|------------|---|---|
| Outokumpu Oyj | Harjavalta smelter | (e) 33 000 | (e) 30 000 | ? | M |
|---------------|--------------------|------------|------------|---|---|

Remarks: Smelter purchased by Boliden AB, effective January 1, 2004, as part of larger deal with Outokumpu Oyj. Nickel smelter takes feed from various sources including concentrates from Hituru mine in Finland (see preceding entry), Titania in Norway, Black Swan in Australia, and Mt. Keith in Australia. Matte is sent to OMG refinery on site (see next entry). No data about tonnage of recycling of nickel and cobalt at smelter were found. Tonnage of Ni concentrates smelted: 205 300 t (2003); 251 300 t (2002); 236 000 t (2001); 235 000 t (2000); 228 000 t (1999).

Sources: Boliden AB 2003 Annual Report; Outokumpu Oyj 2003 Annual Report; see also map showing smelters/refineries at [www.gsf.fi/explor/infstr.htm](http://www.gsf.fi/explor/infstr.htm).

TABLE 6 (cont'd)

| Country                                      | Company  | Operation                    | Nickel Output |        | Cobalt<br>2003 | Type of<br>Ni Output |
|--|--|------------------------------|---------------|--------|----------------|----------------------|
|  |  |                              | 2002          | 2003   |                |                      |
|  |  |                              | (tonnes)      |        |                |                      |
|  | OMG Harjavalta Nickel Oy   | Harjavalta refinery          | 51 000        | 52 500 | ?              | I, Ch                |
|  | Remarks: Refinery receives matte feed from adjacent Harjavalta Ni smelter as well as matte from Fortaleza in Brazil and Kalgoorlie in Australia plus mixed Ni-Co hydroxides from Cause PAL in Australia. No details on whether cobalt recovery is at Harjavalta or Kokkola. OMG as a whole produced 9100 t Co in 2003 from all operations (however, the CDI reported 7990 t for 2003).<br>Sources: INSG April 2004 Bulletin; OM Group press release, July 6, 2004; CDI statistics 1996-2003 on web site.   |                              |               |        |                |                      |
|  | OMG  | Kokkola Chemicals Oy         | –             | –      | 9 100          | I, Ch                |
|  | Remarks: Production of cobalt by OMG was 8100 t in 2003 from all sources, including Harjavalta and Kokkola. Kokkola is principal OMG cobalt production site; no data about amount of cobalt recovered at Harjavalta. OMG as a whole produced 9100 t Co in 2003 from all operations (however, the CDI reported 7990 t for 2003). 10-K for OMG not available at time of writing.<br>Sources: OMG reports, press releases and web site; Cobalt Development Institute web site; see also map showing smelters/refineries at <a href="http://www.gsf.fi/explor/infstr.htm">www.gsf.fi/explor/infstr.htm</a> . |                              |               |        |                |                      |
| <b>FRANCE</b>                                |  |                              |               |        |                |                      |
|  | The Eramet Group   | Sandouville refinery         | 11 444        | 11 138 | 181            | I, Ch                |
|  | Remarks: Plant processes matte from Doniambo smelter in New Caledonia to produce nickel and cobalt chemicals and high-purity Ni; capacity being increased from 13 000 t/y Ni in all forms to 15 000 t/y in parallel with expansion at Doniambo to 75 000 t/y Ni in matte and in FeNi. Output of cobalt in all forms at Sandouville to rise to capacity of 300 t/y (from about 175 t/y) after expansion at Doniambo completed.<br>Sources: Company reports, press releases and web site; Cobalt News 04/2.  |                              |               |        |                |                      |
| <b>FORMER YUGOSLAV REPUBLIC OF MACEDONIA</b> |  |                              |               |        |                |                      |
|  | Feni-Mak   | Feni-Mak mines, FeNi smelter | 5 100         | 5 600  | –              | II                   |
|  | Remarks: Plant purchased in 2000 by Feni-Rudnici i Industrija za Nikel, Celik i Antimon (FENI) of France; production restarted in 2001; continuing investment targeted at restart of second FeNi line in 2005; forecast production of 6000 t in 2004 and 14 000 t in 2005; power availability and cost thought to be bottleneck; laterite sourced from FENI's Rzanovo mine, from Albania, plus small test shipments from Turkey.<br>Source: INSG World Nickel Statistics, June 2004.   |                              |               |        |                |                      |
| <b>GREECE</b>                                |  |                              |               |        |                |                      |
|  | General Mining and Metallurgical Co. S.A.  | Larco mines, FeNi smelter    | (r) 22 700    | 21 400 | –              | II                   |
|  | Remarks: Mine produces FeNi from three main domestic mining areas (Agios Ioannis, Evvia and Kastoria); production in 2002 revised from 19 200 t based upon INSG statistics; imported small quantity of lateritic nickel ore from European Nickel's Caldaq deposit in Turkey in 2003, estimated at less than 500 t in total, of which some went to Greece and some to Macedonia. Capacity of LARCO estimated at 22 000 t/y of Ni in FeNi.<br>Sources: INSG World Nickel Statistics June 2004; European Nickel plc prospectus, pp. 12 and 30.  |                              |               |        |                |                      |



## INDONESIA

|              |                                |            |            |   |   |
|--------------|--------------------------------|------------|------------|---|---|
| PT Antam Tbk | Gebe, Pomaala, Gee, Buli mines | (e) 55 000 | (e) 60 000 | ? | L |
|--------------|--------------------------------|------------|------------|---|---|

Remarks: Total production maintained at 4.4 Mt (wet). Antam processed 625 000 t (wet) of saprolitic ore (most of feed destined for Antam's FeNi operations comes from Pomaala). Remaining 0.3 Mt from Pomaala, 0.5 Mt from Gebe, 1 Mt from Gee, and 0.8 Mt from Taanjung Buli exported to Japanese FeNi smelters. All (1.1 Mt wet) limonitic and low-grade ore exported to BHP Billiton plc's Yabulu hydrometallurgical refinery in Queensland, Australia. Pomaala ore plus some of ore from Gee sent to Antam's FeNi smelters (see next entry). The only cobalt recovered from the output is derived from the ore sent to Yabulu. Antam began selling new product to Yabulu called low-grade saprolite ore (LGSO) from the Pomaala mine to substitute for limonitic ore. Tonnes of Ni in ore were estimated using 2003 proved ore reserve grades and moisture contents for tonnage produced from each ore-body.

Sources: PT Antam reports and web site.

|              |                             |       |       |   |    |
|--------------|-----------------------------|-------|-------|---|----|
| PT Antam Tbk | FeNi I and FeNi II smelters | 8 804 | 8 933 | — | II |
|--------------|-----------------------------|-------|-------|---|----|

Remarks: Two FeNi lines with combined capacities of 11 000 t/y Ni in FeNi. Antam arranged to have an additional 597 t Ni in FeNi toll smelted at PAMCO's smelter in Japan. Contract signed to increase power supply by 6 MW. Contracts signed to proceed with US\$320 million FeNi III project to expand output by 15 000 t/y Ni in FeNi; in October contract for US\$168 million with Mitsui and Co., Ltd. and Kawasaki Heavy Industries, Ltd. for plant construction; in November contract for US\$64.5 million with PT Wartsila Indonesia for 102-MW diesel power plant to supply FeNi III. Expansion scheduled to come on stream in 2006. Long-term offtake agreements signed with Thyssen Krupp Nirosta and Posco. Following 2002 MOU, agreement concluded with PT International Inco to buy ore from East Pomaala orebody to be developed and mined by PT International Inco.

Sources: Company reports and web site.

|  |                       |        |        |   |   |
|--|-----------------------|--------|--------|---|---|
| PT International Nickel Indonesia Tbk<br>(PT Inco) | Soroako mine, smelter | 59 500 | 70 200 | — | M |
|--|-----------------------|--------|--------|---|---|

Remarks: Expansion to 68 000 t Ni in matte completed in 1999; produces Ni in matte (78% Ni) that is sold to Sumitomo and Inco TNC in Japan. Inco owns 61% of company and Sumitomo owns 20%. Inco uses the matte as feed at its plant in Japan. Despite furnace maintenance, production was record high. Hydro-electric power provides 95% of energy needs. 2004 production forecast at 72 500 t finished Ni. Agreement in early 2003 whereby Inco to mine East Pomaala orebody and deliver ore to PT Antam (see preceding entry) for processing into FeNi starting by mid-2004 for initial period of three years.

