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# 2005 Minerals Yearbook

## NICKEL

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# NICKEL

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Stainless steel accounted for more than 60% of primary nickel consumption in the world (Nickel Institute, 2007§[1]). However, in the United States, this percentage was only 42% because of the relatively large number of specialty metal industries and readily available stocks of scrap. Cupronickel alloys, plating, high-temperature nickel-chromium alloys, naval brasses, and superalloys and related aerospace alloys are some of the specialty uses. Nickel metal foam is increasingly being used in the manufacture of rechargeable batteries.

Largely fueled by increased use of stainless steel worldwide and strong economic growth in China, global nickel demand has grown 2% to 8% per year since 2001. World usage of stainless steel weakened during the second half of 2005 but resumed its upward movement in early 2006 (Inco Limited, 2006a, p. 22-29). Demand for nickel in batteries has grown dramatically since 1995, but still accounts for less than 5% of world nickel demand. The world nickel industry was operating close to capacity in 2005, although a few producers experienced production disruptions owing to feed material shortages, inclement weather, and labor problems.

## Legislation and Government Programs

***Decontamination of Radioactive Nickel Metal.***—The U.S. Department of Energy (DOE) was exploring ways of recycling 13,900 metric tons (t) of radioactively contaminated nickel. The contaminated nickel was recovered during the decommissioning of uranium enrichment and related processing facilities at former nuclear defense sites. Much of the nickel is volumetrically contaminated with uranium and trace quantities of technetium-99, neptunium-237, and plutonium-239. DOE had about 8,800 t of metal ingot, typically assaying 99.96% nickel and 0.85 grams per metric ton (g/t) technetium stored at Paducah, KY. An additional 5,100 t of shredded nickel scrap was stored at Oak Ridge, TN (U.S. Department of Energy, 2007).

***New U.S. Coinage.***—As part of the 50 State Quarters™ Program, the U.S. Mint produced 3.01 billion commemorative quarters (25-cent coins) in 2005, up from 2.40 billion in 2004. A total of 26.72 billion of the cupronickel clad coins were minted between December 1998 and December 2005. Between 34 billion and 42 billion quarters will have been minted when the program ends in December 2008, down from previous forecasts. Since each coin weighs 5.67 grams (g) and contains 8.33% nickel, 1,423 t of nickel was used in the five commemoratives released in 2005 (U.S. Mint, 2007b§).

The U.S. Mint began releasing the golden-colored Sacagawea dollar coin in January 2000 and by yearend 2004 had struck 1.45 billion of the manganese brass-clad coins. An additional 5 million were made in 2005, excluding San Francisco proofs. The dollar coin contains 2.0% nickel and weighs 8.1 g. The U.S. Mint began modifying the Jefferson nickel (5-cent coin) in late 2003 (Public Law 108-15). There were two new designs released in 2005. Each coin weighs 5.0 g and comprises solid cupronickel with a nickel content of 25%. The Mint produced 1.74 billion of the new Jefferson nickels in 2005 (U.S. Mint, 2005§; 2007a§).

***Exploration and Development.***—**Alaska.**—Several companies were actively exploring for copper, nickel, and platinum-group elements (PGEs) in southeastern Alaska. Freegold Ventures Limited, Lonmin Plc (South Africa), and Pacific North West Capital Corp. were evaluating a mineralized ultramafic complex at Union Bay, 56 kilometers (km) north of Ketchikan (Freegold Ventures Limited, 2005; Pacific Northwest Capital Corp., 2005). Quattera Resources Inc. continued to evaluate several copper-nickel-PGE prospects on Duke Island, off the southwestern corner of Misty Fjords National Monument. The Duke Island complex consists of two separate, zoned ultramafic bodies—Judd Harbour and Hall Cove (Avalon Development Corporation, 2006).

**Michigan.**—There are no active underground metal mines operating in Michigan. However, this situation may change if the Michigan Department of Environment Quality (DEQ) recommends that the State issue a mining permit to the Kennecott Eagle Minerals Company. The proposed operation would be the only primary nickel mine in the United States.

In 2002, Kennecott Exploration (a subsidiary of London-based Rio Tinto Plc) discovered a relatively small, but high-grade copper-nickel deposit in Marquette County on the Upper Peninsula. Kennecott geologists estimated that the deposit contained 4 million metric tons (Mt) of sulfide ore grading 3.6% nickel and 3.1% copper. In April 2004, the exploration company's immediate parent, the Kennecott Minerals Company (Salt Lake City, UT) assumed responsibility for the newly named Eagle Project and launched a feasibility study (Jackman, 2005).

**Minnesota.**—PolyMet Mining Corp. of Vancouver, British Columbia, Canada, was seeking final regulatory approval to develop a copper-nickel-PGE deposit in northeastern Minnesota. The 250-Mt sheet-like deposit of disseminated chalcopyrite, pentlandite, and other sulfides lies on the western edge of the Duluth Complex, near the towns of Babbitt and Hoyt Lakes. The strip mine proposed by PolyMet would initially produce 25,000 metric tons per day (t/d) of ore and have a design capacity of 32,000 t/d. The ore would be shipped to the former Cliffs Erie mill near Hoyt Lakes for crushing, grinding, and subsequent flotation. In November, PolyMet purchased key parts of the mothballed taconite plant from Cleveland-Cliffs Inc and was planning to construct a state-of-the-art autoclave near

[1]References that include a section mark (§) are found in the Internet References Cited section.

the existing concentrator. The proposed facility would produce 33,000 metric tons per year (t/yr) of copper cathode, 7,800 t/yr of nickel plus cobalt in a mixed hydroxide precipitate, and 3.73 t/yr (120,000 troy ounces per year) of contained gold and PGE in a precious metals precipitate. The NorthMet project could be operational by yearend 2008 (Murray, 2005; PolyMet Mining Corp., 2005§).

## Production

***Byproduct Production.***—The United States did not have any active nickel mines in 2005. Except for limited quantities of byproduct nickel that were recovered at some copper and precious metal refineries, imports or recycling met all needs. In 2005, Stillwater Mining Company (majority owned by MMC Norilsk Nickel Group of Russia) shipped 685 t of nickel in crystalline sulfate (Stillwater Mining Company, 2006, p. 1-2;10-K wrap, p. 9-17). The company mines PGE ore associated with the J-M reef in Montana's Beartooth Mountains. The company's two mills (Nye and East Boulder) together processed 1.17 Mt of ore and subgrade material in 2005, with a combined mill head grade of 16 g/t of palladium and platinum. Concentrates from the two mills were being trucked to the company's smelting and refining complex at Columbus, MT, where a filter cake containing 50% to 55% PGE by weight was produced. The crystalline nickel sulfate is a refinery byproduct and contains minor amounts of cobalt.

ASARCO LLC (wholly owned by Grupo México, S.A. de C.V.) also produced limited quantities of byproduct nickel sulfate at its Amarillo copper refinery in Texas.

Limited tonnages of primary nickel are recovered during the refining of some crude oils where it occurs as porphyrins or other organometallic compounds. The nickel content of crude oil is quite variable and reflects several factors, such as density of the oil, the sulfur content of the oil, the field location, geologic occurrence, and geologic age. The nickel is concentrated in flexicoke and other petroleum refinery residues; fly ash, ash sludge, slag, and boiler scale produced at oil-fired powerplants; and spent petroleum refinery catalysts.

***Secondary Production.***—International Metals Reclamation Company Inc. (a subsidiary of Inco Limited) continued to produce nickel-chromium-iron remelt alloy at its metals recovery facility in Ellwood City, PA. Feed materials included chromium and nickel wastes generated by the stainless steel industry; as well as filter cakes, solutions, and sludges from the plating industry; refractory brick; spent catalysts; and spent nickel-base batteries.

Nickel can also be recovered from spent catalysts. However, extraction of nickel from catalysts is complex and has not been economic in some situations. Gulf Chemical and Metallurgical Corp. of Freeport, TX, was one of a limited number of companies worldwide that processed spent catalysts from petroleum refineries in 2005. The Freeport facility can treat nickel/molybdenum and cobalt/molybdenum hydrotreating catalysts that have been "poisoned" by nickel and vanadium in the porphyrin molecules of crude oil. Gulf Chemical converts the byproduct nickel residue to a crude nickel-cobalt alloy in an electric furnace, and then sells the alloy to nickel refineries.

## Consumption

In 2005, world usage of primary nickel was reported to be 1.24 Mt, down slightly from the alltime high of 1.25 Mt reached in 2004 (International Nickel Study Group, 2006). Most nickel producers continued to operate at full capacity. Demand was buoyed by spiraling apparent consumption in China, which had risen to 198,900 t in 2005 from 43,400 t in 1999. The European Union (EU) steel industry was the leading consumer of primary nickel, followed by its counterparts in Japan and China in order of importance (Eramet Group, 2006, appendix p. 1-3).

U.S. apparent consumption of primary nickel was 136,000 t, or about 11% of world demand. U.S. industry reported consumption of an additional 77,300 t of nickel in scrap. Within the United States, the share of primary nickel consumed in the production of stainless and alloy steels decreased slightly to 46% in 2005 from 47% (revised) in 2004. The meltshop of North American Stainless (NAS) in Ghent, KY, produced 768,000 t of stainless steel slabs—11% more than that of the previous year. NAS, which started up in 2002, is a wholly owned subsidiary of Acerinox, S.A. of Madrid, Spain—the third largest stainless steel producer in the world (Acerinox, S.A., 2006, p. 95-97).

U.S. demand for most nonferrous alloys began to strengthen. Markets for copper-nickel alloys were especially hard hit in 2003, but recovered somewhat in 2004 and 2005. Consumption for superalloys—key fabrication materials for jet engines—increased by 4% compared with that of 2004. Robust sales of superalloys to the defense sector partially offset low growth in sales to civil aircraft manufacturers (Napier, 2005).

The estimated value of apparent primary nickel consumption in the United States was $2.01 billion, up from $1.77 billion in 2004—an increase of 13%. Apparent primary consumption increased by 6% from 128,000 t (revised). The increase in the value of primary consumption resulted from the combined effect of a 7% increase in the London Metal Exchange (LME) cash price and a moderate increase in primary consumption. Apparent primary consumption plus reported secondary consumption totaled 213,000 t.

***Stainless Steel and Low-Alloy Steels.***—In 2005, stainless steel producers accounted for 42% of primary nickel demand in the United States and more than 60% of primary demand in the world. Production of raw stainless steel (excluding production in China, Eastern Europe, and the Commonwealth of Independent States) has been increasing at a compound annual growth rate of 5.7% since 1950. Production grew to 22.08 Mt in 2004 from 14.98 Mt in 1995 (Inco Limited, 2006c, p. 4). In 2005, Western world stainless steel production declined by 5% to 20.95 Mt when stainless steelmakers realized that global production was temporarily outpacing usage despite the situation in China. This was the first year of lower output since 2001. Even with the 2005 correction, the stainless steel industry in the Western World experienced a compound annual growth rate of 3.4% for the 10-year period 1995-2005. A large part of the growth was in India, the Republic of Korea, and Taiwan, where additional melt capacity was being brought onstream to accommodate the projected growth in demand for stainless steel after 2007. There also has been a shift to increasingly larger meltshops, with seven

stainless steel companies now having meltshops with capacities larger than 900,000 t/yr. Since 2001, China has consumed more stainless steel annually than any other country. China consumed 5.58 Mt of stainless steel in 2005, with state-owned mills producing 1.94 Mt. Chinese imports of stainless steel totaled 3.13 Mt; exports, 0.40 Mt (Inco Limited, 2006c, p. 8-9, A-37-A-38).

Production of raw stainless steel and heat-resisting steel in the United States totaled 2.24 Mt in 2005, down 7% from that of 2004, which was the highest annual production ever recorded for the United States. Nickel-bearing grades accounted for 1.41 Mt or 63% of total stainless steel production in 2005 (American Iron and Steel Institute, 2006a, p. 70-75; b).

***Superalloys and Related Nickel-Base Alloys.***—Of the primary nickel consumed in the United States, 17% was used to make high-performance superalloys and related nickel-base alloys for the aerospace, electric power, and petrochemical industries. U.S. production of superalloys was up 4% from that of 2004 owing to improved sales to manufacturers of jet aircraft engines and other sectors of the aerospace industry.

In August, Precision Castparts Corp. (PCC) of Portland, OR, took steps to acquire Special Metals Corporation (SMC), a leading producer of nickel-base alloys and superalloys. PCC specializes in manufacturing large, complex structural investment castings, airfoil castings, and forged components used in jet aircraft engines and industrial gas turbines. At yearend, regulatory authorities were reviewing the proposed acquisition (Precision Castparts Corp., 2005).

In September, Allegheny Technologies Inc. (ATI) announced that it was expanding its premium-melt nickel-base alloy, superalloy, and specialty alloy capabilities by about 20%. ATI was in the process of upgrading and expanding its vacuum induction melting capacity. In addition, two new electro-slag remelt furnaces and three new vacuum arc remelt furnaces were to be added to the company's operations. ATI has begun selling Allvac 718Plus, a new patented, nickel-base superalloy, to manufacturers of gas turbines (Allegheny Technologies, 2005).

***Nickel-Base Batteries.***—U.S. demand for nickel in rechargeable batteries continued to increase. In 2005, most of the newer hybrid electric vehicles (HEVs) on U.S. highways were using nickel-metal hydride (NiMH) batteries to store the energy recovered from the vehicle's regenerative braking circuitry—a system that reduces overall fuel consumption. Most battery manufacturers were using either pasted foam or sintered electrodes in NiMH cell production (Wasmund, 2005). The first, newer type of electrode is formed by pasting nickel hydroxide into nickel metal foam—a skeleton-like material that resembles an air filter made of aluminum.

***Electric and Hybrid Electric Vehicles.***—Growing HEV sales in North America increased demand for nickel foam and specialty nickel metal powders, key NiMH battery components. Since 2000, about 392,000 new HEVs have been registered in the United States. Toyota Motor Corporation has produced more than 550,000 HEVs worldwide since 1997 and was expanding capacity at its plants in Japan to 300,000 units per year (Hybrid & Electric Vehicle Progress, 2005). In the United States, sales of gasoline-electric hybrid vehicles rose sharply in 2005. Nationwide registrations of new hybrid passenger vehicles rose to 199,148 in 2005, up 139% since 2004. The U.S. market for hybrids has grown by 2,460% since its commercial debut in 2000 (R.L. Polk & Co., 2006).

## Stocks

On December 31, U.S. consumer stocks of primary nickel totaled 6,640 t—16% more than the 5,750 t (revised) at yearend 2004. Stocks in LME warehouses dropped sharply during the first quarter of 2005, bottoming out at 6,024 t on April 30—the lowest level reported in more than 8 years. LME stocks, however, began building in the fall and ended the year at 36,042 t—72% more than reported at the end of 2004. Data collected by the International Nickel Study Group indicated that, at yearend 2005, world nickel producers (excluding those in Austria, China, Macedonia, Serbia, and the Ural area of Russia) had approximately 98,700 t of primary nickel stocks. About 69% or 68,400 t of the producer material was Class I materials—refined products with a nickel content of 99% or greater (electrolytic cathode, briquets, pellets, powder, rondelles, etc., in order of decreasing production). The remaining 31% was Class II materials, including ferronickel, oxide sinter, and East Asian utility nickel—products with a nickel content less than 99%. All stocks in LME warehouses are Class I (International Nickel Study Group, 2006).

## Prices

The January 2005 average cash price for 99.8% pure metal on the LME was $14,501 per metric ton ($6.578 per pound)—a relatively high price in historical terms. Nickel prices strengthened during the spring, with the monthly average peaking in May, at $16,920 per ton ($7.675 per pound). Prices declined during the summer and fall and eventually recovered in December to $14,738 per ton ($6.685 per pound). The average annual price was $14,738 per ton ($6.685 per pound)—7% greater than the 2004 average.

## World Industry Structure

At the beginning of 2005, the world's leading nickel producer was MMC Norilsk Nickel Group (Russia), followed by Inco (Canada). Other major producers were BHP Billiton Plc (United Kingdom), Eramet Group (France), Falconbridge Limited (Canada), and WMC Resources Ltd. (Australia). Three major developments during the year, however, triggered several acquisitions and mergers that spilled into 2006 and drastically changed corporate ownership of the nickel industry (McNish, 2006§).

BHP Billiton outbid Xstrata plc (Switzerland) for control of WMC Resources. The acquisition of WMC made BHP Billiton the third leading producer of nickel in the world, and negotiations continued into 2005. BHP Billiton named its new subsidiary Nickel West. Nickel West's nickel assets are concentrated in the State of Western Australia and include mining operations at Leinster and Mt. Keith, a concentrator at Kambalda fed by third party mines, a smelter at Kalgoorlie, and a refinery at Kwinana.

In an era of growing global nickel demand, several Chinese companies have moved to secure future supplies to meet

expected growth in demand on the Asian mainland. Chinese companies negotiated acquisitions, joint ventures, and supply contracts with mining companies in several nickel-rich countries, including Australia, Canada, Cuba, and Papua New Guinea. In September 2004, China Minmetals Corporation offered to buy Noranda Inc., a major Canadian mining company. At the time, Noranda owned almost 59% of Falconbridge, the third leading producer of refined nickel in the world, with key operations in Canada, the Dominican Republic, and Norway. In 2005, Falconbridge produced 113,554 t of refined nickel products—9% more than the previous record high of 104,410 t set in 2003 and 9% of world supply. Minmetals was in the process of transforming itself from a trading-oriented organization into a broadly based resource company. Noranda executives eventually rejected the Chinese offer and, in a dramatic turnaround in June, agreed to be taken over by Falconbridge (Falconbridge Limited, 2005a, p. 87-89; b).

In October, Inco announced that the company was launching a friendly takeover of its long-time competitor, Falconbridge. Falconbridge's Board of Directors agreed to support Inco's takeover. The combined organization would have retained the name, Inco Limited, and would have been the leading nickel producer in the world (Falconbridge Limited and Inco Limited, 2005). At yearend, the proposed takeover was bogged down in an international antitrust review, giving Xstrata time to prepare a competing bid and eventually prevail over Inco.

While Inco was trying to acquire Falconbridge, three other metal mining companies entered the picture—Companhia Vale do Rio Doce (CVRD) S.A. de C.V. (Brazil), Phelps Dodge Corporation (United States), and Teck Cominco Limited (Canada). All three wanted to assimilate Inco into their own base-metal operations. Their entry led to even more complex negotiations in 2006 (McNish, 2006§).

## World Review

***Australia.***—Australia was the third leading nickel-producing country in the world and was beginning to rival Canada. Most of the nickel properties under development were in Western Australia. Key events of 2005 are summarized in the nickel section of the State's Mineral and Petroleum Statistics Digest (Government of Western Australia, 2006, p. 19-20).

**Laterite Operations.**—Three nickel laterite mining and processing operations have been commissioned in the Kambalda-Goldfields region since 1998—Bulong, Cawse, and Murrin Murrin. Combined, the three will probably add about 60,000 t/yr of nickel to world production capacity. In 2005, Murrin Murrin, the largest of the three, produced 28,240 t of nickel, up from 27,950 t in 2004. Management efforts to resolve long-term maintenance issues will probably help boost Murrin Murrin's production in future years. Murrin Murrin is a joint venture of Minara Resources Limited (60% interest) and Glenmurrin Pty. Limited (40%), a subsidiary of Glencore International AG (Switzerland) (Minara Resources Limited, 2006, p. 7-13, 24).

In March 2004, BHP Billiton began developing its Ravensthorpe project in Western Australia and was increasing production capacity at its Yabulu nickel-cobalt refinery near Townsville, Queensland, to accommodate the output from Ravensthorpe. Inflationary pressures in Australia, material shortages, and shortages of skilled workers caused the capital cost of the integrated project to rise to $1.8 billion from the $1.4 billion originally budgeted in 2004. Of the $1.8 billion, about $1.3 billion was being used to develop the first of Ravensthorpe's three deposits and to build an onsite ore treatment facility. The remaining $460 million was being used to expand the Yabulu refinery, extending the life of the refinery by 25 years. The additional production could be available by yearend 2007. Yabulu will continue to process lateritic ores from other parts of the Asia-Pacific region. BHP Billiton has its own berth and ore handling facilities at the port of Townsville, 25 km southeast of the refinery. When the expansion is completed, Yabulu will be able to produce 76,000 t/yr of nickel and 3,500 t/yr of cobalt (BHP Billiton Plc, 2004; BHP Billiton Plc, 2006, p. 38, 93).

The Ravensthorpe minesite is about 45 km inland from Western Australia's Southern Coast and about 155 km west of the port of Esperance. Ravensthorpe had 118 Mt (dry) of proven ore reserves grading 0.75% nickel and 120 Mt (dry) of probable ore reserves grading 0.6% nickel (BHP Billiton Plc, 2006, p. 75). Ravensthorpe is designed to produce up to 220,000 t/yr of mixed nickel and cobalt hydroxide intermediate product. At yearend, much of the 55,000 cubic meters of concrete work had been completed, and the erection of some 70 chemical tanks was underway (Hellsten and Burvill, 2005).

**Sulfide Operations.**—Nickel West was the leading nickel producer in Western Australia. BHP Billiton created Nickel West in June to manage part of the assets acquired in the takeover of WMC. During the second half of 2005, Nickel West produced 31,700 t of nickel metal at Kwinana from concentrates smelted at Kalgoorlie. The Kalgoorlie smelter also produced 23,600 t of nickel in finished matte for export during the same 6-month period. About 45% of the concentrate came from the Mount Keith open pit mine in the Northern Goldfields region. The other 55% came from Leinster and third party mines at Kambalda. Nickel West was in the process of expanding its Mount Keith operation and was preparing to commission its new 11 Mile Well open pit (BHP Billiton, 2007, p. 14). Mount Keith had an estimated 213 Mt (dry) of proven and probable ore reserves (excluding stockpiles) averaging 0.54% nickel plus 140 Mt (dry) of additional resources averaging 0.50% nickel. Nickel West was reevaluating the undeveloped Yakabindie deposit, 25 km south of Mount Keith. Geologists estimated that the low-grade deposit had 248 Mt (dry) of indicated resources averaging 0.57% nickel (BHP Billiton Plc, 2006, p. 74-75).

***Brazil.***—In July, CVRD announced that it would begin developing the Vermelho nickel deposit in the Carajás region. The company's board of directors approved the expenditure of $1.2 billion for the project. Vermelho was being designed to produce 46,000 t/yr of metallic nickel and 2,800 t/yr of cobalt. A high-pressure acid leaching (HPAL) plant would be constructed onsite to extract nickel and cobalt from the lateritic ore. The proposed complex was scheduled to begin producing nickel hydroxide in the fourth quarter of 2008. Pilot-plant work has been underway in Western Australia since 2000 (Companhia Vale do Rio Doce, 2005a§). The final bankable feasibility study

was completed in March 2005, with the original cost estimate of $900 million increased by $300 million to compensate for price increases for equipment and infrastructure (Companhia Vale do Rio Doce, 2006). The Vermelho deposit is in the State of Pará, 70 km south of the Carajás iron mines, and has 290 Mt of proven and probable reserves of limonitic laterites averaging 0.8% nickel (Companhia Vale do Rio Doce, 2005b§).

Lakefield Oretest Pty. Ltd. has been conducting HPAL studies on the Vermelho ores at its research facilities near Perth in Western Australia. A team of CVRD and Oretest engineers had extracted at least 96% of the nickel in the limonitic ore during demonstration leaching campaigns. The purified nickel solution can be used to produce LME-grade cathode (Lakefield Oretest Pty. Ltd., 2005§). The finished products would be trucked 75 km to the Carajás Railroad for transport to the Atlantic Port of Ponta da Madeira.

***Canada.***—Key events of 2005 are summarized in the nickel chapter of the Canadian Minerals Yearbook (Bill McCutcheon, senior commodity advisor, Natural Resources Canada, written commun., 2006-07 and unpub. data, 2006).

**Manitoba and Nunavut.**—Inco's operations at Thompson produced 48,500 t of finished nickel in 2005, about 8% less than the record 53,000 t reported for 2004. Declining production at Thompson from local ores was offset by imports of nickel concentrate from Australia. In August, Inco management approved $34 million to develop a lower deposit in the Thompson Mine and to improve mine productivity. The smelter at Thompson was being upgraded to better handle concentrates from the new mill at Voisey's Bay, Labrador (Inco Limited, 2006b, p. 19-25).

**Newfoundland and Labrador.**—In September, Inco produced its first nickel and copper concentrates at Voisey's Bay (Inco Limited, 2005; 2006c, p. 38-39). Inco began infrastructure work at the mine site in 2003 after SNC Lavalin completed a bankable feasibility study. Construction of the Ovoid open pit and the 6,000-t/d concentrator was expected to cost between $528 million and $582 million. In October, Inco commissioned its $80 million hydrometallurgical demonstration plant at Argentia, Newfoundland, but at yearend management was still evaluating potential sites for the full-scale commercial plant. Inco did not expect to complete the third and final phase of the Voisey's Bay project before 2018. In November, the Voisey's Bay operation began shipping concentrates to the Sudbury and Thompson smelters.