Sources: Inco Limited and PT Inco reports, press releases and web sites.

## JAPAN

Japan imported total of 4.45 Mt of nickel ore in 2003; as little or no nickel sulphide ore is traded, the author estimates that the 4.45 Mt was laterite ore brought into Japan for smelting into FeNi.

Source: Tex Report, June 22, 2004.

|  |                                |            |        |   |    |
|--|--------------------------------|------------|--------|---|----|
| Hyuga Smelting Co., Ltd.<br>Prefecture | FeNi smelter at Hyuga, Miyazak | (r) 21 802 | 21 845 | — | II |
|--|--------------------------------|------------|--------|---|----|

Remarks: Owned 60% by Sumitomo; intention to expand production to 25 000 t/y Ni in FeNi from current 19 000 t/y announced in 2000; plant produced approximately 15% above nameplate capacity for third consecutive year; feed sourced from New Caledonia and Indonesia; imported 528 000 t (wet) saprolitic laterite ore from New Caledonia in 2003, compared to 558 000 t in 2002; FeNi grades 20% Ni although product can vary from 17% to 28% Ni.

Sources: Tex Report, April 25, 2003, January 22, 2004, May 6, 2004; INSG World Nickel Statistics, June 2004.

|                  |                                 |        |        |   |    |
|------------------|---------------------------------|--------|--------|---|----|
| Inco TNC Limited | Nickel refinery, Mie Prefecture | 51 600 | 50 500 | — | II |
|------------------|---------------------------------|--------|--------|---|----|

Remarks: About 80% of matte from PT Inco sent to Inco TNC (56 200 t in 2003 and 49 400 t in 2002) with remainder (14 307 t in 2003 and 12 557 t in 2002) sent to Sumitomo. Inco TNC converts the matte into NiO, which is used in stainless steel industry in Japan and as feed to Ni refineries in Korea and Taiwan — Inco has interests in both these refineries. Production shown as reported by Tex Report, May 6, 2004. About 40% of Inco TNC production was exported to Korea and Taiwan with the remainder going to destinations in Japan.

Sources: Inco reports; Tex Report, May 6, 2004.

TABLE 6 (cont'd)

| Country   | Company  | Operation                                    | Nickel Output |        | Cobalt<br>2003 | Type of<br>Ni Output |
|---|--|--|---------------|--------|----------------|----------------------|
|   |  |  | 2002          | 2003   |                |                      |
|   |  |  | (tonnes)      |        |                |                      |
|   | Nippon Yakin Kogyo Co., Ltd.                   | FeNi smelter at Oheyama,<br>Kyoto Prefecture | (r) 12 411    | 13 029 | –              | II                   |
| Remarks: Produces FeNi from imported ore from New Caledonia and Indonesia (PT Antam); imported 336 000 t (wet) saprolite from New Caledonia in 2003, compared to 352 000 t in 2002; all five kilns operated at capacity during year; FeNi grades less than 20% Ni.  |  |  |               |        |                |                      |
| Sources: Tex Report, January 22, 2004, May 6, 2004, April 25, 2003; INSG World Nickel Statistics, June 2004.  |  |  |               |        |                |                      |
|   | Pacific Metals Co., Ltd. (PAMCO)<br>Prefecture | FeNi smelter at Hachinohe, Aomori            | 40 456        | 40 525 | –              | II                   |
| Remarks: PAMCO has toll smelting arrangement with PT Antam. Produces FeNi from ore imported from Indonesia and Philippines; tolled 597 t of Ni in FeNi for PT Antam; imported 54 000 t (wet) saprolitic laterite ore from New Caledonia, compared to 46 000 t in 2002 (SMSP suspended shipments to PAMCO in January 2001). FeNi grades 20% Ni with products having grades varying from 13% to 28% Ni.   |  |  |               |        |                |                      |
| Sources: Tex Report, January 22, 2004, May 6, 2004, April 25, 2003; INSG World Nickel Statistics, June 2004.  |  |  |               |        |                |                      |
|   | Sumitomo Metal Mining Co., Ltd.<br>Prefecture  | Electrolytic refinery, Niihama, Ehime        | 32 300        | 35 000 | 379            | I                    |
| Remarks: Plant capacity to be increased from 36 000 t/y to 46 000 t/y Ni by mid-2004 to handle additional feed, including material from Coral Bay Nickel project in Philippines scheduled to produce in latter half of 2004; cobalt capacity to be concurrently increased from 350 t/y to 1100 t/y. Sumitomo decision about purchasing a share of the Goro project in New Caledonia suspended pending further re-evaluation of Goro costs. Capacity could be increased to as high as 60 000 t/y Ni. |  |  |               |        |                |                      |
| Sources: Nickel Australasia, 2002-April 2004; Metal Bulletin; CDI; Tex Report, May 6, 2004.   |  |  |               |        |                |                      |
| <b>KAZAKHSTAN</b>   |  |  |               |        |                |                      |
|   | Kempirsai Mining Directorate                   | Laterite mines                               | ?             | ?      | –              | L                    |
| Remarks: No information available for 2003; production believed to be nil.  |  |  |               |        |                |                      |
| <b>KOREA</b>  |  |  |               |        |                |                      |
|   | Korea Nickel Corporation                       | Onsan refinery                               | 29 000        | 31 000 | –              | II                   |
| Remarks: Produces nickel feed for stainless industry using imported NiO (nickel oxide); Korea imports of NiO are from Canada (Sudbury), Japan (Inco TNC) and Australia, but some of this material may go directly to stainless industry. Metal Bulletin article reported that all feed was coming from Inco sources. Plant capacity is about 45 000 t/y; only newer 30 000-t/y furnace operated in 2003. Forecast for 2004 = 35 000 t Ni in Utility™ nickel.  |  |  |               |        |                |                      |
| Sources: Nickel Australasia, February 18, 2004; Metal Bulletin, May 20, 2004.   |  |  |               |        |                |                      |

## NEW CALEDONIA

Data for individual mines in New Caledonia were not found. An overview of the centres of mine production, metallurgical works and projects is found on the Internet at [www.itsee.nc/pe/bilan.pdf/minesmetalbilan.pdf](http://www.itsee.nc/pe/bilan.pdf/minesmetalbilan.pdf). Monthly statistics from 1998 for mine ore production and metallurgical production for New Caledonia are published at [www.itsee.nc/pe/telechargement/minemeta.xls](http://www.itsee.nc/pe/telechargement/minemeta.xls). Service des mines et de l'énergie reported production in 2003 as 4.4 Mt (wet) garnierites (termed "sapolite" by others) and 2.2 Mt (wet) limonite. All limonitic ore is exported to QNI for processing at the Yabulu refinery, which recovers nickel and cobalt. About 900 000 t of saprolite was imported by Japanese FeNi smelters in 2003; the remainder was processed at Le Nickel-SLN's Doniambo smelter where both FeNi and Ni matte were produced. Eramet did not publish ore production data for 2003, but subtracting exports of saprolite from reported production gives an estimate for Le Nickel-SLN's production of about 3.5 Mt (wet), including ore mined by contractors (such as Etoile du Nord mined by SMGM). 2002 production was reported as 3.1 Mt mined by SLN and 0.48 Mt mined by contractors.

|  |                              |   |   |   |   |
|--|------------------------------|---|---|---|---|
| Société des Mines de la Tontouta (SMT) | Nakéty, Monéo, Karembe mines | ? | ? | – | L |
|--|------------------------------|---|---|---|---|

Remarks: Also known as the Ballande Group. Within the Group, various organizations mine at different mining centres: Société Minière du Kalaa at Karembe mine, Société des Mines de Nakéty at Nakéty, and Société des Mines de Cape Bocage at Monéo. Total exports reported to Japan in 2003 were 212 000 t, all to Sumitomo's Hyuga smelter. Sources: Bilan 2003 by Institut de la statistique et des études économiques de la Nouvelle-Calédonie; Tex Report, January 22, 2004; Government of New Caledonia.

|     |  |   |   |   |   |
|-----|--|---|---|---|---|
| SLN | Kouaoua, Nepoui Kopeto, Tiebaghi, Thio, Étoile du Nord, and Poro mines | ? | ? | ? | L |
|-----|--|---|---|---|---|