**Ontario.**—Additional reserves were being developed in Ontario's Sudbury District. Several exploration projects were also underway, particularly in and around some older, largely depleted mines. In 2005, Inco's Ontario operations mined 8.75 Mt of ore with an average grade of 1.28% nickel and 1.38% copper. The division's milling operations produced 98,000 t of nickel in concentrates in 2005, some of which was tolled (Inco Limited, 2006a, p. 1-16; 2006b, p. 25). Falconbridge Limited[2], Sudbury's other principal producer, mined 2.17 Mt of ore with an average grade of 1.16% nickel and 1.26% copper (Xstrata plc, 2007§). FNX Mining Company Inc. continued to extract ore from the reopened McCreedy West Mine and put the adjoining gold and PGE-rich PM Deposit into commercial production. In February, FNX discovered two massive copper-nickel-PGE sulfide veins in the footwall of the Levack Mine. FNX shipped 459,000 t of ore in 2005 (FNX Mining Company Inc., 2006, p. 1-7).

Falconbridge's new Montcalm Mine near Timmins mined 757,000 t of ore averaging 1.52% nickel and treated 750,000 t at the company's Kidd mill, where 9,249 t of nickel in concentrate was recovered. Montcalm has 4.1 Mt of proven and probable reserves averaging 1.38% nickel and 0.64% copper (Xstrata plc, 2007).

**Quebec.**—More than 20 companies are actively exploring for copper, nickel, and PGEs in the Nunavik region of northern Quebec. Much of the work has focused on the Proterozoic Cape Smith fold belt at the tip of the Ungava Peninsula. Exploration of the fold belt has accelerated since 2003 owing to high nickel prices, the continuing success of the Raglan Mine near Katinniq, and the discovery of sulfide mineralization west of Lac Chukotat. Canadian Royalties Inc., Cascadia International Resources Inc., Goldbrook Ventures Inc., Knight Resources Ltd., and Novawest Resources Inc. are just a few of the companies that have been drilling promising pyroxenite and peridotite complexes within the belt.

In 2005, the Raglan Mine, owned by Falconbridge, produced 22,917 t of nickel in concentrate, 14% less than the 26,552 t recovered in 2004. At yearend 2004, Raglan had 17.7 Mt of proven and probable reserves averaging 2.86% Ni and 0.78% Cu.

Knight Resources and its partner, Anglo American Exploration (Canada) Limited (AAEC), have been exploring a 720-square-kilometer area 90 km west of the Raglan property since 2003. Knight Resources has earned a 49% interest in the West Raglan Project operated by AAEC. The partnership has decided to refocus its attention on a 3-km by 1-km tract known as the Greater Frontier area. One particular drill hole intersected multiple mineralized zones with nickel values ranging from 0.26% to 3.37% (Knight Resources Ltd., 2005).

In 2001, Canadian Royalties optioned the Expo-Ungava property south of Raglan. By yearend 2005, Canadian Royalties had identified 11.1 Mt of indicated resources averaging 1.0% nickel and 1.2% copper in the area. The expanded program, now known as the Raglan South Nickel Project, led to the discovery of the Mesamax deposit in 2002, the Lac Mequillon deposit in 2003, and the Ivakkak deposit in late 2005. The company began constructing a 15-km-long road from the Mesamax deposit to the existing road network, providing access to the ports of Deception Bay and Douglas Harbour (Canadian Royalties Inc., 2006, p. 8-12).

***China.***—Chinese demand for nickel has risen dramatically since 1999. Demand for primary forms of nickel was estimated to have reached 188,500 t in 2005, 26% more than in 2004 (Eramet Group, 2006, Appendix, p. 38). Several Chinese companies have greenfield joint ventures with foreign nickel suppliers—ventures that include the Kunshun nickel chemical plant near Shanghai and a state-of-the-art nickel foam project at Dalian. In March, Jinchuan Group Limited, China's leading nickel producer, began receiving nickel matte from Nickel West's Kalgoorlie smelter under a 5-year contract signed in August 2003. The contract calls for Nickel West to export 120,000 t of nickel-in-matte to Jinchuan between 2005 and 2010 (McCutcheon, 2005, p. 23).

[2]Xstrata plc acquired Falconbridge Limited on November 1, 2006.

The Chinese stainless steel industry currently accounts for about 46% of the country's primary nickel demand. Chinese production of stainless steel increased more than 7-fold between 1999 and 2005. Taiyuan Iron & Steel (Group) Company Ltd. (TISCO) and the Baosteel Group accounted for more than 50% of the country's stainless steel melting production (Inco Limited, 2006c, p. 4, 19-20). The country had at least eight melt shop expansions or greenfield projects underway. In April 2004, Baosteel Group commissioned a 750,000-t/yr meltshop at its No. 1 works in Shanghai, making it the largest stainless steel plant in China. China was the world's leading consumer of stainless steel in 2005, accounting for more than 25% of world stainless steel consumption.

China has a large electroplating industry and a number of rechargeable battery manufacturers that use nickel. China's plating industry accounted for about 31% of the country's primary nickel demand in 2004 (Eramet Group, 2006, Appendix, p. 38). In 2003, Inco formed a joint venture with a Chinese developer to produce nickel foam for the world market. The joint venture, Inco Wanzhong Advanced Technology Materials (Dalian) Ltd., proceeded to construct a state-of-the-art foam production plant in Dalian, a port on the Liaotung Peninsula. The Dalian plant became fully operational in 2005 and can produce 2 million square meters per year of high-quality nickel foam—the bulk of which was being sold to manufacturers of rechargeable batteries.

***Cuba.***—In March, Grupo Empresarial del Níquel (Cubaniquel) and its Canadian partner, Sherritt International Corporation, announced that they were planning to upgrade and expand the capacity of the Pedro Soto Alba mining and processing complex at Moa. The acid leaching operation was capable of producing 33,000 t/yr of nickel plus cobalt in a mixed sulfide precipitate and was to be increased to 49,000 t/yr. A parallel expansion was to be carried out at the joint venture's downstream refinery in Fort Saskatchewan, Alberta, Canada. In 2005, the Fort Saskatchewan refinery produced 31,878 t of nickel and 3,392 t of cobalt. About 95% of the feed came from Moa. The entire expansion project was expected to cost $450 million, with construction beginning in April 2006. The two partners were hoping to complete the first phase of the expansion by yearend 2007, increasing capacity initially by 4,000 t/yr of mixed metal. The second phase, scheduled for completion in 2009, would increase capacity an additional 9,000 t/yr (Sherritt International Corporation, 2006, p. 17-19; Granma Internacional, 2005§, 2006§).

In November 2004, China Minmetals Corporation, a parastatal enterprise, agreed to help Cuba complete construction of the long-delayed laterite-processing complex at Las Camariocas in Holguin Province. Cuban officials proposed converting the unfinished ammonia leach operation to ferronickel production, but the construction site, about 10 km southeast of Punta Gorda, has been idle for more than a decade. The adjoining mine site has at least 100 Mt of saprolitic resources averaging 1.3% nickel. Cubaniquel, the state-owned monopoly, was to have a 51% interest in the Las Camariocas project; Minmetals, a 49% interest. Las Camariocas would produce 22,500 t/yr of nickel in ferronickel. As part of the agreement, Cuba was to have supplied China with 4,000 t/yr of nickel from 2005 to 2009. Part of the new nickel production would be shipped to stainless steel plants in coastal China, with the rest going to a greenfield stainless steel plant proposed for the Guayana region of Venezuela. Minmetals was to invest $500 million in the joint venture and was considering investing an additional $1.3 billion to develop a large laterite deposit near San Felipe in Camaguey Province.

The Las Camariocas venture reportedly encountered problems in 2005, missing key project deadlines. According to the Minister of Foreign Investment and Economic Cooperation, the number of joint ventures between foreign investors and the Government of Cuba declined to 258 in December 2005 from 313 at the end of 2004 (Israel, 2007§).

***Kazakhstan.***—Oriel Resources plc has been evaluating the Shevchenko lateritic nickel deposits of north-central Kazakhstan. The deposits are in the Zhitigara district of Kostanai Oblast and are located in an established mining area with existing road, rail, and power networks. In December, Bateman Minerals and Metals Ltd. completed a project feasibility study with support from Mintek (South Africa), Polysius (part of the ThyssenKrupp Group, Germany), and Wardell Armstrong International Limited (WAI) (United Kingdom). The deposits, discovered in 1952, were initially estimated to have 102 Mt of resources containing 730,000 t of nickel and 51,000 t of cobalt (Oriel Resources plc, 2005a, p. 8). Confirmation drilling in 2004-05 identified proven reserves of 21 Mt averaging 0.85% nickel and probable reserves of 83 Mt averaging 0.77% nickel (Oriel Resources plc, 2005b). Three deposit areas were selected in 2004 for trial mining: Shevchenko, Blizhny, and Tarasov (Barcza and others, 2004).

In May 2004, Oriel commissioned Mintek to recommend an extraction process for the Shevchenko ores and to conduct preliminary tests on a 6-t ore sample at Mintek's direct current (DC) arc pilot plant in Randburg, South Africa. The testing was so encouraging that, a few months later, Oriel shipped a 450-t bulk ore sample to Randburg for more extensive evaluation. Mintek was able to produce ferronickel containing more than 20% nickel with a recovery rate of 89% (Mintek, 2004). Based on the Randburg evaluation, the Bateman support group recommended that Mintek's fluidized bed—DC electric furnace technology be used to produce ferronickel at Shevchenko. The smelting plant would have two 80-megawatt DC current arc furnaces. Construction, if approved, could begin in the spring of 2006; commissioning is scheduled for yearend 2008 (Oriel Resources plc, 2005a, p. 8-11; b).

***New Caledonia.***—In October 2004, Inco decided to restart its Goro project after simplifying the design of the hydrometallurgical processing complex. The redesign reduced construction cost estimates by $500 million. The updated capital cost estimate for the mine, processing plant, and infrastructure was $1.88 billion. Goro could begin producing cobalt and nickel by late 2007. At yearend, engineering work was about 70% complete. The plant would have a nameplate capacity of 60,000 t/yr of nickel, with ramp up to full capacity expected to take 3 years. The capacity of the redesigned plant is 9% greater than the 55,000 t/yr estimated for the previous design. Goro has exceptionally large reserves, allowing the operation to be incrementally expanded over time. Inco estimated that Goro had 120 Mt of proven and probable reserves averaging 1.48%

nickel and 0.11% cobalt. Inco also identified 75 Mt of additional resources (Inco Limited, 2006a, p. 5, 12-16).

At yearend 2005, Inco had a 71% interest in Goro Nickel S.A.S., down from 85%. In February, the shares held by the Government of France's Bureau de Recherches Géologiques et Minières were transferred to Société de Participation Minière du Sud Calédonien S.A.S. (SPMSC)—a company owned by the three provinces of New Caledonia. SPMSC had an 8% interest in the project after yearend adjustments. In April, Sumic Nickel Netherlands B.V. [ a company jointly owned by Sumitomo Metal Mining Co., Ltd. (Japan) and Mitsui & Co., Ltd. (Japan)] acquired the remaining 21% (Inco Limited, 2006a, p. 116-117).

***Philippines.***—On April 13, Coral Bay Nickel Corporation (CBNC) formally commissioned its $180 million hydrometallurgical processing plant near Bataraza on the island of Palawan. The plant is a joint venture of Sumitomo (54%), Mitsui (18%), Sojitz Corporation (18%), and a local Filipino company, Rio Tuba Nickel Mining Corporation (10%). The CBNC facility is designed to produce 10,000 t/yr of nickel and 700 t/yr of cobalt as a mixed sulfide precipitate. The new facility produced 4,081 t of contained nickel and about 290 t of contained cobalt in 2005. The two metals were recovered from low-grade ores stockpiled at the adjacent Rio Tuba Mine (Balitang Malacañang Office of the Press Secretary, 2005§).

***Russia.***—MMC Norilsk Nickel was the leading producer of nickel in the world in 2005 and accounted for about 19% of world mine production. The company's operations on the Kola and Taimyr peninsulas had a combined output of 243,000 t of nickel—about 92% of Russia's primary nickel output for the year. Almost all of the nickel was exported; only 6,000 t, or 2%, was sold to Russian consumers (MMC Norilsk Nickel Group, 2006, p. 4-6, 24-27).

The Polar Division is responsible for Norilsk Nickel's nickel mining, smelting, and refining operations on the Taimyr Peninsula of Siberia. A second division, Kola MMC, oversees similar operations on the Kola Peninsula. The PolarDivision was in the process of completing its new Skalisty Mine in the Talnakh ore field, north of the city of Norilsk. Most of the beneficiation facilities on the Taimyr Peninsula were being upgraded and/or expanded. The "Nickel Plant"—the historic sintering and smelting operation in the city of Norilsk—was to be closed and the rest of the smelting operations on the peninsula modernized. Kola MMC has begun developing the Severny-Gluboky deposit near Zapolyarny (Zapoljarnyi) on the Kola Peninsula.

At yearend 2004, proven and probable reserves on the Taimyr Peninsula totaled 318 Mt averaging 1.63% nickel and 2.79% copper, with 75% of the ore volume occurring in the Talnakh ore field. The remaining 25% was in the Norilsk-1 deposit and consisted of 80 Mt of disseminated ores averaging 0.31% nickel and 0.43% copper. The Zhdanovskoye deposit on the Kola Peninsula had 160 Mt of proven and probable reserves averaging 0.67% nickel and 0.31% copper (MMC Norilsk Nickel Group, 2006, p. 42-45, 54-58).

The remaining 8% of Russia's primary nickel output came from independent operations in the Urals region—Rezh Nickel Works JSC (Sverdlovsk Oblast), Ufaleynikel JSC (Chelyabinsk Oblast), and Yuzhuralnikel Combine JSC (Orenburg Oblast).

Amur Minerals Corporation was exploring for nickel sulfide and PGE deposits in the Russian Far East. In April 2004, ZAO Kun-Manie (a wholly owned subsidiary of Amur Minerals) was granted a license to evaluate part of the 40-km long Krumkon trend in the northeast quarter of Amur Province. The trend is close to the border with Khabarovsk Province and hosts more than 100 sills, several of which have copper-nickel mineralization. Work during the 2004 and 2005 field seasons focused on the Kun-Manie area, a 5-km long segment of the trend, about 700 km northeast of Blagoveshchensk and 750 km from the border with China. Diamond core drilling, trenching and geologic mapping helped geologists identify the Ikenskoe and Vodorazdelny target zones, and eventually four other promising zones. If the prefeasibility study is positive, the company is hoping to convert its exploration license to a 25-year mining license. The committee must submit its "Discovery Paper" to the Russian State Committee of Reserves (GKZ) before yearend 2008. The Kun-Manie license area covers some 950 square kilometers, in a region where infrastructure is minimal. Geologists estimate that the Ikenskoe and Vodorazdelny zones have indicated resources of 28 Mt of ore averaging 0.47% nickel and 0.13% copper, plus 18 Mt of inferred resources of similar grade (Amur Minerals Corporation, 2006).

***Serbia.***—In October, the Kosovo Trust Agency sold the ferronickel operation at Glogovac to Alferon/International Mineral Resources (Switzerland and United Kingdom) for 33 million euros (US$40 million). The trust agency has been dealing with the privatization of Kosovo's mineral assets on behalf of the United Nations Mission in Kosovo (UNMIK). Alferon is part of the Eurasian Natural Resources Group, a large privately held metals and mining conglomerate. Alferon has agreed to invest 20 million euros (US$24 million) in the mining and smelting complex before 2009, creating about 1,000 jobs in the disputed and economically depressed province. The former Feronikeli operation was badly damaged when NATO aircraft bombed Serbian forces in 1999, but the electric furnace was reported to have been relatively unscathed. Feronikeli, a socially owned enterprise of the former Socialist Federal Government of Yugoslavia, last operated in 1998. UNMIK was hoping that the privatization of Feronikeli and similar mineral-related assets would help draw international investment into the war ravaged province (Clayson, 2005§; KosovaLive News Agency, 2005§).

***Spain.***—In October 2004, Rio Narcea Gold Mines, Ltd. commissioned its open pit mine at Aguablanca. The new mining complex is designed to produce 8,200 t of nickel, 5,000 t of copper, and 600 kg of PGEs annually in concentrate for the next 10 years. By then, Rio Narcea expects to have its underlying underground mine fully operational. The principal ore minerals are sulfides—pentlandite, chalcopyrite, violarite and cobaltite—and occur in a conical breccia pipe (Martinez and others, 2005). The complex began commercial production in January 2005. The flotation plant can treat 1.5 Mt/yr of ore. Rio Narcea produced 5,380 t of nickel and 4,888 t of copper in concentrate during the year. At yearend, the Aguablanca open pit had 14.5 Mt of proven and probable reserves averaging 0.66% nickel, 0.46% copper, and 0.47 g/t PGE (Rio Narcea Gold Mines, Ltd., 2006, p. 7-9, 20).

Rio Narcea planned to exploit the deposit's deeper resources within the next 4 years. Contractors finished excavating a 2.7-km-long decline to access higher grade mineralization beneath the open pit. Infill and exploratory drilling from underground and the surface continued into 2006 (Rio Narcea Gold Mines, Ltd., 2006, p. 9).

***Tanzania.***—In April, Barrick Gold Corporation (Toronto, Ontario, Canada) and Falconbridge announced that they had formed a joint venture to further evaluate the Kabanga nickel deposits in northwestern Tanzania. Barrick acquired the Kabanga concessions in 1999 as part of its takeover of Sutton Resources Limited. In 2005, Falconbridge acquired a 50% indirect interest in the project for $15 million and agreed to operate the joint venture. Falconbridge will fund and conduct a $50 million exploration and developmental drilling program. Barrick has significantly increased the value of Kabanga since 1999 by identifying additional resources. Three deposits have been identified to date—Main, North, and MNB. The current inferred resources total 26.4 Mt grading 2.6% nickel (Barrick Gold Corporation, 2005).

Falconbridge was prepared to fund an additional $95 million of project development to advance the Kabanga project. Project engineers have proposed an underground mining operation with an onsite surface concentrator. If the final feasibility study is successful, the proposed operation would mine 2 Mt/yr of ore and produce 30,000 to 35,000 t/yr of nickel in sulfide concentrates.

***Turkey.***—European Nickel PLC (ENickel) (London, United Kingdom) has been evaluating the Caldag laterite deposit since 2002. The Caldag deposit is 15 km north of the town of Turgutlu and 75 km northeast of the Port of Izmir. In July 2004, the Government of Turkey issued an environmental license to the company, allowing it to begin trial heap leaching. ENickel has since shown that acid heap leaching can be used to economically recover nickel from laterites with low clay contents, like those in the Balkans and Turkey. Equatorial laterites, in contrast, have significantly higher clay contents and are less amenable to the ENickel process. The cobalt and nickel were being recovered as a mixed hydroxide (European Nickel PLC, 2006a, p. 4-5; b).

A feasibility study was launched in October 2004 and completed in November 2005. The bankable feasibility study allowed the company to seek full funding of the project and move forward to the detailed design phase. Aker Kvaerner Australia Pty. Limited was selected for front-end engineering and design. Three trial leach pads and a precipitation plant were built onsite as part of the feasibility study to demonstrate the viability of the ENickel process. More than 70% of the nickel contained in the heap was recovered. The trial precipitation plant has produced mixed hydroxide on a near continuous basis since May 2005. ENickel completed a 31,000-meter drilling program at Caldag. Analysis of the drill data by independent resource consultants, using a 0.6% nickel cutoff, indicated that the deposit had 23.1 Mt of proven reserves grading 1.32% nickel and 0.07% cobalt. The deposit also had 12.9 Mt of "provable" [sic] reserves grading 1.27% nickel and 0.07% cobalt (European Nickel PLC, 2006a, p. 5).

Development of the $300 million project was scheduled to start in September 2006, with full-scale production of hydroxide to begin in late 2008. The design capacity of the project was recently raised. The operation is now expected to produce 20,400 t/yr of nickel and 1,200 t/yr of cobalt as mixed hydroxide. Limited mining had been underway since 2003, when 40,000 t of ore was shipped to ferronickel smelters in Greece and Macedonia (European Nickel PLC, 2006b).

ENickel hoped to adapt the technology developed at Caldag to similar deposits in Albania and Serbia. The company had obtained licenses from the Government of Serbia to evaluate the Lipovac and Mokra Gora deposits in the central part of that country. ENickel continued to collect geological information on Lipovac, but returned its Mokra Gora license to the Serbian Government after the Mokra Gora area became part of a national park (European Nickel PLC, 2006a, p. 8-9). At yearend, BHP Billiton had an 8% interest in ENickel. The two companies have been discussing ways of improving collaboration on the Caldag project and the jointly developed heap-leach process.

***Zimbabwe.***—Bindura Nickel Corporation operated two underground mines during 2005—Shangani and Trojan. Geologists estimate that the Shangani Mine has only 2 years of reserves remaining and were trying to determine how best to extend the existing shaft system to reach additional resources. The Trojan Mine has an estimated 7 years of reserves. The Trojan shaft was being deepened by some 600 meters to access new reserves that could extend the life of the mine to the year 2024. The company was also conducting a feasibility study of the Hunters Road deposit.

Nickel sulfide concentrates from Shangani and Trojan are processed in the smelter and refinery at the town of Bindura. In 2005, the refinery produced 11,000 t of nickel cathode. About 7,000 t was recovered from Shangani and Trojan concentrates; the remaining 4,000 t came from toll material shipped from Botswana and South Africa. Mwana Africa plc has a 52.9% interest in Bindura. Mwana acquired the controlling stake from Anglo American Corporation of Zimbabwe in July 2003 (Mwana Africa plc, 2006§).

## Current Research and Technology

Growing demand for rechargeable NiMH batteries has encouraged researchers to reevaluate existing processes for recovering nickel from spent batteries. Spent NiMH batteries typically contain 36% to 42% nickel, 3% to 4% cobalt, and 8% to 10% mischmetal (consisting largely of lanthanum, cerium, praseodymium and neodymium). The cathode of the battery is made of nickel metal coated with nickel hydroxide, while the anode consists of a hydrogen storage alloy made from cobalt, mischmetal, and nickel. The bulk of the nickel currently recovered from spent NiMH and nickel-cadmium batteries ends up in an iron-chromium remelt alloy, which is then sold to stainless steel producers as a relatively inexpensive source of chromium and nickel. In this process, the cobalt follows the nickel while the rare earths are lost to the slag. Researchers at Aachen University in Germany recently published their study of the rare earth recovery problem. They propose using a calcium oxide-calcium fluoride slag system to recover the rare earths as oxides, making NiMH battery recycling more profitable. A centralized dedicated battery recycling plant could make

economic sense for highly industrialized regions such the EU, Japan, and the United States where recycling systems already exist. An estimated 10,000 t of NiMH batteries was sold in the EU in 2003 (Müller and Friedrich, 2006).

## Outlook

No primary nickel producer is expected to be operating in the United States before 2015, with the possible exception of Kennecott's proposed underground mine in the Upper Peninsula of Michigan. Grupo México and Stillwater will continue to recover limited amounts of byproduct nickel from precious metals and base-metals refining operations in the western United States. Larger amounts of byproduct nickel could also be generated in Minnesota if PolyMet or Teck Cominco Limited decide to proceed with their PGE projects in the Duluth Gabbro. Increased byproduct nickel production from North American PGE operations could materialize if current forecasts for fuel cell-battery hybrid vehicles are accurate.

U.S. nickel consumers will apparently be dependent on foreign sources for at least two decades. The ongoing expansion of nickel laterite mining operations in Australia, Cuba, Indonesia, New Caledonia, and the Philippines will help meet the growing demand for nickel worldwide. Laterite projects are also under consideration in Brazil, Cote d'Ivoire, Guatemala, and Kazakhstan. The sulfide concentrate from Inco's state-of-the-art mill and concentrator at Voisey's Bay will also help meet the near-term growth in demand projected for nickel. The world consolidation of nickel operations is expected to continue.

Rising prices for petroleum products have increased demand for hybrid automobiles and with it, NiMH batteries. In the United States, hybrid vehicles were in short supply, reportedly because of the limited availability of NiMH battery packs and the large financial costs associated with scaling-up production. The life and replacement cost of the different NiMH battery packs remain important issues (Williams, 2006§).

Between 1997 and yearend 2005, Toyota Motor Corporation of Tokyo, Japan, sold more than 550,000 hybrid vehicles worldwide. The second-generation hybrids currently being manufactured by Toyota perform better and are less costly to manufacture than the original 1997 Prius. The company is now planning to produce more than 1 million hybrid vehicles annually by 2012 (Toyota Motor Corporation, 2006, p. 11).