Remarks: As noted above, estimated production including contractors' output of about 3.5 Mt (wet). Exports of garnieritic ore in 2003 to Japanese FeNi smelters reported as 78 000 t to Nippon Yakin. SLN also exports limonitic ore to BHP Billiton plc's Yabulu refinery in Australia. This entry shows estimated nickel in ore exported, and this total does not include the nickel in ore shipped to the Doniambo smelter. The Poro mine operated by Centre de formation aux techniques de la mine et des carrières as a training operation. Étoile du Nord is operated by Société Minière Georges Montagna, operating as a contractor. Source: Bilan 2003 by Institut de la statistique et des études économiques de la Nouvelle-Calédonie.

|     |                       |        |        |   |       |
|-----|-----------------------|--------|--------|---|-------|
| SLN | Doniambo FeNi smelter | 59 867 | 61 523 | – | II, M |
|-----|-----------------------|--------|--------|---|-------|

Remarks: Expansion under way from 60 000 t/y to 75 000 t/y of Ni in FeNi and matte, necessitating temporary shut-down of a furnace in early 2004 for modification. Doniambo is already the world's largest FeNi smelter. Part of output is in form of nickel matte, which is sent to Sandouville refinery in France where nickel metal and chemicals are produced as well as cobalt chloride. Ni in FeNi produced in 2003 was 50 666 t (48 650 t in 2002); Ni in matted produced in 2003 was 10 857 t (11 217 t in 2002). Sources: Bilan 2003 by Institut de la statistique et des études économiques de la Nouvelle-Calédonie; company reports, press releases and web site; Service des Mines et de l'Énergie.

|  |             |   |   |   |   |
|--|-------------|---|---|---|---|
| La Société Minière du Sud Pacifique S.A. | Poum, Ouaco | ? | ? | ? | L |
|--|-------------|---|---|---|---|

Remarks: Owned by investment agency of the Northern Province. Mines reported as Teoudie, Poya and Kouaoua in mining centres noted above. Exports were 540 000 t of saprolite in 2003 to Japanese smelters and to Sumitomo's Hyuga plant and Nippon Yakin. Unknown amount of limonite shipped to BHP Billiton's Yabulu refinery in Australia. SMSP holds 51% of Koniambo project being studied by Falconbridge (60 000 t/y of Ni in FeNi planned).

|  |                          |   |   |   |   |
|--|--------------------------|---|---|---|---|
| Société Minière Georges Montagnat S.A. | Tontouta, Koumac, Ouinné | ? | ? | ? | L |
|--|--------------------------|---|---|---|---|

Remarks: In addition to mines listed, which export limonite ore to Yabulu, as noted above, operates Étoile du Nord for SLN. Vulcain mine also reported to be operated by SMGM. Nakéty leaching project remains halted with no progress during 2003 except for legal actions. Sources: Bilan 2003 by Institut de la statistique et des études économiques de la Nouvelle-Calédonie; Tex Report, January 22, 2004; communication from Government of New Caledonia.

TABLE 6 (cont'd)

| Country   | Company                              | Operation                       | Nickel Output |        | Cobalt<br>2003 | Type of<br>Ni Output |
|---|--------------------------------------|---------------------------------|---------------|--------|----------------|----------------------|
|   |                                      |                                 | 2002          | 2003   |                |                      |
| (tonnes)  |                                      |                                 |               |        |                |                      |
| <b>NORWAY</b>   |                                      |                                 |               |        |                |                      |
|   | Falconbridge Nikkelverk Aktieselskap | Nikkelverk refinery             | 77 183        | 68 538 | 4 556          | I                    |
| Remarks: Refinery takes nickel-copper-cobalt matte feed from company's Sudbury smelter, mixed sulphides from Kwinana, secondary feeds, and matte from BCL and other sources. Operation could be expanded to 100 000 t/y Ni, 60 000 t/y Cu, and 5000 t/y Co. Acid plant produced 102 000 t in 2003. Precious and platinum group metals recovered at refinery. Sources: Falconbridge and Noranda reports, press releases and web sites.   |                                      |                                 |               |        |                |                      |
|   | Titania A/S                          | TiO <sub>2</sub> magnetite mine | 370           | 700    | –              | S                    |
| Remarks: Ilmenite mine producing low-grade by-product Ni concentrate, which is sent to Boliden's smelter at Harjavalta, Finland; ilmenite reserves are in excess of 400 Mt. Source: Titania.  |                                      |                                 |               |        |                |                      |
| <b>PHILIPPINES</b>  |                                      |                                 |               |        |                |                      |
| Data for Philippine mine production by operation were incomplete and narrative about their operations was sparse. INSG reported mine production of 23 000 t in 2002 and 24 000 t in 2003. (USGS cited reported production of 26 500 t Ni in ore in 2002.) National nickel production was reported to have declined by 20% relative to 2002 output, but no final ore production data were found. Philippine mines export saprolitic ore to Japanese FeNi smelters and limonitic ore to BHP Billiton's Yabulu refinery. The Philippine Mines and Geosciences Bureau reported mine production for the first half of 2003 at 540 000 t. No production data were found for the second half of 2003, although 400 000 t (dry) of ore was reported shipped to Australia in the second half of 2003. INSG reported exports of almost 12 000 t of Ni in ore to Japan, likely saprolitic ore delivered to FeNi smelters. United Nations Statistics reported that 2002 exports of nickel ore were 1.1 Mt to Japan and 0.4 Mt to Australia. Sources: United Nations; INSG World Nickel Statistics, June 2004; Philippine Mines and Geosciences Bureau web site. |                                      |                                 |               |        |                |                      |
|   | Cagdianao Mining Corporation         | Mine                            | ?             | ?      | ?              | L                    |
| Remarks: Production of 31 500 t of ore in Q1 2003, but no subsequent data found. Operation still reported as producing ore in Q1 2004. Overall production in 2003 reported as less than that in 2002, due in part to inclement weather. Sources: Mines and Geosciences Bureau, February 14, 2004; Comparative Philippine Nickel Production, January to March 2004 vs. January to March 2003.  |                                      |                                 |               |        |                |                      |
|   | Coral Bay Nickel Corporation         | Mine/HPAL plant                 | –             | –      | –              | S                    |
| Remarks: Project under construction for completion in late 2004. Sumitomo's HPAL process to take stockpiled limonitic ore as feed to produce intermediate sulphides containing about 10 000 t/y of Ni and 700 t/y of Co to be processed at Sumitomo's refinery in Japan. Project owned 54% by Sumitomo, 18% by Mitsui & Co, 18% by Sojitz Corporation and 10% by Rio Tuba Nickel Mining Corporation (itself owned 27% by Pacific Metals Corporation, plus 4-5% by each of Nippon Steel Corporation, Nisshin Steel Co. Ltd., and Nissho Iwai Corporation). First commercial shipments to Japan scheduled for early 2005. Sources: Nickel Australasia, May 16 and June 4, 2003; Philippine Mines and Geosciences Bureau, February 17, 2004.   |                                      |                                 |               |        |                |                      |
|   | Hinatuan Mining Corporation          | Mine                            | –             | ?      | –              | L                    |
| Remarks: South Dinagat project started up in 2003. Hinatuan's operations had closed in 2000 and permission to ship stockpiled ore was denied in 2001. Source: Philippine Mines and Geosciences Bureau, February 17, 2004.   |                                      |                                 |               |        |                |                      |

|                             |               |   |   |   |   |
|-----------------------------|---------------|---|---|---|---|
| Rio Tuba Mining Corporation | Rio Tuba mine | ? | ? | - | L |
|-----------------------------|---------------|---|---|---|---|

Remarks: Company part owner of Coral Bay Nickel HPAL project. Rio Tuba's production in 2003 was less than that in 2002 due to longer haul distances; the mine reported no ore production from August to December 2003.

Sources: Phillipine Mines and Geosciences Bureau, February 17, 2004.

|                             |                                   |   |   |   |   |
|-----------------------------|-----------------------------------|---|---|---|---|
| Taganito Mining Corporation | Mine located in Suriago del Norte | ? | ? | ? | L |
|-----------------------------|-----------------------------------|---|---|---|---|

Remarks: Mine production continued in 2003 but at a lower rate than in 2002. Mine exports limonitic ore to Yabulu refinery in Australia. No data on whether saprolitic ore is exported to Japanese FeNi smelters.