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TABLE 1
SALIENT NICKEL STATISTICS[1]

(Metric tons of contained nickel unless otherwise specified)

| | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| United States: | | | | | |
| Mine production | -- | -- | -- | -- | -- |
| Plant production | -- | -- | -- | -- | -- |
| Secondary recovery from purchased scrap: | | | | | |
| From ferrous scrap | 69,300 | 74,900 | 74,000 | 73,500 | 68,900 |
| From nonferrous scrap | 11,900 | 9,060 | 9,510 | 9,790 | 8,380 |
| Shipments of purchased scrap[2] | 121,000 | 114,000 | 119,000 | 113,000 | 117,000 |
| Exports: | | | | | |
| Primary | 8,450 | 6,520 | 6,330 | 8,000 | 7,630 |
| Secondary | 48,600 | 39,400 | 47,300 | 48,300 | 55,600 |
| Imports for consumption: | | | | | |
| Ore | -- | -- | -- | -- | -- |
| Primary | 136,000 | 121,000 | 125,000 | 136,000 | 143,000 |
| Secondary | 8,760 | 9,110 | 11,500 | 18,800 | 15,500 |
| Consumption: | | | | | |
| Reported: | | | | | |
| Primary | 98,800 | 88,200 | 87,300 r | 98,900 r | 96,800 |
| Secondary, purchased scrap[3] | 81,200 | 83,900 | 83,500 | 83,300 | 77,300 |
| Total | 180,000 | 172,000 | 171,000 | 182,000 | 174,000 |
| Apparent: | | | | | |
| Primary | 129,000 | 121,000 | 117,000 | 128,000 | 136,000 |
| Secondary, purchased scrap[4] | 41,800 | 54,600 | 48,400 | 54,900 | 37,600 |
| Total | 171,000 | 175,000 | 165,000 | 183,000 r | 174,000 |
| Apparent primary plus reported secondary | 210,000 | 205,000 | 200,000 | 212,000 | 213,000 |
| Stocks, yearend: | | | | | |
| Government | -- | -- | -- | -- | -- |
| Producers and traders | 12,600 | 6,150 | 8,040 | 6,580 | 4,960 |
| Consumer, primary | 4,500 | 4,520 | 4,800 | 5,750 r | 6,640 |
| Consumer, secondary | 7,980 | 7,040 | 6,270 | 5,210 | 4,860 |
| Total | 25,100 | 17,700 | 19,100 | 17,500 r | 16,500 |
| Employment, yearend: | | | | | |
| Mine | -- | -- | -- | -- | -- |
| Smelter | -- | -- | -- | -- | -- |
| Port facility | -- | -- | -- | -- | -- |
| Price, cash, London Metal Exchange: | | | | | |
| Average annual dollars per metric ton | 5,945 | 6,772 | 9,629 | 13,823 | 14,738 |
| Average annual dollars per pound | 2.696 | 3.072 | 4.368 | 6.270 | 6.685 |
| Price, 18/8 stainless steel scrap, gross weight:[5] | | | | | |
| Average annual dollars per metric ton | 623 | 692 | 927 | 1,450 | 1,450 |
| Average annual dollars per long ton | 633 | 703 | 942 | 1,470 | 1,470 |
| World, mine production | 1,350,000 r | 1,350,000 | 1,370,000 r | 1,400,000 r | 1,480,000 e |

eEstimated. rRevised. -- Zero.

[1]Data are rounded to no more than three significant digits; except prices; may not add to totals shown.

[2]Defined as scrap receipts less shipments by consumers plus exports minus imports plus adjustments for consumer stock changes.

[3]More clearly delineates the amount consumed than does apparent consumption.

[4]Internal evaluation indicates that apparent secondary consumption is considerably understated.

[5]Derived from the average of the Friday consumer buying price range for 18% chromium—8% nickel scrap in bundles, solids, and clips, Pittsburgh, PA, in American Metal Market.

TABLE 2
NICKEL RECOVERED FROM PURCHASED SCRAP IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons of contained nickel)

| | 2004 | 2005 |
|---|---|---|
| Kind of scrap: | | |
| Aluminum-base[2] | 2,960 | 2,410 |
| Copper-base | 2,590 r | 2,290 |
| Ferrous-base[3] | 73,500 | 68,900 |
| Nickel-base | 4,230 r | 3,680 |
| Total | 83,300 | 77,300 |
| Form of recovery: | | |
| Aluminum-base alloys | 2,960 | 2,410 |
| Copper-base alloys | 4,080 r | 3,630 |
| Ferrous alloys | 73,500 | 68,900 |
| Nickel-base alloys | 2,690 r | 2,340 |
| Miscellaneous and unspecified | 48 r | -- |
| Total | 83,300 | 77,300 |

rRevised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Primarily borings and turnings of wrought alloys, such as 2218, 2618, 4032, and 8280, or special casting alloys, such as 203.0.
[3]Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

TABLE 3
REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM[1]

(Metric tons of contained nickel)

| Form | 2004 | 2005 |
|---|---|---|
| Primary: | | |
| Metal | 78,100 r | 81,700 |
| Ferronickel | 13,800 r | 13,300 |
| Oxide and oxide sinter[2] | 187 r | 164 |
| Chemicals | 5,860 | 981 |
| Other | 1,010 | 639 |
| Total | 98,900 r | 96,800 |
| Secondary, scrap[3] | 83,300 | 77,300 |
| Grand total | 182,000 | 174,000 |

rRevised.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes chemical-grade oxide.
[3]Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4
U.S. CONSUMPTION OF NICKEL, BY USE[1]

(Metric tons of contained nickel)

| Use | 2005 | | | | | | | | Grand total in 2004 |
|---|---|---|---|---|---|---|---|---|---|
| | Metal | Ferronickel | Oxide and oxide sinter | Chemicals | Other forms | Total primary | Secondary (scrap) | Grand total | |
| Consumption reported: | | | | | | | | | |
| Cast irons | 51 | W | W | -- | W | 51 | 128 | 179 | 306 r |
| Chemicals and chemical uses | 1,350 | -- | W | 678 | -- | 2,030 | W | 2,030 | 6,270 r |
| Electric, magnet, expansion alloys | 161 | -- | -- | -- | -- | 161 | W | 161 | 192 |
| Electroplating, sales to platers | 11,200 | -- | -- | 128 | -- | 11,300 | -- | 11,300 | 11,900 |
| Nickel-copper and copper-nickel alloys | 2,910 | -- | W | -- | 15 | 2,930 | 2,930 | 5,860 | 5,990 r |
| Other nickel and nickel alloys | 15,000 | W | W | -- | 61 | 15,000 | 2,200 | 17,200 | 15,400 |
| Steel: | | | | | | | | | |
| Stainless and heat resistant | 27,700 | 13,200 | 68 | W | 200 | 41,200 | 67,500 | 109,000 | 115,000 r |
| Alloys, excludes stainless | 3,430 | W | -- | -- | W | 3,430 | 593 | 4,020 | 3,770 |
| Superalloys | 15,900 | -- | W | W | 251 | 16,100 | 139 | 16,300 | 15,700 r |
| Other[2] | 4,150 | 117 | 96 | 175 | 112 | 4,650 | 3,790 | 8,430 | 7,800 r |
| Total | 81,700 | 13,300 | 164 | 981 | 639 | 96,800 | 77,300 | 174,000 | 182,000 |
| Consumption, apparent | XX | XX | XX | XX | XX | 136,000 | 37,600 | 174,000 | 183,000 |

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes batteries, catalysts, ceramics, coinage, other alloys containing nickel, and data indicated by the symbol “W.”

TABLE 5
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES, BY FORM, DECEMBER 31[1]

(Metric tons of contained nickel)

| Form | 2004 | 2005 |
|---|---|---|
| Primary: | | |
| Metal | 4,060 r | 4,780 |
| Ferronickel | 909 r | 944 |
| Oxide and oxide sinter | 58 r | 68 |
| Chemicals | 570 | 778 |
| Other | 150 | 69 |
| Total | 5,750 r | 6,640 |
| Secondary, scrap | 5,210 | 4,860 |
| Grand total | 11,000 r | 11,500 |

rRevised.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS[1, 2]

| Class | 2004 Quantity (metric tons, contained Ni) | 2004 Value (thousands) | 2005 Quantity (metric tons, contained Ni) | 2005 Value (thousands) |
|---|---|---|---|---|
| Primary: | | | | |
| Unwrought: | | | | |
| Cathodes, pellets, briquets, shot | 972 | $10,900 | 1,190 | $17,600 |
| Ferronickel | 68 | 466 | 72 | 520 |
| Powder and flakes | 2,130 | 34,800 | 1,910 | 33,900 |
| Metallurgical-grade oxide | 201 | 2,140 | 233 | 2,120 |
| Chemicals: | | | | |
| Catalysts | 1,980 | 104,000 | 2,150 | 134,000 |
| Salts[3] | 2,650 | 34,500 | 2,070 | 30,200 |
| Total | 8,000 | 186,000 | 7,630 | 219,000 |
| Secondary: | | | | |
| Stainless steel scrap | 35,900 | 548,000 | 43,800 | 670,000 |
| Waste and scrap | 12,400 | 60,800 | 11,700 | 60,000 |
| Total | 48,300 | 609,000 | 55,600 | 731,000 |
| Grand total | 56,300 | 795,000 | 63,200 | 949,000 |
| Wrought, not alloyed: | | | | |
| Bars, rods, profiles, wire | 302 | 3,880 | 215 | 4,030 |
| Sheets, strip, foil | 579 | 10,900 | 786 | 19,700 |
| Tubes and pipes | 234 | 1,590 | 335 | 3,030 |
| Total | 1,120 | 16,400 | 1,340 | 26,700 |
| Alloyed, gross weight: | | | | |
| Unwrought alloyed ingot | 7,510 | 80,600 | 10,400 | 99,900 |
| Bars, rods, profiles, wire | 12,300 | 224,000 | 16,400 | 374,000 |
| Sheets, strip, foil | 4,720 | 92,900 | 4,320 | 118,000 |
| Tubes and pipes | 1,800 | 50,700 | 3,000 | 81,200 |
| Other alloyed articles | 3,440 | 118,000 | 3,580 | 147,000 |
| Total | 29,700 | 566,000 | 37,700 | 819,000 |

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]The nickel contents are as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; and sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.
[3]Excludes nickel carbonate (more information can be found in the Harmonized Tariff System Schedule B, export commodity code 2836.99.9050).

Source: U.S. Census Bureau.

TABLE 7
U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY[1]

(Metric tons, contained Ni)[2]

| | 2005 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | Cathodes, pellets, and briquets (unwrought) | Powder and flakes | Ferronickel | Metallurgical-grade oxide[3] | Waste and scrap | Stainless steel scrap | Chemicals | Total | Total in 2004 | Wrought nickel in 2005[4] |
| Australia | -- | 10 | -- | (5) | 500 | 6 | 21 | 537 | 123 | 36 |
| Belgium | 17 | 39 | -- | -- | 19 | 53 | 126 | 254 | 256 | (5) |
| Brazil | 20 | 16 | -- | -- | -- | 7 | 9 | 52 | 167 | 13 |
| Canada | 124 | 467 | 10 | 77 | 8,990 | 1,790 | 1,190 | 12,700 | 13,900 r | 96 |
| China | -- | 143 | 7 | 2 | 157 | 18,100 | 190 | 18,600 | 12,400 | 180 |
| Colombia | 2 | 10 | -- | -- | -- | (5) | 5 | 17 | 123 | 254 |
| Finland | -- | 38 | -- | -- | 113 | 4,830 | 229 | 5,210 | 5,670 r | -- |
| France | -- | 111 | -- | -- | 12 | 11 | 18 | 152 | 170 | 40 |
| Germany | (5) | 199 | 1 | 113 | 339 | 79 | 37 | 768 | 848 | 30 |
| India | -- | 9 | -- | -- | 30 | 2,560 | 102 | 2,700 | 1,940 | 8 |
| Italy | -- | 35 | -- | (5) | -- | 1,370 | 45 | 1,450 | 85 | 21 |
| Japan | 16 | 87 | 7 | 14 | 246 | 451 | 372 | 1,190 | 1,100 | 132 |
| Korea, Republic of | -- | 57 | -- | -- | -- | 3,740 | 228 | 4,020 | 7,000 | 130 |
| Mexico | 986 | 121 | -- | 1 | 1 | 2,320 | 196 | 3,620 | 1,240 | 58 |
| Netherlands | -- | 16 | -- | -- | 69 | 874 | 82 | 1,040 | 1,260 | 8 |
| South Africa | -- | 10 | -- | -- | 19 | -- | 62 | 91 | 72 | 16 |
| Spain | (5) | 24 | -- | -- | -- | 771 | -- | 795 | 696 | (5) |
| Sweden | -- | (5) | -- | -- | 347 | 4 | 57 | 408 | 351 | 4 |
| Taiwan | 7 | 47 | -- | 1 | 41 | 5,280 | 86 | 5,470 | 3,400 | 23 |
| United Kingdom | 1 | 125 | 37 | 18 | 695 | 221 | 133 | 1,230 | 1,270 | 31 |
| Other | 18 | 345 | 10 | 7 | 162 | 1,350 | 1,040 | 2,930 | 4,150 r | 256 |
| Total | 1,190 | 1,910 | 72 | 233 | 11,700 | 43,800 | 4,230 | 63,200 | 56,300 | 1,340 |

rRevised. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]The nickel contents are assumed to be as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The chemicals category contains the following: chemical-grade oxide, sesquoxide, and hydroxide, 65%; chlorides, 25%; and sulfate, 22%. Other salts and various catalysts are assumed to be 22% nickel.

[3]Chemical-grade oxide is included in the "Chemicals" category.

[4]Excluded from "2005, total."

[5]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY CLASS[1]

| Class | 2004 | | 2005 | |
|---|---|---|---|---|
| | Quantity (metric tons, contained Ni)[2] | Value (thousands) | Quantity (metric tons, contained Ni)[2] | Value (thousands) |
| Primary: | | | | |
| Unwrought: | | | | |
| Cathodes, pellets, briquets, shot | 107,000 | $1,450,000 | 110,000 | $1,620,000 |
| Ferronickel | 13,900 | 168,000 | 19,200 | 185,000 |
| Powder and flakes | 9,220 | 140,000 | 8,120 | 128,000 |
| Metallurgical-grade oxide | 1,210 | 17,500 | 1,540 | 24,500 |
| Chemicals: | | | | |
| Catalysts | 1,310 | 68,800 | 1,220 | 70,800 |
| Salts[3] | 3,130 | 45,700 | 2,410 | 39,100 |
| Total | 136,000 | 1,890,000 | 143,000 | 2,060,000 |
| Secondary: | | | | |
| Stainless steel scrap | 11,000 | 160,000 | 8,340 | 124,000 |
| Waste and scrap | 7,850 | 89,700 | 7,170 | 99,200 |
| Total | 18,800 | 250,000 | 15,500 | 223,000 |
| Grand total | 155,000 | 2,140,000 | 159,000 | 2,290,000 |
| Wrought, not alloyed: | | | | |
| Bars, rods, profiles, wire | 499 | 9,740 | 534 | 12,200 |
| Sheets, strip, foil | 260 | 9,220 | 419 | 11,100 |
| Tubes and pipes | 38 | 1,350 | 104 | 2,670 |
| Total | 797 | 20,300 | 1,060 | 26,000 |
| Alloyed, gross weight: | | | | |
| Unwrought alloyed ingot | 3,000 | 37,400 | 4,840 | 74,700 |
| Bars, rods, profiles, wire | 8,860 | 137,000 | 10,300 | 209,000 |
| Sheets, strip, foil | 2,920 | 58,600 | 3,490 | 83,700 |
| Tubes and pipes | 3,060 | 52,100 | 1,850 | 38,400 |
| Other alloyed articles | 2,080 | 63,600 | 2,800 | 75,500 |
| Total | 19,900 | 349,000 | 23,300 | 481,000 |

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]The nickel contents are as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.
[3]Excludes nickel carbonate (more information can be found at Harmonized Tariff Schedule of the United States subheading 2836.99.5000).

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY[1]

(Metric tons of contained nickel)[2]

| | 2005 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | Cathodes, pellets, and briquets (unwrought) | Powder and flakes | Ferronickel | Metallurgical-grade oxide[3] | Waste and scrap | Stainless steel scrap | Chemicals | Total | Total in 2004 | Wrought nickel in 2005[4] |
| Australia | 11,700 | 419 | -- | -- | 28 | -- | -- | 12,100 | 11,400 | 10 |
| Austria | -- | 1 | -- | -- | -- | -- | -- | 1 | 5 | 138 |
| Belgium | 4 | 76 | -- | -- | 14 | 5 | 326 | 426 | 358 | -- |
| Brazil | 1,410 | (5) | -- | -- | 36 | 1 | -- | 1,450 | 2,080 | -- |
| Canada | 51,800 | 4,420 | -- | 1,520 | 2,080 | 5,490 | 25 | 65,400 | 69,600 | 3 |
| China | 380 | 23 | -- | -- | 74 | 108 | 26 | 611 | 77 | 21 |
| Colombia | -- | -- | 3,670 | -- | -- | 52 | -- | 3,730 | 3,280 | -- |
| Dominican Republic | -- | 41 | 13,800 | -- | -- | 33 | -- | 13,800 | 8,710 | -- |
| Finland | 1,910 | 869 | -- | -- | 10 | 3 | 1,130 | 3,920 | 6,490 | -- |
| France | 792 | -- | -- | -- | 1,230 | 25 | 273 | 2,320 | 2,420 | 183 |
| Germany | 1 | 47 | -- | -- | 416 | (5) | 455 | 919 | 2,040 | 498 |
| Japan | -- | 50 | -- | 1 | 187 | 8 | 357 | 603 | 854 | 64 |
| Mexico | -- | -- | -- | -- | 247 | 2,340 | 24 | 2,610 | 2,200 | (5) |
| Netherlands[6] | 228 | -- | 3 | -- | 77 | -- | 579 | 887 | 914 | (5) |
| New Caledonia | -- | -- | 1,500 | -- | -- | -- | -- | 1,500 | 1,360 | -- |
| Norway | 19,400 | -- | -- | -- | 29 | 3 | -- | 19,400 | 14,800 | 4 |
| Russia | 20,900 | 1,050 | 321 | -- | 25 | -- | -- | 22,200 | 20,100 | -- |
| South Africa | 112 | 557 | -- | -- | -- | -- | -- | 669 | 817 | -- |
| United Kingdom | 341 | 538 | 1 | 15 | 1,730 | 9 | 131 | 2,770 | 3,670 | 83 |
| Venezuela | -- | -- | -- | -- | 174 | 77 | -- | 252 | 443 | -- |
| Zimbabwe | 1,550 | -- | -- | -- | -- | -- | -- | 1,550 | 941 | -- |
| Other | 24 | 28 | -- | 4 | 813 | 190 | 296 | 1,360 | 2,170 | 53 |
| Total | 110,000 | 8,120 | 19,200 | 1,540 | 7,170 | 8,340 | 3,630 | 159,000 | 155,000 | 1,060 |

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]The nickel contents are assumed to be as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The chemicals category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel. Waste and scrap is assumed to be 50% nickel, and stainless steel scrap, 7.5% nickel.

[3]Primarily oxide, rondelles, and sinster.

[4]Excluded from "2005, total."

[5]Less than ½ unit.

[6]The different nickel products (cathode, powder, etc.) are apparently materials that have transited through bonded warehouses in the Netherlands, including warehouses overseen by the London Metal Exchange.

Source: U.S. Census Bureau.

TABLE 10
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of contained nickel)

| Country | 2001 | 2002 | 2003 | 2004 | 2005[e] |
|---|---|---|---|---|---|
| Australia, content of concentrate | 205,000 | 207,800 | 210,000 | 178,100 | 189,000 [3] |
| Botswana, content of ore milled | 26,714 | 28,600 | 32,740 | 32,980 | 28,000 |
| Brazil, content of ore | 45,456 | 44,928 | 45,160 | 45,200 [e] | 52,000 [p, 3] |
| Burma, content of ore[e] | 10 [r] | 10 [r] | 10 [r] | 10 [r] | 10 |
| Canada, content of concentrate | 194,058 | 189,297 | 163,244 | 186,694 [r] | 198,369 [p, 3] |
| China[e] | 51,500 | 53,700 | 61,000 | 75,600 [r] | 77,000 |
| Colombia, content of laterite ore | 52,962 | 58,196 | 70,844 | 75,032 | 89,031 [3] |
| Cuba, content of oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor[4] | 72,585 | 71,355 [r] | 67,306 [r] | 71,933 [r] | 72,000 |
| Dominican Republic, content of laterite ore | 39,120 | 38,859 | 45,253 [r] | 46,000 [r] | 46,000 |
| Finland, content of concentrate[5] | 2,600 [r] | 3,120 [r] | 3,640 [r] | 3,700 [r] | 3,400 |
| Greece, content of laterite ore | 20,830 | 22,670 | 21,410 | 21,700 | 23,210 [3] |
| Indonesia, content of laterite ore | 102,000 | 123,000 | 143,000 | 133,000 | 160,000 |
| Kazakhstan, content of laterite ore | -- | -- | -- | -- | 193 [3] |
| Macedonia, content of ferronickel produced | 2,970 [e] | 5,149 | 5,555 | 5,300 [r] | 8,100 [3] |
| Morocco, content of nickel sulfate | 151 | 109 | 126 | 130 [r] | 130 |
| New Caledonia, content of ore | 117,734 | 99,841 | 112,013 | 118,279 | 111,900 [3] |
| Norway, content of concentrate[6] | 2,529 | 2,052 | 169 | 181 | 150 |
| Philippines: | | | | | |
| Content of ore | 27,359 | 26,532 | 19,537 | 16,973 | 22,555 [p, 3] |
| Content of concentrate[7] | -- | -- | -- | -- | 4,081 [p, 3] |
| Russia, content of ore[e] | 320,000 | 310,000 [r] | 300,000 [r] | 315,000 | 315,000 |
| South Africa, content of concentrate | 36,443 | 38,546 | 40,842 | 39,853 [r] | 42,497 [p, 3] |
| Spain, content of concentrate | -- | -- | -- | (8) | 5,398 [3] |
| Turkey, content of laterite ore[9] | -- | -- | 640 | 40 [r, e] | 1,000 |
| Ukraine, content of laterite ore[e] | 1,500 | 2,000 | 2,000 | 2,000 | 2,000 |
| Venezuela, content of laterite ore | 13,600 | 18,600 | 20,700 | 20,468 | 20,000 |
| Zimbabwe, content of concentrate | 10,120 | 8,092 | 9,517 | 9,520 | 9,500 |
| Grand total | 1,350,000 [r] | 1,350,000 | 1,370,000 [r] | 1,400,000 [r] | 1,480,000 |
| Of which: | | | | | |
| Content of concentrate | 451,000 [r] | 449,000 [r] | 427,000 [r] | 418,000 [r] | 452,000 |
| Content of ore and ore milled | 537,000 | 510,000 [r] | 509,000 [r] | 528,000 | 529,000 |
| Content of laterite ore | 230,000 | 263,000 | 304,000 | 298,000 [r] | 341,000 |
| Content of ferronickel produced | 2,970 | 5,150 | 5,560 | 5,300 [r] | 8,100 |
| Content of nickel sulfate | 151 | 109 | 126 | 130 [r] | 130 |
| Content, unspecified and/or undifferentiated | 124,000 | 125,000 | 128,000 [r] | 148,000 [r] | 149,000 |

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output and this is noted parenthetically. North Korea may have an active nickel mine, but information is inadequate to make reliable estimates of output. Table includes data available through August 3, 2006.

[3]Reported figure.

[4]The Government of Cuba reports plant production on a contained nickel plus cobalt basis. The tonnages shown in this table for Cuba have been adjusted downward to correct for the cobalt. The cobalt content was determined to be 1.16% for granular and powdered oxide, 1.21% for oxide sinter, 7.56% for sulfide precipitate, and 33% for leach ammoniacal precipitate.

[5]The gross weight of concentrates processed in Finland from domestic ores was, as follows, in metric tons: 2001—27,610; 2002—47,797; 2003—41,289; 2004—45,914; and 2005—39,854.

[6]A/S Nikkel Og Olivin halted mining operations in October 2002. Outokumpu Oyj sold its 70% interest in the Norwegian mining company to Boliden AB on December 30, 2003.

[7]Nickel content of concentrate produced at Rio Tuba in 2005 by Coral Bay Nickel Corp.

[8]The Aguablanca operation of Rio Narcea Gold Mines, Ltd. was commissioned in December 2004.

[9]European Nickel PLC began large scale heap–leaching trials at its Caldag laterite operation in October 2004.