Sources: Phillipine Mines and Geosciences Bureau, February 17, 2004; Townsville shipping records.

## RUSSIA

The major producer in Russia was MMC Norilsk Nickel, the world's largest Ni company, which produced 239 000 t of nickel in 2003 (218 000 t in 2002). No Norilsk cobalt production data released by the company were found for 2002 or 2003 (past production was 2700 t in 1996, 3800 t in 1997, 3700 t in 1998, 4000 t in 1999, 4100 t in 2000 and 4600 t in 2001); however, past Norilsk data correspond with the CDI production data for Russia and it is therefore assumed that Norilsk's production in 2002 and 2003 was 4200 t and 4650 t, respectively. Ufaleynikel is reported to be tolling about half of Norilsk's cobalt production. As well as Norilsk, there are three other companies producing FeNi and other products; no web sites were found for these companies, and production data are mentioned in various reports and press releases on a sporadic basis. INSG data in June 2003 issue of World Nickel Statistics apparently does not show Ni production for 2003 for Russia.

|                                       |  |         |         |           |      |
|---------------------------------------|--|---------|---------|-----------|------|
| MMC Norilsk Nickel (Taimyr Peninsula) | 7 mines, 2 mills, 2 smelter/refineries | 185 000 | 204 000 | (e) 3 700 | M, I |
|---------------------------------------|--|---------|---------|-----------|------|

Remarks: Ni tonnage shown is tonnage of finished nickel originating in Arctic Division. Mines produced 13 Mt ore @ 1.7% Ni; 35% of output is recovered from matte sent to Norilsk's refining operation in Kola peninsula. Taimyr estimated to be source of over 80% of Russian cobalt production, or about 3700 t. Norilsk's Taimyr mines are the source of most of the company's Russian copper, cobalt and PGM production. Production in 2003 included 1000 t from purchased material. Stockpiled pyrrhotite concentrates also provided some of nickel and copper feed to smelters. No road or rail links exist to outside; all output shipped to markets either by Arctic Ocean or Enisey River. Three mines incorporated into Talhakh mining department; other mines in 2003 were Oktyabrsky, Taimyrsky, Zapolyarny and Medvezhy Rucey (all underground mines except for the latter). Skalistaya mine construction continued in 2003. Norilsk and Talmakh concentrators (enrichment plants) had recoveries of 73%, up from 68% in 2002. Oktyabrsky mine is most important of company's mines, producing nearly half of the Ni, 63% of Cu and 55% of PGMs produced in Taimyr.

Sources: Company reports, press releases and web site; author's estimates.

|                                     |                        |        |        |         |   |
|-------------------------------------|------------------------|--------|--------|---------|---|
| MMC Norilsk Nickel (Kola Peninsula) | 3 mines, mill, smelter | 33 000 | 35 000 | (e) 800 | M |
|-------------------------------------|------------------------|--------|--------|---------|---|

Remarks: Ni tonnage is estimate of finished nickel production originating in Kola mines, also referred to as Pechanganickel; produced 6.6 Mt of ore grading 0.7% Ni. Ore also contains copper and cobalt. Target is to produce concentrate grading 9-10% to reduce costs. Matte from Nikel smelter near mines shipped to Severonickel for refining. Ore production was supplemented by processing 0.6 Mt of low-grade stockpile (0.4% Ni). Modernization of smelter begun in 2001 after grant of US\$31 million from Norwegian government and US\$30 million credit from Nordic Investment Bank. Mines in operation were: Tsentralny pit, Severy and Kauia-Kotselvaara. Development at Severny-Gluboky underground mine continued in 2003. Mill recovery for nickel in 2003 was 76%.

Sources: Company reports, press releases and web site; author's estimates.

|                                      |                         |                  |   |   |   |
|--------------------------------------|-------------------------|------------------|---|---|---|
| MMC Norilsk Nickel (Kola Pensinsula) | Severonickel refineries | (see text below) | ? | ? | I |
|--------------------------------------|-------------------------|------------------|---|---|---|

Remarks: Severonickel has no mine production; processes matte from Pechanganickel's Nikel smelter plus matte from Arctic Division, plus domestic and imported scrap and recyclables, including auto catalysts. A small carbonyl plant operates at Severonickel with estimated capacity in the order of 5000 t/y. Nickel output in 2003 was 107 000 t Ni compared to 100 000 t in 2002.

Sources: Company reports, press releases and web site.

TABLE 6 (cont'd)

| Country              | Company  | Operation  | Nickel Output |           | Cobalt<br>2003 | Type of<br>Ni Output |
|----------------------|--|--|---------------|-----------|----------------|----------------------|
|                      |  |  | 2002          | 2003      |                |                      |
|                      |  |  | (tonnes)      |           |                |                      |
|                      | MMC Norilsk Nickel, total all divisions  |  | 218 000       | 239 000   | 4 650          | I                    |
|                      | Remarks: About half the output of cobalt appears to be tolled at Ufalenikel on behalf of Norilsk; cobalt produced grades 99.3% Co; Norgem S.A., a joint venture between Norilsk (51%) and Sogem S.A. (49%) of Umicore, markets cobalt from Norilsk. Norilsk sold 70 000 t of nickel from stockpile in addition to its 2003 production. Norilsk produces about half the world's palladium and about 15% of the world's platinum supply.   |  |               |           |                |                      |
|                      | Sources: Company reports, press releases and web site; cobalt production from Cobalt Development Institute data; specifications from Norilsk Nickel web site.  |  |               |           |                |                      |
|                      | Rezh Nickel Plant Joint Stock Company  | Talovsk mine, smelter  | 2 823         | (e) 6 000 | ?              | M                    |
|                      | Remarks: Obtained quota to export 60 000 t/y matte to China in 2003; FeNi thought to average about 10% Ni.   |  |               |           |                |                      |
|                      | Sources: Export licence from Interfax, January 10, 2003 (but INSG World Nickel Statistics, June 2003, does not list Russian FeNi exports to China); Interfax April 29, 2004.   |  |               |           |                |                      |
|                      | Ufaleynikel Joint Stock Co.  | Ufaley and Serovskoye mines, refinery  | (e) 7 000     | 7 550     | 2 400          | I, II                |
|                      | Remarks: Nameplate capacity of 17 000 t/y Ni as granules, NiO, and in FeNi but unlikely achievable; production has been about 7000 t/y of Ni in FeNi granules, much from matte from Rezh (see above); tolls Co believed to be from Norilsk to produce metal and oxide; status of Ni laterite mines at Ufalei and Serov unknown.  |  |               |           |                |                      |
|                      | Note: Two production totals reported by Interfax for 2003 Ni and Co production: April 29, 2004, says 2000 t Co and 7000 t Ni, while May 27, 2004, says 2408 t Co and 7543 t Ni.  |  |               |           |                |                      |
|                      | Source: Interfax: April 25, 2003, April 29, 2004, and May 27, 2004.  |  |               |           |                |                      |
|                      | Yuzhuralnikel Kombinat Joint Stock Co.   | 2 mines, FeNi smelter  | (r) 12 700    | 13 500    | ?              | L, II, Ch            |
|                      | Remarks: Buruktalskoye mine is located in Orenburg region, Sakharinskoye mine is in Chelyabinsk and FeNi smelter is in Orenburg region. Produces FeNi and Ni in chemicals. 2003 production data cited in Interfax implied 2002 production of 12 700 t, down from author's estimate last year of 18 400 t in 2002. Production thought to be about 9500 t Ni and 4000 t Ni in FeNi. Mechel Steel Group owns about 70% of operation with group supplying coke and receiving nickel for use in steel production. |  |               |           |                |                      |
|                      | Source: Interfax, February 12, 2004.   |  |               |           |                |                      |
| <b>SERBIA-KOSOVO</b> |  |  |               |           |                |                      |
|                      | Ferro-Nickel D.D. Glogovac   | Cikotava and Gllavica laterite mines and FeNi smelter near Pristina                | –             | –         | –              | II                   |
|                      | Remarks: Plant believed to be inactive during 2002 and 2003.   |  |               |           |                |                      |
| <b>SOUTH AFRICA</b>  |  |  |               |           |                |                      |
|                      | South African refined nickel production was reported by the INSG at 40 800 t. Except for the production from Nkomati, South African nickel is a by-product of the Pt/Pd mines. In addition, concentrate containing Ni from Zimplats in Zimbabwe is processed by Impala (see below). Not all producers release information about Ni production.   |  |               |           |                |                      |
|                      | Anglo American Platinum Corporation Limited  | Underground and open-pit mines, smelters, base-metal and precious-metal refineries | 19 400        | 22 100    | ?              | I                    |
|                      | Remarks: Nickel is a by-product of mining PGMs. Company's expansion program to 2006 will increase company's nickel output to 33 000 t/y at "steady state." New mines under development, UG2 concentrator to be expanded; commissioned Anglo Converting Process (ACP) to replace Pierce Smith converters with Austmelt technology allowing increased sulphur dioxide capture; Polokwane smelter commissioned in 2003. Production included small amount of purchased Ni in concentrates.                       |  |               |           |                |                      |