TABLE 11
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons of contained nickel)

| Country and product[3] | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Australia: | | | | | |
| Metal | 116,900 | 120,800 | 115,800 | 111,500 r | 113,000 p |
| Unspecified[4] | 11,200 | 11,400 | 13,600 | 10,700 r | 9,000 p |
| Total | 128,100 | 132,200 | 129,400 | 122,200 r | 122,000 p |
| Austria, ferronickel[e] | 1,600 | 1,500 | 1,500 | 1,500 | 1,500 |
| Brazil:[5] | | | | | |
| Ferronickel | 5,768 | 6,011 | 6,409 | 6,493 r | 6,500 p |
| Metal | 17,663 | 17,676 | 18,155 | 19,742 r | 19,750 p |
| Total | 23,431 | 23,687 | 24,564 | 26,235 r | 26,250 p |
| Canada, unspecified[6] | 140,591 | 144,476 | 124,418 | 151,518 | 139,683 p |
| China, metal[e] | 49,700 | 52,400 | 64,700 | 75,800 r | 95,000 |
| Colombia, ferronickel | 38,438 | 43,987 | 47,868 | 48,818 r | 52,749 |
| Cuba, oxide sinter and oxides[7] | 40,750 r | 38,751 r | 35,605 r | 38,231 r | 38,200 e |
| Dominican Republic, ferronickel | 21,661 | 23,303 | 27,227 | 29,477 | 28,668 p |
| Finland: | | | | | |
| Metal | 51,275 | 49,151 | 45,417 r | 40,088 r | 40,000 e |
| Chemicals | 3,700 | 3,600 | 3,600 | 3,500 | 3,500 e |
| Total | 54,975 | 52,751 | 49,017 r | 43,588 r | 43,500 e |
| France: | | | | | |
| Metal | 11,033 | 9,444 | 9,138 | 10,103 | 10,684 |
| Chemicals[e] | 2,000 [8] | 2,000 | 2,000 | 2,000 | 2,000 |
| Total[9] | 13,033 | 11,444 | 11,138 | 12,103 | 12,684 p |
| Greece, ferronickel | 16,870 | 19,229 | 18,000 | 18,115 | 19,235 p |
| Indonesia, ferronickel | 10,302 | 8,804 | 8,933 | 7,945 | 7,338 |
| Japan: | | | | | |
| Ferronickel | 68,113 | 74,418 | 75,399 | 74,261 | 77,600 e |
| Metal | 32,526 | 32,303 r | 34,991 | 32,769 r | 29,399 |
| Oxide sinter | 50,771 | 48,950 | 52,663 r | 60,285 r | 58,100 e |
| Chemicals | 2,394 | 1,820 | 2,084 | 2,082 | 2,208 |
| Total | 153,804 | 157,491 r | 165,137 r | 169,397 r | 167,307 |
| Korea, Republic of, metal | (10) | (10) | (10) | (10) | (10) |
| Macedonia, ferronickel | 2,970 e | 5,149 | 5,555 | 5,300 r | 8,100 |
| Morocco, chemicals | 151 | 109 | 126 | 130 r | 130 e |
| New Caledonia, ferronickel | 45,912 | 48,650 | 50,666 | 43,016 | 46,738 p |
| Norway, metal | 68,221 | 68,530 | 77,183 | 71,410 | 84,886 p |
| Poland, chemicals[11] | 704 | 744 | 785 | 820 | 800 |
| Russia:[e] | | | | | |
| Ferronickel | 8,000 | 12,000 | 13,500 | 14,000 | 13,000 |
| Metal | 252,000 r | 239,000 r | 260,000 r | 261,000 r | 266,000 |
| Oxide sinter | 12,000 | 6,000 | 5,000 | 5,000 | 5,000 |
| Chemicals | 2,000 | 2,000 | 2,500 | 3,000 | 3,000 |
| Total | 274,000 r | 259,000 r | 281,000 r | 283,000 r | 287,000 |
| South Africa: | | | | | |
| Metal | 30,500 | 31,646 | 25,500 e | 32,680 | 35,000 |
| Chemicals[12] | 5,943 | 6,900 | 15,342 | 7,170 e | 7,500 |
| Total | 36,443 | 38,546 | 40,842 | 39,850 | 42,500 |
| Taiwan, metal | (10) | (10) | (10) | (10) | (10) |
| Ukraine, ferronickel[e, 13] | 2,500 | 6,000 | -- r | 12,000 r | 14,000 |
| United Kingdom, metal | 33,817 | 33,790 | 26,788 | 38,606 | 37,127 p |
| Venezuela, ferronickel | 9,700 | 15,500 | 17,200 | 17,400 | 16,900 p |
| Zimbabwe, metal: | | | | | |
| Refined from domestic materials[14] | 7,440 | 8,092 | 9,517 | 9,520 | 9,500 e |
| Toll refined from imported materials[15] | 12,084 | 10,812 | 3,140 | 2,500 e | 2,500 |
| Total | 19,524 | 18,904 | 12,657 | 12,020 | 12,000 e |

See footnotes at end of table.

TABLE 11—Continued
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons of contained nickel)

| Country and product[3] | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Grand total | 1,190,000 r | 1,200,000 r | 1,220,000 | 1,270,000 r | 1,300,000 |
| Of which: | | | | | |
| Ferronickel | 232,000 | 265,000 | 272,000 r | 278,000 r | 292,000 |
| Metal | 683,000 r | 674,000 r | 690,000 r | 706,000 r | 743,000 |
| Oxide sinter | 104,000 r | 93,700 | 93,300 r | 104,000 r | 101,000 |
| Chemicals | 16,900 | 17,200 | 26,400 | 18,700 | 19,100 |
| Unspecified | 152,000 | 156,000 | 138,000 | 162,000 r | 149,000 |

eEstimated. pPreliminary. rRevised. -- Zero.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through August 3, 2006.

[3]In addition to the countries listed, North Korea is believed to have produced metallic nickel and/or ferronickel, but information is inadequate to make reliable estimates of output levels. Several countries produce nickel-containing matte, but output of nickel in such materials has been excluded from this table to avoid double counting. Countries producing matte for export are listed in table 12.

[4]Class II products with a nickel content of less than 99%. Includes oxides and oxide sinter. Excludes intermediate nickel-cobalt sulfide matte, regulus, and speiss for further refining.

[5]Brazil produced nickel carbonate (an intermediate product), in metric tons: 2001—17,063; 2002—18,100; 2003—18,406; 2004—19,897 (revised); and 2005–19,900 (preliminary).

[6]Nickel contained in products of smelters and refineries in forms, which are ready for use by consumers. Figures include the nickel content of nickel oxide sinter exported to the Republic of Korea and Taiwan. More information can be found in footnote 9.

[7]Cuba also produces nickel sulfide, but because it is used as feed material elsewhere, it is not included to avoid double counting. Combined output of processed sulfide and ammoniacal liquor precipitate was, as follows, in metric tons of contained nickel: 2001—31,884; 2002—28,548; 2003—31,736; 2004—32,115; and 2005—not available. More information can be found in table 12.

[8]Reported figure.

[9]Reported by Eramet for Sandouville. Excludes secondary production from spent rechargeable batteries.

[10]Nickel metal production for the Republic of Korea and Taiwan are not included because the production is derived wholly from imported metallurgical-grade oxides and to include them would result in double counting. Metal estimates are as follows, in metric tons: Republic of Korea: 2001—26,429; 2002—30,337; 2003—31,340 (revised); 2004—27,200 (revised); and 2005–26,300 (estimated). Taiwan: 2001—11,500 and 2002-05—11,000.

[11]Nickel content of nickel sulfate ($NiSO_4 \bullet 6H_2O$). Most of the nickel sulfate was a byproduct of the concentrating, smelting, and refining of domestically mined copper ores. Some production, however, may have been derived from imported nickeliferous raw materials that were blended with the domestic copper concentrates.

[12]Includes nickel sulfate plus exported metal in concentrate.

[13]May include nickel in remelt alloys derived from scrap.

[14]Data represent production from domestic nickel ore.

[15]Previously published as "Other, metal." Data represent production from matte imported from Botswana as well as nickel sulfate imported from South Africa.

TABLE 12

NICKEL: WORLD PRODUCTION OF INTERMEDIATE PRODUCTS FOR EXPORT, BY COUNTRY[1, 2]

(Metric tons of contained nickel)

| Country | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Matte: | | | | | |
| Australia[3] | 34,978 | 25,762 | 38,216 | 32,256 r | 44,536 |
| Botswana | 22,454 | 23,896 | 27,400 | 22,292 | 20,000 e |
| Brazil[4] | 10,183 | 6,274 r | 5,950 r | 6,708 r | 6,710 p |
| Canada[e, 5] | 48,000 | 50,000 | 45,000 | 58,000 r | 60,000 |
| China, exports[e, 6] | -- | -- | 4,530 | 20 | 26 |
| Indonesia[7] | 62,600 | 59,500 | 70,200 | 72,200 r | 76,400 |
| New Caledonia | 13,061 | 11,217 | 10,857 | 11,857 | 12,838 |
| Russia[8] | -- | 7,783 | 3,866 | 599 | 600 |
| Total | 191,000 | 184,000 | 206,000 | 204,000 r | 221,000 |
| Other, Cuba:[9] | | | | | |
| Sulfide precipitate | 29,914 | 30,858 | 30,198 r | 31,860 r | 32,000 e |
| Ammoniacal liquor precipitate | 1,957 r | 1,746 | 1,502 r | 1,842 r | 1,900 e |
| Total | 31,871 r | 32,604 | 31,700 r | 33,702 r | 33,900 e |

eEstimated. pPreliminary. rRevised. -- Zero.

[1]Table includes data available through July 22, 2006. Data represent nickel content of matte and other intermediate materials produced for export.

[2]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3]Total matte production on a contained nickel basis, in metric tons, was as follows: 2001—96,550; 2002—91,574; 2003—107,000; 2004–108,000 (estimated); and 2005—96,000. Figures exclude toll-refined material.

[4]Represents the output of the Fortaleza smelter. All of the Fortaleza matte is being shipped to Finland for further processing.

[5]Estimated nickel content of reported exports. Matte from the Falconbridge smelter of Falconbridge Limited typically assays 55% nickel.

[6]Chinese exports were estimated to have a nickel content of 63%. Total matte production on a contained nickel basis, in metric tons, was estimated as follows: 2001—59,000; 2002—59,200; 2003—69,300; 2004—74,000 (revised); and 2005–75,000.

[7]Represents the nickel output of the Soroako smelter. The Soroako matte, which also contains cobalt, is being shipped to Japan for further processing.

[8]Russian figures reported primarily for exports to China from 2002 to 2004. Source: United Nations Statistics Division.

[9]Corrected for coproduct cobalt.

TABLE 13
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BEFORE 2020

(Metric tons unless otherwise specified)