|   |                      |       |       |         |   |
|---|----------------------|-------|-------|---------|---|
| Anglovaal Mining Limited and Anglo American plc (operation became African Rainbow Minerals Limited in 2004) | Nkomati JV mine/mill | 5 025 | 5 430 | (e) 250 | S |
|---|----------------------|-------|-------|---------|---|

Remarks: Cobalt in concentrates estimated using concentrate production tonnage at a grade of 0.49% Co; operation was paid for 57 t of Co in 2003. Decision about expansion using Activox™ technology to produce 16 000 t/y Ni, 900 t/y Co and PGMs expected in Q3 2004. Historical information and expansion details available in Circular to Shareholders issued in March 2004. Concentrate sent to BCL smelter in Botswana.

Sources: Anglovaal Mining annual and interim reports; Circular to Shareholders dated March 2004, available as 15-Mb file at [www.arm.co.za/content/webdata/transformation/Avmin\\_Full.pdf](http://www.arm.co.za/content/webdata/transformation/Avmin_Full.pdf).

|                                  |  |            |            |   |   |
|----------------------------------|--|------------|------------|---|---|
| Impala Platinum Holdings Limited | Various mines, smelter, base-metals refinery in Bushveld Complex | (e) 13 900 | (e) 15 600 | ? | I |
|----------------------------------|--|------------|------------|---|---|

Remarks: Ni is by-product of PGM operations; Impala supplements own feed with tolled and purchased concentrates processed by Impala Refining Services (IRS); some refined Ni production is returned to unspecified customers and that production is included in above estimate. Plan to expand Ni refinery by processing output from Nonoc mine and intermediate plant in Philippines apparently on hold due to delay at Nonoc.

Sources: Company reports and web site.

|            |  |   |   |   |    |
|------------|--|---|---|---|----|
| Lonmin plc | Eastern Platinum Limited, Western Platinum Limited mines, smelter and refinery | ? | ? | ? | Ch |
|------------|--|---|---|---|----|

Remarks: Produces Ni as Ni sulphate; production data not released.

|                           |   |           |           |   |    |
|---------------------------|---|-----------|-----------|---|----|
| Northern Platinum Limited | Mines, mills, smelter, base-metal removal plant | (e) 1 400 | (e) 1 500 | ? | Ch |
|---------------------------|---|-----------|-----------|---|----|

Remarks: Ni is by-product of PGM operation; produced approximately 1400 t/y Ni in concentrate in 2002, which is sold in form of Ni sulphate to Anglo American Platinum Corporation Limited. With higher PGM production in 2003, Ni production in 2003 estimated to have increased. Final Annual Report for 2003-2004 unavailable when report written.

Source: Company's 2002 Annual Report.

## SPAIN

|                             |                    |   |   |   |   |
|-----------------------------|--------------------|---|---|---|---|
| Rio Narcea Gold Mines, Ltd. | Aguablanca project | – | – | – | S |
|-----------------------------|--------------------|---|---|---|---|

Remarks: Company began underground development in December following arrangements in August for US\$45 million financing from Investec Bank (UK) Ltd. and Macquarie Bank Ltd. and a contract for the concentrates until 2010 with Glencore International AG announced in January; the project is expected to process 1.5 Mt/y ore @ 0.66% Ni, 0.46% Cu and 0.47 g/t PGMs to produce 960 000 t/y concentrates @ 8-9% Ni, 6-7% Cu, 0.2% Co and 5-8 g/t PGMs.

Sources: Company reports, press releases and web site.

## TAIWAN

|                                    |  |              |            |   |    |
|------------------------------------|--|--------------|------------|---|----|
| Taiwan Nickel Refining Corporation | Converts NiO to make UTILITY™ Ni (97% Ni) at Kaohsiung Hsien | (e,r) 14 000 | (e) 15 000 | – | II |
|------------------------------------|--|--------------|------------|---|----|

Remarks: Transforms NiO UTILITY™ Ni. As production data are not released, plant output estimated assuming 76% Ni in feed and 99% recovery in process with no changes in inventory. Obtains feed 68% from Japan, 16% from Australia and 16% from Canada. Inco's operations at Sudbury and in Japan are the only producers of NiO in those countries; BHP Billiton's Yabulu plant is the only producer of NiO in Australia.

Source: INSG World Nickel Statistics, June 2004, p. 58.

TABLE 6 (cont'd)

| Country   | Company                         | Operation                         | Nickel Output |         | Cobalt<br>2003 | Type of<br>Ni Output |
|---|---------------------------------|-----------------------------------|---------------|---------|----------------|----------------------|
|   |                                 |                                   | 2002          | 2003    |                |                      |
| (tonnes)  |                                 |                                   |               |         |                |                      |
| <b>TURKEY</b>   |                                 |                                   |               |         |                |                      |
|   | European Nickel plc and As Krom | Çaldag mine                       | –             | (e) 530 | –              | L                    |
| Remarks: Test mining in 2003 amounted to 44 000 @ 1.37% Ni with moisture content of 11.7% equal to about 530 t of contained nickel of which 40 000 t at 1.38% Ni, or 490 t, exported to Greece and Macedonia during 2003.<br>Source: European Nickel plc, Prospectus.   |                                 |                                   |               |         |                |                      |
|   | Meta Madencilik                 | Gordes project                    | –             | 50      | –              | L                    |
| Remarks: Test shipment of 3500 t ore @ 1.37% Ni and 0.08% Co to LARCO's FeNi plant in Greece in October 2003.<br>Source: Oriel Resources plc web site.  |                                 |                                   |               |         |                |                      |
| <b>UKRAINE</b>  |                                 |                                   |               |         |                |                      |
|   | Nikomel Limited                 | Pobuzhsky Ferronickel Works       | –             | 2 700   | –              | II                   |
| Remarks: Nikomed Limited sold interest in smelter and by year-end Dagascara Development Ltd. of Cyprus acquired 100% ownership; imported 150 000 t (wt) laterite from New Caledonia in 2003 containing 2700 t Ni.<br>Source: Nickel Australasia January 21, 2004, and March 3, 2004.  |                                 |                                   |               |         |                |                      |
| <b>UNITED KINGDOM</b>   |                                 |                                   |               |         |                |                      |
|   | Inco Limited                    | Clydach carbonyl refinery         | 33 800        | 24 200  | –              | I                    |
| Remarks: Takes NiO from Sudbury to produce Ni pellets, foams and powders; residue from refining is returned to Sudbury for reprocessing; data shown are INSG production reported for U.K. These data are reported by Inco as "Ontario production."<br>Source: INSG World Nickel Statistics, June 2004.  |                                 |                                   |               |         |                |                      |
| <b>UNITED STATES</b>  |                                 |                                   |               |         |                |                      |
|   | Stillwater Mining Company       | Mines, mill, PGM smelter/refinery | 639           | 636     | ?              | Ch                   |
| Remarks: Palladium operation producing by-product nickel sulphate. Nickel, copper, cobalt and iron are removed from converter matte using Sherritt process. Nickel sulphate with minor amounts of cobalt is crystallized and sent to Canada. Norilsk Nickel owned 55.4% of Stillwater as of the end of 2003.<br>Sources: Company 2003 10-K and web site; 2003 production from USGS. |                                 |                                   |               |         |                |                      |
| <b>VENEZUELA</b>  |                                 |                                   |               |         |                |                      |
|   | Minera Loma de Niquel, C.A.     | Loma de Niquel mine, FeNi smelter | 15 500        | 17 200  | –              | II                   |
| Remarks: Plant completed ramp-up up to full production; processed 1.22 Mt @ 1.7% Ni (1.1 Mt @ 1.7% Ni in 2002); proven + probable ore reserves 38.5 Mt @ 1.46% Ni.<br>Source: Anglo American plc reports.   |                                 |                                   |               |         |                |                      |



## ZIMBABWE

|                                    |  |           |           |   |   |
|------------------------------------|--|-----------|-----------|---|---|
| Bindura Nickel Corporation Limited | Trojan and Shangani mines, smelter, refinery | (e) 7 700 | (e) 7 700 | ? | I |
|------------------------------------|--|-----------|-----------|---|---|

Remarks: Operation sold by Anglo American plc to Mwana Africa Holdings in April for US\$8 million. As Bindura operates only mines in country, INSG data for country mine production used as estimate of company's mine production; company tolls matte plus recovers undetermined tonnage of nickel from chemicals from South Africa; contract for toll processing expired. BCL sends some of matte to Bindura for refining.

Sources: Business Day, April 2004, Insider Publications; INSG World Nickel Statistics, June 2004.

|                            |                  |       |       |   |   |
|----------------------------|------------------|-------|-------|---|---|
| Rio Tinto Zimbabwe Limited | Empress refinery | 6 412 | 6 199 | ? | I |
|----------------------------|------------------|-------|-------|---|---|

Remarks: Toll refines matte from BCL by leaching and electrowinning. Operations hampered by foreign exchange controls and deteriorating economic situation in country.

Source: Company reports.

|  |   |     |       |   |   |
|--|---|-----|-------|---|---|
| Zimbabwe Platinum Mines Limited (Zimplats) | Ngezi mine, Selous metallurgical complex (mill/smelter) | 413 | 1 470 | ? | S |
|--|---|-----|-------|---|---|

Remarks: PGM operation producing by-product nickel. Tonnage reported is "nickel sales" and may be less than the Ni contained in matte. Trial u/g mine test of 0.2 Mt under way, producing 75 000 t in 2003; pit produced 2 Mt. Bankable feasibility study under way of proposed first phase 1-Mt/y u/g mine and concentrator starting production in 2005 with expanded output and new smelter in Phase 2. Ore trucked 77 km from Ngezi mine to Selous metallurgical site for processing. Tonnage milled in 2003 was 1.96 Mt. Smelter output sent to Impala for refining (Impala owns 83% interest). Zimplats owns 70% of Makwiro Platinum Mines (Private), which holds 100% of Mimosa Mining Company (Pvt) Limited, the operator of the Ngezi mine and Selous mill and smelter.

Source: Company reports.

– Nil; (e) Author's estimate; (r) Revised.

Ch = Ni content in Ni chemicals such as nickel sulphate, nickel chloride, etc.

Co = cobalt

FeNi = ferronickel

I = Class I Ni (e.g., cathodes, briquettes, pellets, powders, etc., which have a Ni content of 99% or more)

II = Class II Ni (e.g., products with a Ni content of less than 99% such as FeNi, NiO, UTILITY™ Ni)

L = laterite ore

M = matte

NiO = nickel oxide

S = sulphide concentrates

SO = sulphide ore mined

T = Ni intermediates such as Ni carbonates, Ni sulphides or Ni hydroxides

Note: Cobalt Development Institute data for cobalt production used when producer data not available or are listed as sales or deliveries.

**TABLE 7. CANADIAN NICKEL PROCESSING CAPACITY, 2003**

|  | Smelter                   | Refinery |
|--|---------------------------|----------|
|  | (t/y of contained nickel) |          |
| Falconbridge Limited<br>Sudbury, Ontario                       | 70 000                    | n.a.     |
| Inco Limited   |                           |          |
| Sudbury, Ontario (1)   | 100 000                   | 59 000   |
| Sudbury, Ontario (2)   | 18 000                    | n.a.     |
| Thompson, Manitoba (3)   | n.a.                      | 55 000   |
| The Cobalt Refinery Company Inc.<br>Fort Saskatchewan, Alberta | n.a.                      | 32 000   |
| Canmine Resources Corporation (4)<br>Cobalt, Ontario           | n.a.                      | 300      |

Source: Natural Resources Canada.

n.a. Not applicable.

(1) Smelter feed capacity increased to 4540 t/d (5000 st/d) in 2003.

(2) Produces nickel oxides sinter. (3) Thompson smelter capacity listed at 63 000 t/y in 2001. (4) Plant shut by financial problems before capacity could be verified; production to have been by-product nickel in salts.

**TABLE 8. TOP SIX PRODUCERS OF MINE NICKEL, (1) 2000-2003**

|                       | 2000         | 2001   | 2002    | 2003  |
|-----------------------|--------------|--------|---------|-------|
|                       | (000 tonnes) |        |         |       |
| Russia                | 235          | 235    | 235     | 240   |
| Australia             | 166          | 205    | (r) 208 | 180   |
| Canada                | 191          | 194    | 188     | 164   |
| New Caledonia         | 118          | 118    | 100     | 112   |
| Indonesia             | 98           | 102    | 122     | 144   |
| Cuba                  | 71           | (r) 77 | 77      | 78    |
| Other                 | 879          | 930    | 930     | 918   |
| Total                 | 1 174        | 1 224  | 1 247   | 1 264 |
| Top 6 as a % of total | 75%          | 76%    | 75%     | 73%   |

Source: INSG *World Nickel Statistics* (June 2004).

(r) Revised.

(1) Ni content of sulphide concentrates or Ni content of lateritic ore mined.

Note: Totals may not add due to independent rounding.

**TABLE 9. TOP SIX PRODUCERS OF PRIMARY NICKEL, 2000-2003**

|                       | 2000         | 2001  | 2002  | 2003  |
|-----------------------|--------------|-------|-------|-------|
|                       | (000 tonnes) |       |       |       |
| Russia                | 221          | 252   | 239   | 260   |
| Japan                 | 161          | 154   | 158   | 165   |
| Australia             | 110          | 128   | 132   | 128   |
| Canada                | 134          | 141   | 145   | 124   |
| Norway                | 59           | 68    | 68    | 77    |
| China                 | 51           | 50    | 54    | 65    |
| Other                 | 736          | 793   | 796   | 819   |
| Total                 | 1 082        | 1 160 | 1 182 | 1 201 |
| Top 6 as a % of total | 68%          | 68%   | 67%   | 68%   |

Source: INSG *World Nickel Statistics* (June 2004).

Note: Totals may not add due to independent rounding.

**TABLE 10. LEADING SIX USERS OF PRIMARY NICKEL,  
2000-2003**

|                       | 2000         | 2001  | 2002  | 2003  |
|-----------------------|--------------|-------|-------|-------|
|                       | (000 tonnes) |       |       |       |
| Japan                 | 200          | 162   | 191   | 193   |
| China                 | 62           | 83    | 94    | 125   |
| United States         | 150          | 129   | 121   | 120   |
| Germany               | 104          | 110   | 107   | 100   |
| Taiwan                | 90           | 81    | 91    | 97    |
| South Korea           | 78           | 75    | 83    | 95    |
| Other                 | 684          | 640   | 687   | 750   |
| Total                 | 1 123        | 1 104 | 1 177 | 1 233 |
| Top 6 as a % of total | 61%          | 58%   | 58%   | 59%   |

Source: INSG *World Nickel Statistics* (June 2004).

Note: Totals may not add due to independent rounding.

**TABLE 11. AVERAGE ANNUAL  
NICKEL PRICES, 1981-2003**

|      | Settlement Price |                           |
|------|------------------|---------------------------|
|      | (US\$/t)         | (converted<br>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 | 6 015            | 2.73                      |
| 2000 | 8 641            | 3.92                      |
| 2001 | 5 948            | 2.70                      |
| 2002 | 6 772            | 3.07                      |
| 2003 | 9 640            | 4.37                      |

Sources: INSG *World Nickel Statistics* (various issues); Metalprices.com; *Metal Bulletin*.

Note: Conversion to US\$/lb by dividing US\$/t price by 2204.62 lb per tonne.