| Projected year of first production | Country and state/province | Project and company[1] | Resource grade (% Ni) | Estimated resources (thousands)[2] | Annual production capacity (contained Ni) | Nickel product |
|---|---|---|---|---|---|---|
| 2005 | Philippines | Adlay-Cagdianao-Tandawa | 1.61 | 5,800 | 5,000 | Ore. |
| | (Surigao del Norte) | BHP Billiton Group and Case Mining and Development Corp. | 1.58 | 13,000 | | |
| 2005 | Philippines | Rio Tuba | 1.26 | 16,000 | 10,000 | Ni-Co sulfide. |
| | (Palawan) | Coral Bay Nickel Corp. (Sumitomo consortium) | | | | |
| 2007 | Do. | Berong | 2.30 | 4,200 | 17,000 | Ore. |
| | Do. | Toledo Mining Corp. PLC, Atlas Consolidated Mining and Development Corp., Investika Ltd. | 1.30 | 270,000 | | |
| 2007 | Turkey | Caldag | 1.32 | 23,000 | 21,000 | Leachate precipitate. |
| | (Manisa) | European Nickel PLC and BHP Billiton Group | 1.26 | 17,600 | | |
| | | | 1.32 | 7,100 | | |
| 2008 | Australia | Ravensthorpe | 0.75 | 118,000 | 50,000 | Ni-Co hydroxide. |
| | (Western Australia) | BHP Billiton Group | 0.60 | 120,000 | | |
| 2008 | New Caledonia | Goro | 1.34 | 96,000 | 60,000 | Ni oxide. |
| | (Southern) | Goro Nickel S.A. | 2.01 | 24,000 | | |
| | | CVRD Inco Limited, Société de Participation Minière du Sud Calédonien S.A.S., Sumitomo consortium | 1.70 | 83,000 | | |
| 2009 | Australia | Jump-up Dam | 1.07 | 19,000 | 5,000 | Leachate precipitate. |
| | (Western Australia) | Heron Resources Ltd. | 0.82 | 22,000 | | |
| 2009 | Brazil | Onca-Puma | 1.86 | 78,000 | 57,000 | Ferronickel. |
| | (Para) | Mineração Onça Puma | 1.25 | 91,000 | | |
| | | Companhia Vale do Rio Doce | | | | |
| 2010 | Brazil | Barro Alto | 1.85 | 23,000 | 36,000 | Do. |
| | (Goias) | Anglo American plc | 1.79 | 7,000 | | |
| 2010 | Brazil | Vermelho | 0.80 | 290,000 | 46,000 | Metal or oxide. |
| | (Para) | Companhia Vale do Rio Doce | | | | |
| 2010 | Guatemala | Fenix saprolite (pyrometallurgical process) | 1.81 | 8,700 | 22,700 | Ferronickel. |
| | (Izabal) | Skye Resources Inc. and CVRD Inco Ltd. | 1.58 | 33,000 | | |
| 2011 | Australia | Marlborough/Gladstone | 0.94 | 49,000 | 60,000 | Metal. |
| | (Queensland) | Gladstone Pacific Nickel Ltd. | 0.93 | 6,000 | | |
| 2011 | Cuba | Pinares de Mayari West | 1.10 | 400,000 | 40,000 | Metal, oxide, or ferronickel. |
| | (Holguin) | Government of Cuba | | | | |
| 2011 | Kazakhstan | Shevchenko | 0.85 | 21,000 | 15,700 | Ferronickel. |
| | (Kostanai Oblast) | Oriel Resources plc | 0.77 | 83,000 | | |
| 2011 | New Caledonia | Koniambo | 2.40 | 63,000 | 60,000 | Do. |
| | (Northern) | Xstrata Nickel and Soc. Miniere du Sud Pacifique S.A. | 2.47 | 13,000 | | |
| | | | 1.60 | 100,000 | | |
| 2011 | Papua New Guinea | Ramu | 0.91 | 76,000 | 33,000 | Ni-Co intermediate. |
| | (Madang) | China Metallurgical Construction (Group) Corp., Highlands Pacific Ltd., and Mineral Resources Development Co. | 1.01 | 67,000 | | |
| 2012 | Australia | Young | 0.99 | 58,000 | 4,500 | Leachate precipitate, initially. |
| | (New South Wales) | Jervois Resources Ltd. | 0.72 | 110,000 | | |
| | | | 0.38 | 110,000 | | |
| 2012 | Cuba | Las Camariocas | 1.32 | 110,000 | 22,500 | Metal, oxide, or ferronickel. |
| | (Holguin) | Government of Cuba and others[3] | | | | |
| 2012 | Guatemala | Fenix limonite (hydrometallurgical process) | 1.18 | 33,000 | 22,200 | Ni-Co hydroxide. |
| | (Izabal) | Skye Resources Inc. and CVRD Inco Ltd. | | | | |
| 2012 | Indonesia | Weda Bay (Santa Monica, Pintu, Boki Mokot deposits) | 1.45 | 154,000 | 48,000 | Ni-Co sulfide. |
| | (Halmahera Island) | | 1.53 | 123,000 | | |
| | | Weda Bay Minerals Inc. (Eramet Group) and PT Aneka Tambang | | | | |
| 2012 | Madagascar | Ambatovy (Ambatovy and Analamay deposits) | 1.12 | 44,000 | 60,000 | Ni-Co intermediate. |
| | | Dynatec Corp., Sumitomo Corp., South Korean Consortium | 0.99 | 81,000 | | |

See footnotes at end of table.

TABLE 13—Continued
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BEFORE 2020

(Metric tons unless otherwise specified)

| Projected year of first production | Country and state/province | Project and company[1] | Resource grade (% Ni) | Estimated resources (thousands)[2] | Annual production capacity (contained Ni) | Nickel product |
|---|---|---|---|---|---|---|
| 2013 | Australia (Western Australia) | Mount Margaret<br>Minara Resources Ltd. | 0.78 | 170,000 | 45,000 | Ni-Co hydroxide. |
| 2013 | Guatemala | Sechol (El Inicio, El Segundo, Rio Negro, Poza Azul deposits)<br>Jaguar Nickel S.A. (BHP Billiton Ltd.) | 1.40<br>1.50 | 37,000 [4]<br>100,000 | NA | Ni-Co intermediate. |
| 2013 | Philippines (Mindoro Island) | Sablayan (Kisluyan, Buraboy, Shabo areas)<br>Crew Minerals ASA | 0.94<br>0.95<br>0.88 | 73,000<br>47,000<br>88,000 | 60,000 | Ni-Co sulfide. |
| 2014 | Australia (New South Wales) | Syerston<br>Ivanhoe Nickel and Platinum Ltd. | 0.73 | 77,000 | 18,000 | Ni-Co sulfide concentrate. |
| 2014 | Australia (Western Australia) | Kalgoorlie and North Kalgoorlie—Ghost Rocks, Goongarrie, Kalpini<br>Heron Resources Ltd. and Inco Limited | 1.20<br>0.83 | 100,000<br>225,000 | 50,000 | Ni-Co hydroxide. |
| 2014 | Cuba (Camaguey) | San Felipe<br>Government of Cuba and others | 1.30 | 250,000 | 45,000 | Metal or oxide. |
| 2015 | New Caledonia (Southern) | Prony<br>CVRD Inco Limited, Bureau de Recherches Geologiques et Minieres, Sumitomo consortium | 1.50 | NA [4] | NA [4] | Ni oxide. |
| 2016 | Papua New Guinea (Oro) | WoWo Gap<br>Resource Mining Corp. Ltd. | 1.09<br>1.44 | 31,000<br>18,000 | 45,000 | Metal. |
| 2017 | New Caledonia (Northern) | Nakety-Bogota<br>Argosy Minerals, Inc. and Soc. des Mines de la Tontouta | 1.47<br>1.50 | 88,000<br>140,000 | 52,000 | Ni-Co intermediate. |
| 2019 | Dominican Republic (Las Jarditas) | Cerro de Maimon (Cumpie Hill and Loma Mala)<br>Rio Tinto plc | 1.70 | NA | NA | NA |
| 2019 | Indonesia (Sulawest) | La Sampala<br>Rio Tinto plc | 1.50<br>1.30 | 195,000<br>185,000 | 46,000 | NA |
| 2020 | Côte d'Ivoire | Biankouma, Touba, Sipilou<br>Xstrata Nickel and Soc. d'Etat pour le Developpement Minier | 1.57<br>1.40 | 120,000<br>140,000 | 45,000 | Ni-Co intermediate or ferronickel. |
| 2020 | Indonesia (Maluku) | Gag Island<br>BHP Billiton Group and PT Aneka Tambang | 1.35 | 240,000 | 30,000 | Intermediate, metal, or ferronickel. |

NA Not available.

[1]Company names reflect organizational structure as of February 26, 2007. BHP Billiton Group is a dual listed company comprising of BHP Billiton Limited and BHP Billiton Plc.

[2]Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources.

[3]China Minmetals Corporation and the Government of Venezuela have both expressed an interest in investing in this long-stalled project.

[4]New resource estimate in progress.

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

TABLE 14
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BEFORE 2020

(Metric tons unless otherwise specified)

| Projected year of first production | Country and state/province | Project and company[1] | Resource grade (% Ni) | Estimated resources (thousands)[2] | Annual production capacity (contained Ni) | Nickel product |
|---|---|---|---|---|---|---|
| 2005 | Canada | Voisey's Bay | 2.75 | 32,000 | 50,000 | Concentrates, initially. |
| | (Labrador) | CVRD Inco Ltd. | 1.89 | 40,000 | | |
| | | | 1.90 | 6,000 | | |
| 2006 | Australia | Forrestania-Flying Fox, New Morning and Digger | 5.59 | 1,200 | 7,000 | Concentrates. |
| | (Western Australia) | South | 1.84 | 1,700 | | |
| | | Western Areas NL | 4.50 | 26 | | |
| 2006 | Do. | Lanfranchi | 2.61 | 1,200 | 6,300 | Ore. |
| | Do. | Sally Malay Mining Ltd. and Donegal Resources Ltd. | | | | |
| 2006 | Do. | Waterloo and Amorac | 3.50 | 299 | 10,000 | Concentrates. |
| | Do. | LionOre Australia Ltd. | | | | |
| 2007 | Australia | Avebury | 1.16 | 4,400 | 5,700 | Do. |
| | (Tasmania) | Allegiance Mining NL | 1.00 | 8,400 | | |
| 2008 | Canada | Podolsky, '2000', and Whistle Pit | 0.30 | 3,200 | NA | Ore. |
| | (Ontario) | FNX Mining Company, Inc. | 0.39 | 1,200 | | |
| 2008 | United States | NorthMet | 0.11 | 810,000 | 7,100 | Byproduct concentrate of Ni-Co hydroxide. |
| | (Minnesota) | PolyMet Mining Corp. | | | | |
| 2009 | Australia | Cosmos South, Alec Mairs, Anomaly 1 | 0.74 | 36,000 | 10,000 | Concentrates. |
| | (Western Australia) | Jubilee Mines NL | | | | |
| 2009 | Canada | Nickel Rim South | 1.80 | 13,000 | 10,000 | Do. |
| | (Ontario) | Xstrata Nickel | | | | |
| 2009 | Finland | Kylylahti copper-cobalt | 0.20 | 7,400 | 1,000 | Ni-Co hydroxide. |
| | | Vulcan Resources Limited | | | | |
| 2009 | Tanzania | Kabanga | 2.60 | 26,000 | 30,000 | Do. |
| | (Kagera region) | Barrick Gold Corp. and Falconbridge Limited | | | | |
| 2009 | Vietnam | Ban Phuc | 2.40 | 1,010 | 4,000 | Do. |
| | | Asian Mineral Resources Limited | 2.77 | 220 | | |
| 2009 | Zambia | Munali | 1.40 | 4,500 | 8,000 | Do. |
| | | Albidon Limited | 1.40 | 2,400 | | |
| 2010 | Australia | Sherlock Bay | 0.49 | 33,000 | 8,500 | Precipitated leachate. |
| | (Western Australia) | Australasian Resources Ltd. | | | | |
| 2010 | United States | Eagle | 3.80 | 3,600 | NA | Ore. |
| | (Michigan) | Kennecott Minerals Company | 2.20 | 500 | | |
| 2011 | South Africa | Sheba's Ridge | 0.18 | 409,000 | 23,700 | Concentrates. |
| | (Mpumalanga) | Ridge Mining plc and Anglo Platinum Ltd. | 0.18 | 313,000 | | |
| | | | 0.17 | 53,000 | | |
| 2012 | Australia | Honeymoon Well and Avalon (Bulong) | 0.65 | 120,000 | 40,000 | Concentrates, initially. |
| | (Western Australia) | LionOre Australia Ltd. and OM Group, Inc. | 0.65 | 120,000 | | |
| 2012 | Do. | Yakabindie | 0.58 | 290,000 | 40,000 | Ore. |
| | Do. | BHP Biliton Group | | | | |
| 2012 | Canada | Maskwa | 0.64 | 8,100 | 3,800 | Do. |
| | (Manitoba) | Mustang Minerals Corp. | 0.46 | 990 | | |
| 2012 | Russia (Amur) | Kun-Manie (Vodorazdelny, Ikensoe, Maly | 0.61 | 3,700 | NA | NA |
| | | Krumkon, and Falcon) | 0.47 | 33,000 | | |
| | | Amur Minerals Corp. | 0.47 | 17,000 | | |
| 2012 | United States | Mesaba | 0.12 | 300,000 | 20,000 | Byproduct concentrate of Ni-Co sulfide or hydroxide. |
| | (Minnesota) | Teck Cominco American, Inc. | | | | |
| 2012 | Zimbabwe | Hunters Road | NA | (2) | NA | Ore. |
| | | Bindura Nickel Corp. | | | | |
| 2014 | Canada (Ontario) | Totten | 0.74 | 6,000 | 3,800 | Concentrates. |
| | | CVRD Inco Ltd. | 0.75 | 550 | | |
| 2015 | Canada (Quebec) | South Raglan (Mesamax, Mequillon, Expo, | 1.00 | 11,000 | NA | Do. |
| | | Ivakkak, TK deposits) | | | | |
| | | Canadian Royalties Inc. | 1.60 | 950 | | |

See footnotes at end of table.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BEFORE 2020

(Metric tons unless otherwise specified)

| Projected year of first production | Country and state/province | Project and company[1] | Resource grade (% Ni) | Estimated resources (thousands)[2] | Annual production capacity (contained Ni) | Nickel product |
|---|---|---|---|---|---|---|
| 2017 | Canada (Ontario) | Kelly Lake<br>CVRD Inco Ltd. | NA | NA | NA | Concentrates. |
| 2018 | Do. | Victoria<br>FNX Mining Company Inc. | NA | (3) | NA | Ore. |

NA Not available.

[1]Company names reflect organizational structure as of February 26, 2007. BHP Billiton Group is a dual listed company comprising of BHP Billiton Limited and BHP Billiton Plc.

[2]Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources.

[3]Resource estimate in progress.

Sources: Canadian Minerals Yearbook 2004; company annual reports, presentations, and press releases; and CRU International, Ltd.