**TABLE 12. AVERAGE MONTHLY NICKEL PRICES, SETTLEMENT PRICE, 1997-2003**

|           | 1997                   | 1998  | 1999  | 2000   | 2001  | 2002  | 2003   |
|-----------|------------------------|-------|-------|--------|-------|-------|--------|
|           | (US \$/t)              |       |       |        |       |       |        |
| January   | 7 047                  | 5 495 | 4 272 | 8 314  | 6 999 | 6 047 | 8 030  |
| February  | 7 737                  | 5 390 | 4 630 | 9 658  | 6 528 | 6 033 | 8 627  |
| March     | 7 899                  | 5 399 | 5 015 | 10 284 | 6 138 | 6 541 | 8 382  |
| April     | 7 318                  | 5 397 | 5 106 | 9 731  | 6 334 | 6 962 | 7 914  |
| May       | 7 485                  | 5 023 | 5 403 | 10 134 | 7 064 | 6 764 | 8 334  |
| June      | 7 065                  | 4 479 | 5 198 | 8 415  | 6 645 | 7 123 | 8 858  |
| July      | 6 838                  | 4 329 | 5 704 | 8 168  | 5 940 | 7 146 | 8 866  |
| August    | 6 763                  | 4 084 | 6 452 | 8 010  | 5 525 | 6 720 | 9 355  |
| September | 6 507                  | 4 106 | 7 031 | 8 642  | 5 030 | 6 644 | 9 969  |
| October   | 6 383                  | 3 875 | 7 325 | 7 683  | 4 828 | 6 808 | 11 052 |
| November  | 6 142                  | 4 135 | 7 953 | 7 344  | 5 082 | 7 317 | 12 091 |
| December  | 5 949                  | 3 881 | 8 087 | 7 319  | 5 268 | 7 197 | 14 170 |
|           | (converted to US\$/lb) |       |       |        |       |       |        |
| January   | 3.20                   | 2.49  | 1.94  | 3.77   | 3.17  | 2.74  | 3.64   |
| February  | 3.51                   | 2.44  | 2.10  | 4.38   | 2.96  | 2.74  | 3.91   |
| March     | 3.58                   | 2.45  | 2.27  | 4.66   | 2.78  | 2.97  | 3.80   |
| April     | 3.32                   | 2.45  | 2.32  | 4.41   | 2.87  | 3.16  | 3.59   |
| May       | 3.40                   | 2.28  | 2.45  | 4.60   | 3.20  | 3.07  | 3.78   |
| June      | 3.20                   | 2.03  | 2.36  | 3.82   | 3.01  | 3.23  | 4.02   |
| July      | 3.10                   | 1.96  | 2.59  | 3.70   | 2.69  | 3.24  | 4.02   |
| August    | 3.07                   | 1.85  | 2.93  | 3.63   | 2.51  | 3.05  | 4.24   |
| September | 2.95                   | 1.86  | 3.19  | 3.92   | 2.28  | 3.01  | 4.52   |
| October   | 2.90                   | 1.76  | 3.32  | 3.48   | 2.19  | 3.09  | 5.01   |
| November  | 2.79                   | 1.88  | 3.61  | 3.33   | 2.31  | 3.32  | 5.48   |
| December  | 2.70                   | 1.76  | 3.67  | 3.32   | 2.39  | 3.26  | 6.43   |

Sources: INSG, various issues of *World Nickel Statistics* to April 2002; Metalprices.com; *Metal Bulletin*.  
 Note: Conversion to US\$/lb by dividing US\$/t price by 2204.62 lb per tonne.

**TABLE 13. REFINED COBALT PRODUCTION AND STOCKPILE DELIVERIES, 1997-2003**

| Company  | 1997   | 1998   | 1999   | 2000      | 2001      | 2002      | 2003      |
|--|--------|--------|--------|-----------|-----------|-----------|-----------|
| (tonnes)   |        |        |        |           |           |           |           |
| <b>PRODUCTION OF COMPANIES BELONGING TO THE COBALT DEVELOPMENT INSTITUTE</b> |        |        |        |           |           |           |           |
| OMG  | 5 000  | 5 250  | 6 200  | 7 700     | 8 100     | 8 200     | 7 990     |
| Russia   | 3 800  | 3 700  | 4 000  | 4 100     | 4 600     | 4 200     | 4 654     |
| China  | 1 200  | 1 200  | 1 200  | 1 200     | 1 470     | 1 842     | (d) 4 576 |
| Falconbridge   | 3 417  | 3 851  | 4 009  | 3 433     | 3 314     | 3 993     | 4 556     |
| Zambia (a)   | 3 949  | 5 011  | 3 946  | (c) 2 316 | (c) 2 789 | (c) 4 344 | (c) 4 570 |
| ICCI   | 2 250  | 2 640  | 2 770  | 2 855     | 2 943     | 3 065     | 3 141     |
| Mopani Copper  |        |        |        | 1 026     | 1 876     | 1 800     | 2 050     |
| Murrin Murrin  |        |        | 83     | 925       | 1 452     | 1 838     | 2 039     |
| QNI  | 617    | 1 395  | 1 539  | 1 520     | 1 818     | 1 863     | 1 800     |
| Umicore (1)  | 1 200  | 1 200  | 950    | 1 110     | 1 090     | 1 135     | 1 704     |
| Gécamines (b)  | 2 808  | 4 490  | 5 180  | 4 320     | 3 199     | 2 149     | 1 200     |
| CTT  | 220    | 241    | 470    | 1 200     | 1 200     | 1 100     | 1 100     |
| Brazil   | 266    | 364    | 630    | 792       | 889       | 960       | 1 097     |
| Inco   | 1 500  | 1 740  | 1 420  | 1 470     | 1 450     | 1 480     | 1 000     |
| Sumitomo   | 263    | 329    | 221    | 311       | 350       | 354       | 379       |
| South Africa   | 294    | 320    | 320    | 320       | 252       | (e) 250   | 307       |
| India  | 110    | 120    | 120    | 206       | 250       | 270       | 255       |
| Eramet   | 159    | 172    | 180    | 204       | 199       | 176       | 181       |
| Kasese   |        |        | 77     | 420       | 634       | (e) 450   | –         |
| Bulong   |        |        | 79     | 192       | 203       | (e) 200   | –         |
| Subtotal   | 27 053 | 32 023 | 33 394 | 35 621    | 38 078    | 39 669    | 42 599    |
| <b>STOCKPILE DELIVERIES</b>  |        |        |        |           |           |           |           |
| DLA  | 1 621  | 2 310  | 1 679  | 3 083     | 1 893     | 1 284     | 1 987     |
| <b>TOTAL COBALT AVAILABILITY</b>   |        |        |        |           |           |           |           |
| Grand total  | 28 674 | 34 333 | 35 073 | 38 704    | 39 971    | 40 953    | 44 586    |

Source: Data reproduced with permission of The Cobalt Development Institute from *Cobalt News* of April 2001, April 2002, April 2004, and updated by CDI subsequent to April 2004.

"Refined cobalt" includes:

All cobalt units whether in metal or chemicals that are derived from feed requiring further refining.

Production from Likasi and lower-grade production from Moroccan mines are not counted as "feed" or as production.

(a) Zambian production includes ZCCM, RAMZ, and Avmin for 1996-99; then only Chambishi Metals.

(b) Revised to include Central Mining Group.

(c) Chambishi Metals plc production only.

(d) Chinese production excludes that produced by Umicore in China, which is included in their figure in the table.

(e) Estimate.

(1) Union Minière SA changed its name to Umicore.

ICCI = International Cobalt Company Inc. (marketed by Sherritt International Corporation)

OMG = OM Group, Inc.

CTT = Cie. de Tifnout-Tiranimine

DLA = Defense Logistics Agency

ZCCM = Zambia Consolidated Copper Limited

RAMZ = Roan Antelope Mining Corporation

Gécamines = La Générale des Carrières et des Mines

Mopani Copper = Mopani Copper Mines plc (a JV comprising the Mufilira mine/smelter/refinery plus the Nkana mine and cobalt plant)

**TABLE 14. NICKEL, NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BEFORE 2015, AS PUBLISHED BY THE USGS, 2002**

| Projected First Year of Production | Country and State/Province   | Project and Company  | Resource Grade       | Estimated Resources        | Annual Production Capacity of Contained Nickel | Nickel Product                      |
|------------------------------------|------------------------------|--|----------------------|----------------------------|--|-------------------------------------|
|                                    |                              |  | (%)                  | (000 t) (1)                | (tonnes)                                       |                                     |
| 2004                               | Turkey, Manisa               | Caldag, European Nickel plc.   | 1.40                 | 44 000                     | 20 000   | Ore and concentrate                 |
| 2005                               | Philippines, Mindanao        | Adlay, BHP Billiton plc.   | 1.61                 | 6 000                      | 5 000  | Ore                                 |
|                                    | Philippines, Palawan         | Rio Tuba, Coral Bay Nickel Corp.   | 1.26                 | 16 000                     | 10 000   | Ni-Co sulphide                      |
| 2006                               | Australia, Western Australia | Ravensthorpe, BHP Billiton plc.  | 0.80                 | 150 000                    | 45 000   | Ni-Co hydroxide                     |
|                                    | New Caledonia                | Goro, Inco Ltd., Bureau de Recherches Geologiques et Minières, and Sumitomo consortium           | 1.57                 | 200 000                    | 55 000   | Ni oxide                            |
| 2007                               | Madagascar                   | Ambatovy, Dynatec Corp. and Phelps Dodge Corp.   | 1.10                 | 210 000                    | 50 000   | Metal                               |
|                                    | New Caledonia                | Koniambo, Falconbridge Ltd. and Société Minière du Sud Pacifique S.A.                            | 2.57                 | 150 000                    | 60 000   | Ferronickel                         |
| 2008                               | Brazil, Para                 | Vermelho, Companhia Vale do Rio Doce   | 1.23                 | 220 000                    | 45 000   | Metal or oxide                      |
| 2009                               | Brazil, Para                 | Onca-Puma, Canico Resource Corp.   | 2.22                 | 33 000                     | 25 000   | Matte or oxide                      |
|                                    | Cuba, Holguin                | Pinares de Mayari West, Government of Cuba   | 1.10                 | 200 000                    | 40 000   | Metal or oxide                      |
|                                    | Indonesia, Maluku            | Gag Island, BHP Billiton plc. and PT Aneka Tambang   | 1.35                 | 240 000                    | 30 000   | Intermediate, metal, or ferronickel |
| 2010                               | Cuba, Camaguey               | San Felipe, BHP Billiton plc. and Government of Cuba   | 1.30                 | 250 000                    | 45 000   | Metal or oxide                      |
|                                    | Indonesia, Halmahera Island  | Weda Bay, Weda Bay Minerals, Inc. and PT Aneka Tambang   | 1.35                 | 220 000                    | 48 000   | Ni-Co sulphide                      |
|                                    | New Caledonia                | Nakety-Bogota, Argosy Minerals, Inc. and Société des Mines de la Tontouta                        | 1.47<br>1.50         | 88 000<br>140 000          | 52 000   | Ni-Co intermediate                  |
| 2011                               | Australia, Western Australia | Mount Margaret, Anaconda Nickel Ltd.   | 0.78                 | 170 000                    | 45 000   | Ni-Co hydroxide                     |
| 2012                               | Australia, New South Wales   | Syerston, Black Range Minerals Ltd.  | 0.65                 | 96 000                     | 18 000   | Ni-Co sulphide concentrate          |
|                                    | Australia, Queensland        | Marlborough, Preston Resources Ltd.  | 1.02                 | 210 000                    | 25 000   | Metal                               |
| 2013                               | Papua New Guinea             | Ramu River, Highlands Pacific Ltd. and Orogen Minerals Ltd.                                      | 0.91<br>1.01         | 76000<br>67000             | 33 000   | Metal                               |
|                                    | Philippines, Mindoro Island  | Sablayan, Crew Development Corp.   | 0.94                 | 72 000                     | 40 000   | Metal                               |
| 2014                               | Australia, Western Australia | North Kalgoorlie – Ghost Rocks, Goongarrie, and Kalpini, Heron Resources Ltd.                    | 1.24                 | 110 000                    | 45 000   | Concentrate                         |
| 2015                               | Brazil, Goias                | Barro Alto, Anglo American plc.  | 1.20                 | 120 000                    | 40 000   | Ferronickel                         |
|                                    | Ivory Coast                  | Biankouma, Touba, and Sipilou, Falconbridge Ltd. and Société d'État pour le Développement Minier | 1.48                 | 260 000                    | 45 000   | Ni-Co intermediate or ferronickel   |
|                                    | Papua New Guinea             | Wowo Gap, Resource Mining Corp. Ltd.   | 1.09<br>1.44<br>1.02 | 31 000<br>18 000<br>18 000 | 45 000   | Metal                               |

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Sources: Company annual reports, presentations, and press releases; CRU International, Ltd.

(1) Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits.

**TABLE 15. NICKEL, NEW SULPHIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BEFORE 2015, AS PUBLISHED BY THE USGS, 2002**

| Projected First Year of Production | Country and State/Province        | Project and Company   | Resource Grade       | Estimated Resources     | Annual Production Capacity of Contained Nickel | Nickel Product  |
|------------------------------------|-----------------------------------|---|----------------------|-------------------------|--|---|
|                                    |                                   |   | (%)                  | (000 t) (1)             | (tonnes)                                       |   |
| 2002                               | Zimbabwe, Mhondoro region         | Ngezi platinum, Makwiro Platinum Mines (Pvt.) Ltd. and Zimbabwe Platinum Mines Ltd. | 0.12                 | 32 000                  | 1 300  | Matte   |
| 2003                               | Australia, Western Australia      | Cosmos Deeps, Jubilee Mines NL  | 7.20<br>3.90         | 520<br>110              | 10 000   | Concentrates  |
| 2004                               | Australia, Western Australia      | Forrestania-New Morning and Diggers South, Western Areas NL                         | 1.63                 | 3 000                   | 3 000  | Concentrates  |
|                                    | Australia, Western Australia      | Maggie Hays, LionOre Australia Ltd.   | 1.47                 | 12 000                  | (2)  | Concentrates  |
|                                    | Australia, Western Australia      | Sally Malay, Sally Malay Mining Ltd.  | 1.80                 | 4 000                   | 8 000  | Concentrates  |
|                                    | Canada, Ontario                   | McCreedy West/Levack, FNX Mining, Inc. and Dynatec Corp.                            | 1.91<br>1.90<br>1.80 | 1 200<br>2 700<br>2 400 | 7 000  | Ore   |
|                                    | Spain, Extremadura Province       | Aguablanca, Rio Narcea Gold Mines Ltd.  | 0.67                 | 23 000                  | 10 000   | Concentrates  |
| 2005                               | Canada, Ontario                   | Montcalm, Falconbridge Ltd.   | 1.48                 | 7 700                   | 8 000  | Concentrates  |
| 2006                               | Canada, Newfoundland and Labrador | Voisey's Bay, Inco Limited  | 2.88<br>1.29         | 31 000<br>97 000        | 50 000   | Concentrates, initially                               |
| 2007                               | Canada, Ontario                   | Norman, FNX Mining, Inc. and Dynatec Corp.  | 0.95                 | (3)                     | ..   | Ore   |
| 2008                               | Australia, Western Australia      | Honeymoon Well, Mining Project Investors Pty. Ltd. and OM Group, Inc.               | 0.82                 | 140 000                 | 30 000   | Concentrates, initially                               |
|                                    | Australia, Western Australia      | Yakabindie, WMC Ltd.  | 0.56                 | 290 000                 | 32 000   | Ore   |
|                                    | Canada, Ontario                   | Nickel Rim South, Falconbridge Ltd.   | 1.70                 | 6 300                   | 10 000   | Concentrates  |
|                                    | United States, Minnesota          | Mesaba, Teck Cominco American, Inc.   | 0.12                 | 300 000                 | 20 000   | By-product concentrate of Ni-Co sulphide or hydroxide |
| 2009                               | Tanzania, Kagera region           | Kabanga, Barrick Gold Corp.   | 2.18                 | 21 000                  | 17 000   | Concentrates  |
| 2011                               | Canada, Manitoba                  | Maskwa, Canmine Resources Corp.   | 1.27                 | 2 900                   | 3 800  | Concentrates  |

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Sources: Company annual reports, presentations, and press releases; CRU International, Ltd.

.. Not available.

(1) Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits.