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NICKEL [ADVANCE RELEASE]

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NICKEL

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The global recession in 2008 affected the nickel industry even though nickel mine production had been at the highest level in history in mid-2007. The London Metal Exchange (LME) cash mean for nickel metal reached an alltime high of $52,161 per metric ton in May 2007, but weakened during the second half of 2007 and then began plummeting in the spring of 2008 as the global economy began to soften. By December 2008, the monthly cash mean had dropped to $9,682 per ton—a price level not seen since 2003. At the same time, stocks of nickel metal began to build up in LME warehouses and reached a high of 78,822 metric tons (t) by the end of December. The buildup of stocks continued into early 2009, setting a new record every month.

Primary nickel usage diminished significantly in 2008 as stainless steel production plummeted in the second half of the year. Stainless steel still accounted for more than 60% of primary nickel consumption in the world (Nickel Institute, 2009). China was the largest consumer of primary nickel in 2008 and also the largest producer of stainless steel. The European Union (EU) was the second ranked producer of stainless steel. On a global basis, nonferrous alloys accounted for about 12% of primary nickel use, followed by electroplating and other surface finishing with 11%. Cupronickel alloys and naval brasses made up the bulk of the nonferrous alloys group. Another 10% was divided among a broad range of specialty materials, including alloy steels, high-temperature nickel-chromium alloys, superalloys and related aerospace alloys, and titanium-nickel alloys. Nickel metal foam was increasingly being used in the manufacture of rechargeable batteries. Consumption of nickel in batteries had risen dramatically since 1995, but still accounted for less than 5% of world nickel use.

In 2008, reported nickel consumption (primary plus secondary) in the United States decreased by 6% compared with that of 2007. Stainless steel comprised 37% of U.S. primary consumption, a relatively low percentage because of the large number of specialty metal industries and readily available stocks of stainless steel scrap. Global nickel consumption increased by an average of 1.5% per year between 2002 and 2008, largely fueled by increased use of stainless steel worldwide and strong economic growth in China. The year-on-year growth rate for global stainless steel usage declined 5.9% in 2007, and then dropped an additional 4.7% in 2008 (Vale Inco Ltd., 2009, p. 7–9; International Nickel Study Group, 2010, p. A1–A10). The world nickel-producing industry was operating at close to capacity in mid-2007, but in the fourth quarter, global demand for stainless steel began to weaken, leading to a record buildup in warehouse stocks of nickel metal by mid-2008.

Recent acquisitions and mergers have changed the structure of the global nickel industry significantly. In January 2007, Brazilian mining company Companhia Vale do Rio Doce (CVRD) completed its takeover of Inco Ltd., the leading nickel producer in Canada. At the same time, OJSC MMC Norilsk Nickel (Moscow, Russia), the leading nickel producer in the world, launched a series of takeovers that gave the company footholds in mine development programs and production operations in Australia, the EU, North America, and southern Africa. China acquired mining interests and/or offtake agreements in Australia, Burma, Canada, Papua New Guinea, Turkey, and Zambia.

Mining companies were constructing new mines and/or processing facilities in Australia, Brazil, Canada, Madagascar, New Caledonia, and several other countries. The long-term expansion was needed to meet projected demand from India and similar emerging economies.

Legislation and Government Programs

Bridge and Pier Corrosion.—Corrosion of conventional carbon steel rebar in reinforced concrete is a major concern for the U.S. Department of Transportation Federal Highway Administration (FHWA) and other government agencies in North America responsible for the repair and rehabilitation of the transportation system. Carbon steel rebar is particularly susceptible to corrosion by seawater in tropical environments and by deicing salts spread heavily on many North American highways in the winter. The FHWA estimates that more than $8 billion was needed annually just to correct steel-corrosion problems with U.S. highway bridges. The Mexican Institute of Transportation estimates that between 65 and 330 of the 10,000 bridges in Mexico require comprehensive inspection for rebar corrosion (Perez-Quiroz and others, 2008).

Some structural engineers believe that much of this costly maintenance and repair could be eliminated by switching to nickel-bearing stainless steel or to even lower nickel-bearing duplex steels. The concrete pier at Puerto Progreso on the Yucatan Peninsula of Mexico is frequently cited in life-cycle analyses as an example of the benefits of using stainless steel rebar. The 2,100-meter-long pier was constructed from 1937 to 1941 using ASTM-grade 304 stainless steel rebar (containing 8.0% to 10.5% nickel). A sample from a protruding piece of rebar assayed 18.07% chromium, 8.63% nickel, 0.31% molybdenum, and 71.3% iron. The pier was extended an additional 4,000 meters (m) in 1988 and showed no signs of serious deterioration 11 years later. The Progreso pier was expected to last at least until 2018 with minimal maintenance (Arminox A/S and Rambøll Consulting Engineers and Planners, 1999).

The biggest drawback to substitution is increased cost. Nickel-bearing rebar can be as much as 20 times more expensive than conventional carbon steel rebar. One option

is to use a duplex stainless steel that contains less nickel. In November 2008, the U.S. Navy awarded a contract to American Arminox Inc. to address corrosion problems on Pier B3 at Pearl Harbor, HI. Pearl Harbor, the leading ship repair facility between the West Coast and the Far East, has a tropical marine environment similar to that of Puerto Progreso. Project engineers decided to use UNS S32304, a duplex stainless steel (containing 22.00% to 24.00% chromium and 3.5% to 5.5% nickel) that offered corrosion resistance comparable to the more expensive ASTM-grade 316 (containing 10% to 14% nickel). The same grade of Arminox duplex stainless steel rebar was being used to rehabilitate the Richibucto Bridge in New Brunswick, Canada (American Arminox Inc., 2008, 2009).

Greenhouse Gas Emissions, Climate Change Impacts, and Renewable Energy.—On December 18, the Nickel Institute cohosted a public debate on climate change with Friends of Europe, a EU policy institute. The debate was held in Brussels, Belgium, shortly after the United Nations Climate Change Conference in Poznan, Poland. The Brussels debate was intended to remind regulators, the media, and the public of the critical role that nickel will play in meeting global greenhouse gas reduction targets, regardless of the clean energy pathways adopted (Dunn, 2009).

Nickel-containing materials are an important part of the climate change solution because they meet a wide range of engineering and environmental requirements (Wong and Coates, 2010). At least 80 U.S. coal-fired powerplants have reached or are approaching their life expectancy and cannot be economically retrofitted with existing carbon-capture technology. Austenitic stainless steel and nickel-bearing superalloys would be needed to construct replacement powerplants that operate on natural gas, nuclear energy, or renewable energy.

Austenitic grades of stainless steel, such as S30400 and S31600, are often used to fabricate storage tanks and piping for liquefied natural gas (LNG). Engineers frequently line LNG tanks with 9% nickel steels or related low-expansion nickel alloys because the nickel lowers the ductile brittle transition temperature of the steel below that of LNG (-161 ˚C) (Wong and Coates, 2010).

Solar-generated power currently meets less than 1% of U.S. electrical demand but is expected to increase tenfold during the next 10 years. One type of solar powerplant uses mirrors to concentrate sunlight onto piping filled with molten salt or an equivalent heat transfer fluid. The transfer fluid flows to a heat exchanger where water is heated to steam. The steam is then fed into a turbine to generate electricity. The pipes, tubing, valves, and vessels in the molten salt part of the system are frequently fabricated from S31600 stainless steel to minimize corrosion from the circulating salt (Wong and Coates, 2010). Stainless steel is also used to make hot water tanks for thermo-solar systems (International Stainless Steel Forum, undated b, p. 2–4).

Austenitic stainless steel has a number of key applications in photovoltaic powerplants and smaller generating facilities, such as complexes of commercial buildings. As an example, United Solar Ovonic, LLC (Auburn Hills, MI) was manufacturing several types of amorphous silicon (a-Si) photovoltaic laminates for roofing at two locations in Michigan. The product, marketed under the Uni-Solar label, generates electrical energy, while protecting the roof from the weather. The photovoltaic laminates are hot bonded onto a flexible stainless steel substrate that is only about 120 micrometers thick. A patented, automated processor continuously deposited the nine-layered solar cells onto six rolls of stainless steel at a time. Each roll of stainless steel was about 2.4 kilometers (km) long. Some architects have successfully integrated the laminates into buildings with stainless steel roofs and facades (International Stainless Steel Forum, undated a; b, p. 16–18).

In late 2008, Florida Power & Light Co. (FPL) began constructing a 25-megawatt (MW) solar energy power farm in Desoto County, FL. The farm, outside Arcadia, was to have 90,500 solar panels and was scheduled to be completed in October 2009. FPL also had two other solar powerplants in the early stages of construction—a 75-MW hybrid thermal solar facility in Martin County and a 10-MW photovoltaic facility at the Kennedy Space Center (Florida Power & Light Co., 2008a).

The U.S. wind energy industry brought online more than 8,500 megawatts (MW) of new generating capacity in 2008, raising the nation's total wind energy capacity to 25,300 MW. Almost 30,000 wind turbines were operating at yearend in the United States, of which more than one-half were 1.5 MW utility units (American Wind Energy Association, 2009, p. 2–5, 15). FPL's sister company, FPL Energy, submitted plans to construct a six-turbine wind farm on Hutchinson Island in St. Lucie County (Florida Power & Light Co., 2008b). Nickel-bearing steels and related alloys were expected to play an especially important role in making offshore wind farms commercially feasible. The materials in offshore wind turbines must be able to meet challenges from both saltwater and severe ocean storms. Cape Wind had applied for a permit to build North America's first offshore wind farm on Horseshoe Shoal in Nantucket Sound, south of Cape Cod, MA. The wind farm would have 130 turbines with a combined generating capacity of 468 MW (Cape Wind Associates, LLC, undated; U.S. Department of the Interior, 2010).

New U.S. Coinage.—The popular and highly successful 50 State Quarters™ Program ended in December, after a 10-year run. The U.S. Mint produced 2.44 billion commemorative quarters in 2008, down from 2.71 billion in 2007. Each coin weighed 5.67 grams (g) and contained 8.33% nickel; thus 1,150 metric tons (t) of nickel was used in the five commemoratives released in 2008 (U.S. Mint, undated a, b). A total of 34.8 billion of the cupronickel-clad coins was minted during the 10-year period, representing 16,400 t of nickel. Because of the popularity of the 50 State Quarters™ Program, the U.S. Congress approved the U.S. Mint's request to extend the program and similarly honor the District of Columbia and five U.S. Territories in 2009.

The U.S. Mint began releasing the golden-colored Sacagawea dollar coin in January 2000 and, by yearend 2007, had struck 1.48 billion of the manganese brass-clad coins. An additional 24.6 million coins was made in 2008, excluding San Francisco, CA, proofs. The dollar coin contained 2.0% nickel and weighed 8.1 g. In 2007, the U.S. Mint began implementing the Presidential $1 Coin Act (Public Law 109–145) under which it was to issue circulating coins bearing the image of each

of the Nation's Presidents in the order that they served. Four Presidents were to be honored each year for the following 11 years. The U.S. Mint produced 464 million Presidential dollar coins in 2008. The composition and weight of the new coin were identical to those of the Sacagawea coin. In 2007, the U.S. Congress also passed the Native American $1 Coin Act (Public Law 110–82) authorizing the U.S. Mint to start a new $1 coin series commemorating Native Americans in 2009. The combined production of dollar coins in 2008 required 79 t of nickel (U.S. Mint, undated b, c).

Production

***Exploration and Development.*—Alaska.**—Several companies were actively exploring for copper, nickel, and platinum-group elements (PGEs) in southern Alaska. Quaterra Resources Inc. (Vancouver, British Columbia, Canada) has been evaluating sulfide mineralization on Duke Island, 48 km south of Ketchikan, since 2001. New air and ground geophysical data obtained by Quaterra in 2008 suggested that the mineralization may be related to an elongate sill or dike complex in the Marquis area (Quaterra Resources Inc., 2010).

Michigan.—Kennecott Eagle Minerals Co. slowed development of its Eagle Mine near Big Bay, west of Marquette, because of declining nickel prices and the global recession. In late 2007, the State of Michigan issued a mining permit, an air use permit, and a groundwater discharge permit to Kennecott Eagle Minerals Co. to develop the relatively small but high-grade copper-nickel deposit. Shortly after the permits were issued, the National Wildlife Foundation and three other environmentally focused organizations filed administrative appeals contesting the issuance of two of the permits. Key legal issues were still being reviewed at yearend (Michigan Department of Environmental Quality, 2008; Pepin, 2009; PR Newswire, 2009).

The proposed Kennecott operation would be the only primary nickel mine in the United States. Ore would be trucked from the $300 million mine to a renovated mill at the defunct Humboldt iron ore mine near Champion, where the copper-nickel sulfides would be concentrated. The concentrates would then be railed to Ontario, Canada, for smelting. In February, the Michigan Department of Environmental Quality (MDEQ) began holding hearings on Kennecott's plans to renovate the Humboldt Mill at a cost of $80 million, and by yearend, Kennecott had submitted its permit application for the mill to MDEQ.

Minnesota.—PolyMet Mining Corp. (Vancouver, British Columbia) sought final regulatory approval to develop the NorthMet project—a copper-nickel-PGE deposit in the Duluth Complex. The Minnesota Department of Natural Resources (MDNR) was responsible for drafting the environmental impact statement (EIS) and was being assisted by the U.S. Army Corps of Engineers. The MDNR planned to release a draft of the EIS to the public for comment in October 2009, 1 year later than originally envisioned.

The NorthMet deposit, at the western end of the Duluth Complex, was estimated to have 249 million metric tons (Mt) of proven and probable reserves averaging 0.28% copper and 0.08% nickel. Ore from the proposed NorthMet open pit would be shipped to the reconditioned Cliffs Erie mill near Hoyt Lakes, MN, for crushing, grinding, and subsequent flotation. The concentrate would be processed at the Erie site in a new hydrometallurgical plant to produce copper cathode, nickel-cobalt hydroxide, and a precious-metals precipitate (PolyMet Mining Corp., 2008, p. 2–14). In October, Glencore International AG (Baar, Switzerland) agreed to loan Polymet $50 million in exchange for the right to purchase and market all of the production from the project (Newby, 2009, slides 30–35). Duluth Metals Ltd. (Toronto), Franconia Minerals Corp. (Spokane, WA), and Teck Cominco American Inc. (Spokane) continued to actively develop other disseminated sulfide deposits in the Duluth Complex.

Kennecott Exploration Co. has been exploring for copper and nickel sulfides in Aitkin and Carlton Counties of Minnesota since 2001. Exploration is not straightforward in this part of the State because the bedrock in many areas is covered by 30 to 50 meters (m) of glacial overburden. In 2008, Kennecott discovered high-grade copper-nickel mineralization near Tamarack (Rio Tinto Group, 2009, p. 74; Schram, 2010).

Byproduct Production.—The United States had no active nickel mines in 2008. Except for limited quantities of byproduct nickel that were recovered at some copper and precious metal refineries, imports and recycling met all needs. In 2008, Stillwater Mining Co. (majority owned by Norilsk Nickel) shipped 423 t of nickel in crystalline sulfate. Stillwater mined PGE ore in Montana's Beartooth Mountains. The company's two mills (East Boulder and Nye) together processed 1.09 Mt of ore and subgrade material. Concentrates from the two mills were trucked to the company's smelting and refining complex at Columbus, MT, where a PGE filter cake and byproduct crystalline nickel sulfate containing minor amounts of cobalt were produced (Stillwater Mining Co., 2009, p. 6–21, 49–51).

Freeport-McMoRan Copper & Gold Inc. (New Orleans, LA) has produced byproduct nickel carbonate at its El Paso, TX, copper refinery since 2004 (Freeport-McMoRan Copper & Gold Inc., 2010, p. 1–6, 25–26).

No ferronickel was produced in the United States in 2008 from either domestic or imported ores. Almost all U.S. ferronickel exports were either re-exports or material upgraded for specialty purposes. The steel industry accounted for virtually all the ferronickel consumed in 2008, with more than 98% used in stainless and heat-resistant steels.

Secondary Production.—International Metals Reclamation Co. Inc. (a subsidiary of Vale Inco Ltd.) produced a remelt alloy typically averaging 13% chromium and 12% nickel from recycled materials at Ellwood City, PA. Stainless steel producers used the remelt alloy as a substitute for ferrochromium and ferronickel.

Gulf Chemical and Metallurgical Corp. of Freeport, TX, [owned by Eramet Group (Paris, France)] was one of a limited number of companies worldwide that processed spent catalysts from petroleum refineries in 2008. The Freeport facility can treat nickel-molybdenum and cobalt-molybdenum hydrotreating catalysts that have been "poisoned" by nickel and vanadium tied up in porphyrins and other organometallic molecules of crude oil. Gulf Chemical converted the byproduct nickel residue to a crude nickel-cobalt alloy in an electric furnace, and then sold the alloy to nickel refineries.

Consumption

U.S. apparent consumption of primary nickel was 115,000 t, or about 9% of world consumption. U.S. industry reported consumption of an additional 85,200 t of nickel in scrap. On the basis of U.S. reported consumption, the share of primary nickel consumed in the production of stainless and alloy steels was 43%, about the same as that in 2007.

U.S. consumption of nickel to make superalloys—key fabrication materials for jet engines—increased by 3% (in terms of nickel content) compared with that of 2007. For the fifth year in a row, U.S. aerospace sales increased in every sector of the industry except for related product sales (Blakey, 2009). Shipments of U.S. manufactured civil jet transport dropped from 441 in 2007 to 375 in 2008, in part owing to a work stoppage at The Boeing Co. On a global basis, Airbus and Boeing, the two leading manufacturers of large jet transport, delivered a combined total of 858 aircraft in 2008, compared with 894 in 2007. The decline in their deliveries reflected delays in aircraft construction schedules and the weakening global economy.

The estimated value of apparent primary nickel consumption in the United States was $2.43 billion, down from $4.19 billion (revised) in 2007. Apparent primary consumption increased slightly from 112,000 t (revised), despite the recession. The sharp decrease in the value of primary consumption resulted from a 43% decrease in the LME cash price, which may have spurred usage. Apparent primary consumption plus reported secondary consumption totaled 200,000 t (table 1).

Nickel-Based Batteries and Hybrid Electric Vehicles.—U.S. demand for nickel in rechargeable batteries continued to increase. In 2008, most of the newer hybrid electric vehicles (HEVs) on U.S. highways used nickel-metal hydride (NiMH) batteries to store the energy recovered from the vehicle's regenerative braking circuitry—a system that reduces overall fuel consumption. Growing HEV sales in East Asia and North America increased demand for nickel foam and specialty nickel metal powders, key NiMH battery components.

Nationwide registrations of new HEVs were just over 312,000 in 2008, an 11% decrease from 350,289 in 2007 (Gravigny, 2009). Cobasys (Orion, MI) was the principal North American manufacturer supplying NiMH battery systems for HEV applications. Overseas, HEV sales were mixed. HEV registrations increased dramatically in Canada, Israel, Japan, and the Netherlands, in part because of tax incentives and increasing emphasis on environmental programs.

High crude oil prices, shrinking petroleum reserves, and growing concerns about climate changes have spurred development of novel batteries and other new electrochemical power sources. The lithium ion (Li-ion) battery and the NiMH battery currently lead the field in automobile propulsion, but both still exhibit large gaps between expected and practical performances. Safety remains an important concern for the large-scale Li-ion batteries used to propel several of the newer electric vehicles. Researchers at the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan, may have been able to minimize a number of key battery problems by designing a rechargeable nickel-lithium (Ni-Li) battery that has separate compartments for aqueous and organic electrolytes. A nickel-hydroxide electrode working in an aqueous solution serves as the cathode and lithium metal working in an organic electrolyte serves as the anode. A superionic conductor glass ceramic film separates the two electrolytes. The integrated Ni-Li battery has a theoretical energy density of 935 watthours/kilogram (Wh/kg), compared with 414 Wh/kg for the Li-ion battery and 214 Wh/kg for the NiMH battery (Li and others, 2009).

Stainless Steel and Low-Alloy Steels.—In 2008, stainless steel producers accounted for 37% of apparent primary nickel consumption in the United States (table 4) and more than 60% of primary consumption in the world. Production of raw stainless steel and heat-resisting steel in the United States totaled 1.93 Mt in 2008, down by 11% from 2.17 Mt in 2007. Nickel-bearing grades accounted for 1.29 Mt, or 67% of total stainless steel production (American Iron and Steel Institute, 2009a, p. 72–73; b).

The meltshop of North American Stainless (NAS) in Ghent, KY, produced 709,000 t of stainless steel slabs—6% less than that of 2007. NAS was able to maintain its leading position in the flat products market in spite of the global economic crisis. NAS poured the first heat from its new ladle furnace in March and commissioned its no. 2 argon-oxygen decarburization (AOD) converter in September. The new equipment raised the capacity of the meltshop to 1.42 million metric tons per year (Mt/yr) from 0.77 Mt/yr, making it the leading stainless steel producer in North America (Acerinox, S.A., 2009, p. 23–24, 39–40, 168–171).

New duplex stainless alloys, such as ATI 2003® and ATI 2102™, were becoming increasingly popular. They contain less nickel and molybdenum than traditional stainless steel alloys and have improved corrosion resistance and strength. Some of these high-strength stainless alloys can be used in offshore oil and gas production operations at water depths of several kilometers where extreme pressure and saltwater corrosion are serious problems (Allegheny Technologies Inc., 2010, p. 3–4).

Superalloys and Related Nickel-Based Alloys.—Of the primary nickel consumed in the United States, approximately 22% was used to make high-performance superalloys and related nickel-based alloys for the aerospace, electric power, and petrochemical industries. U.S. production of superalloys increased by 3% from that of 2007. Flat or declining sales to manufacturers of jet aircraft engines and other sectors of the aerospace industry were offset by a sharp rise in sales to the electrical energy and defense sectors.

Allegheny Technologies Inc. (ATI) had a long-term sourcing agreement with General Electric Aviation to supply nickel-base superalloys for commercial and military jet engines (Allegheny Technologies Inc., 2007). ATI 718Plus®, a new nickel-base superalloy, has been approved for legacy and next-generation jet engines. Jet engine components fabricated from the alloy can tolerate temperatures approximately 55 ºC (or 100 ºF) hotter than those made from 718, Waspaloy, or other approved traditional superalloys. The melting range of ATI 718Plus® is 1,260º to 1,343 ºC (Allegheny Technologies Inc. Allvac, 2008).

Stocks

On February 28, 2007, stocks in LME warehouses worldwide bottomed at 3,342 t, the lowest end-of-month figure reported in at least 12 years (International Nickel Study Group, 2010, p. A1–A2). During the next 10 months, LME stocks rapidly built up as a result of decreased demand. On January 1, 2008, LME stocks totaled 47,940 t. The stock buildup halted temporarily during the second quarter of 2008 but began growing again in August, reaching 78,822 t on December 31. Data collected by the International Nickel Study Group indicated that, at yearend 2008, world nickel producers (excluding those in Austria, China, Macedonia, Serbia, and the Ural region of Russia) had an additional 103,200 t of primary nickel stocks. About 68%, or 70,400 t, of the producer stocks was class I material (refined products with a nickel content of 99% or greater), which included, in order of decreasing quantity, electrolytic cathode, briquets, pellets, powder, and rondelles. The remaining 32% was class II material (products with a nickel content of less than 99%), which included ferronickel, oxide sinter, and East Asian utility nickel. All stocks in LME warehouses were class I (International Nickel Study Group, 2010, p. A7–A8). In comparison, at yearend, U.S. consumer stocks of primary nickel totaled 9,150 t, 24% more than the 7,350 t (revised) in stock at yearend 2007 (tables 1 and 5).

Prices

Nickel price movements in 2008 reflected the onset of the global recession. The January average cash price for 99.8%-pure metal on the LME was $27,680 per metric ton ($12.555 per pound)—still an extremely high price in historical terms. Nickel prices recovered slightly in the first quarter, peaking at $31,217 per ton ($14.160 per pound) in March, but then steadily declined for the remainder of the year. The average price for June was $22,539 per ton ($10.224 per pound). The midyear price could not be sustained and weakened further during the second half of 2008. The monthly average for December was $9,682 per ton ($4.392 per pound), about one-third that of January. The average annual LME price was $21,104 per ton ($9.572 per pound)—43% less than the 2007 average (as posted by the LME and published in Platts Metals Week).

World Review

The world's leading nickel producer was Norilsk, followed by CVRD. PT Antam moved into third place because of its surge in production of direct shipping ore for the Chinese nickel pig iron (NPI) industry. Other major producers were BHP Billiton (Australia and United Kingdom), Eramet, and Xstrata plc.

The global restructuring of the nickel industry that began in 2005 continued into 2008. CVRD's acquisition of Inco Ltd. in 2006 allowed the two companies to pool their nickel expertise and focus on development of Onca Puma and Vermelho—CVRD's two flagship laterite projects in northern Brazil. CVRD's new subsidiary, Vale Inco (now Vale Nickel), was given supervisory responsibility for both projects. Development of Onca Puma was accelerated, with the ferronickel smelter scheduled to come onstream in 2010. Scheduled commissioning of Vermelho, on the other hand, was postponed so that some critical metallurgical issues could be analyzed (table 13). At yearend, Vale Inco slowed work on Onca Puma when demand for stainless steel decreased significantly.

In late 2007, Xstrata agreed to buy Jubilee Mines NL (Perth, Western Australia) for $2.88 billion. The takeover was completed in early 2008 and gave Xstrata control of the Cosmos Mine in Western Australia plus access to eight neighboring nickel deposits (Pearson and Foley, 2007; Xstrata plc, 2009a, p. 43, 65–66, 127).

Norilsk continued to consolidate its overseas mining and processing holdings. These assets included the former nickel refinery of OM Group Inc. (OMG) in Harjavalta, Finland, the Cawse mining and leaching operations in Western Australia, and partial interests in three other Australian nickel mines. In June 2007, Norilsk acquired LionOre Mining International Ltd. (Toronto), a company with nickel mining operations in Australia, Botswana, and South Africa. Norilsk's purchase of LionOre was one of the largest foreign acquisitions in the history of post-Soviet Russia. LionOre and the nickel businesses of OMG were integrated into Norilsk Nickel International, an overseas subsidiary of Norilsk. The LionOre acquisition also gave Norilsk a 50% position in the Nkomati nickel mining venture in Mpumalanga Province, South Africa. The remaining 50% was held by African Rainbow Minerals Ltd. (ARM) (Sandton, South Africa). The Nkomati concentrator can process 302,000 metric tons per year (t/yr) of sulfide ore and produce 5,500 t/yr of nickel concentrate (OJSC MMC Norilsk Nickel, 2009; p. 5–7, 32–33, 61–73).

In 2008, world use of primary nickel was reported to be 1.28 Mt, down by 9% from the alltime high of 1.40 Mt consumed in 2006 (International Nickel Study Group, 2010, p. A–1). A few nickel producers continued to operate at full capacity despite the global recession. Others, however, cut back production and slowed development or postponed projects because of the decline in nickel prices. Demand continued to be buoyed by spiraling apparent consumption in China, which had risen to 350,000 t in 2008 from 47,900 t in 1999. The Chinese stainless steel industry continued to expand and used 224,000 t of primary nickel in 2008. The Chinese stainless steel industry was expected to overtake the steel industry of the EU in 2009 to become the leading consumer of primary nickel. The steel industry of the EU consumed 231,000 t of primary nickel in 2008, and the Japanese steel industry was in third place (91,700 t) (Eramet Group, 2010, p. 42–45).

Production of raw stainless steel (excluding production in China, the Commonwealth of Independent States, and Eastern Europe) had been increasing at a compound annual growth rate of 5.5% since 1950. Production dropped to 18.9 Mt in 2008 from 20.8 Mt in 2007 and 23.0 Mt in 2006 (Vale Inco Ltd., 2009, p. 4). According to the International Stainless Steel Forum (2010), stainless steel production for the entire world declined to 25.9 Mt in 2008 (preliminary) from 27.8 Mt in 2007.

European Union.—At least 7 of the 27 sovereign Member States had nickel mining or related downstream processing operations. Finland, Greece, and Spain had active mines in 2008.

The EU's new registration and environmental testing law took effect on June 1, 2007. The law—the Registration, Evaluation,

Authorization, and Restriction of Chemicals (REACH, regulation no. 1907/2006)—required chemical manufacturers worldwide to register more than 30,000 chemicals with the European Chemicals Agency in Helsinki, Finland (Scott, 2007). A number of common nickel chemicals were affected by the legislation. All exporters of nickel chemicals to the EU must comply with the new law. In September 2008, EU regulators classified nickel carbonate as a category 1 carcinogen and a category 2 reproductive toxin. At least 125 other nickel chemicals were declared category 1 carcinogens by extrapolation and could be banned outright or have their use restricted (European Commission, Joint Research Centre, Institute for Health and Consumer Protection, 2010, EINECS database; Minerals and Metals Sector Staff, Natural Resources Canada, 2009, p. 32.5, 32.7).

Albania.—Cunico Resources N.V. (Amsterdam, Netherlands) mined lateritic ore at its Bitinçka and Treni Mines in the Devolli region close to the Greek border. The ore was exported to the company's smelter at Kavadarci in Macedonia. A third party also supplied Albanian ore to both the Kavadarci smelter and Cunico's sister smelter at Gllogovac, about 20 km west of Pristina, Kosovo (Cunico Resources N.V., 2009). In November, European Nickel PLC and privately owned Balkan Resources Inc. formed a joint venture to develop two contiguous laterite deposits elsewhere in the Devolli region. The joint venture would develop European Nickel's Devolli deposit and Balkan Resources' Kokogllave deposit as a single mining operation (European Nickel PLC, 2008; 2010) (table 13).

Australia.—Australia was the third ranked nickel-producing country in the world. Seven companies in Western Australia reported producing salable nickel in 2008. Two other companies, plus three of the seven, trucked sulfide ore to BHP Billiton's concentrator at Kambalda for further processing [Department of Industry and Resources (Western Australia), 2009, p. 35–38]. An eighth company operated an underground sulfide mine in Tasmania.

Laterite Operations.—BHP Billiton's newly constructed Ravensthorpe mining and processing complex, northwest of Esperance in Western Australia, used both pressure acid leaching and atmospheric leaching to extract nickel and cobalt from local laterite ores. The Ravensthorpe plant was designed to recover up to 50,000 t/yr of contained nickel and 1,400 t/yr of cobalt. In December 2007, the first nickel-cobalt hydroxide precipitates were shipped by sea from Esperance to the company's Yabulu refinery in Queensland for further processing and evaluation. The capacity of the Yabulu refinery had been increased in 2006 to 76,000 t/yr of nickel and 3,500 t/yr of cobalt to accommodate the additional feed from Ravensthorpe. The $2.09 billion complex at Ravensthorpe was officially opened in May 2008 and became part of Nickel West (BHP Billiton, 2008, p. 35, 74–75).

BHP Billiton suspended production at Ravensthorpe in December 2008 and announced that the Yabulu refinery would no longer process the mixed hydroxide precipitate produced at Ravensthorpe and would revert to processing ore only. The decision was made because of concerns about the profitability of Ravensthorpe and Yabulu in a rapidly deteriorating nickel market (BHP Billiton, 2009b; c, p. 34, 53–54). After the announcement was made, several companies approached BHP Billiton about acquiring Ravensthorpe.

The Yabulu refinery continued to process laterite ores purchased from third party mines in Indonesia, New Caledonia, and the Philippines as its main feedstocks. In 2008, the refinery produced 35,100 t of nickel in compacts averaging 98.5% nickel or greater (a product similar to rondelles) (BHP Billiton, 2009a, p. 11).

The Murrin Murrin joint venture near Leonora was the second ranked nickel producer in Western Australia after BHP Billiton's Nickel West. The laterite mining and processing operation produced 30,514 t of nickel, up by 11% from 27,585 t produced in 2007. Murrin Murrin was jointly owned by Minara Resources Ltd. (60% interest) and Glenmurrin Pty. Ltd. (a subsidiary of Glencore International AG of Switzerland) (40%). Production was higher in 2008 than that of 2007 because the complex was shut down in 2007 for 7 weeks to perform statutory maintenance and make major capital improvements to both the hydrogen sulfide and the sulfuric acid plants. In 2008, Minara purchased a sixth reduction autoclave for the refinery. The new autoclave cost about $1.7 million and was to be operated in parallel with the existing five units (Minara Resources Ltd., 2009, p. 7, 19).

Murrin Murrin's heap-leach demonstration project reached full capacity in 2008 and may be expanded when market conditions improve. The heap-leach project was intended to determine if it was economically feasible to extract nickel and cobalt from the Murrin Murrin's scats (material rejected during slurry preparation) and/or from low-grade ores in the surrounding area. Minara was also evaluating whether it would be commercially feasible to truck ore from the Irwin Hills/Coglia Well District to Murrin Murrin. The Irwin Hills project (a joint venture with Yilgarn Mining Ltd.) had 17.9 Mt of resources averaging 1.07% nickel at a 0.8% nickel cutoff grade (Minara Resources Ltd., 2009, p. 1–5, 16, 19–20).

In 2008, the Cawse mine and ore-leaching facility, northwest of Kalgoorlie, produced 1,400 t of salable nickel from 678,000 t of lateritic ore averaging 0.69% nickel. The final product, a nickel-cobalt carbonate intermediate, was shipped to the Harjavalta smelter in Finland for conversion into cathode, briquettes, metal powder, or chemicals. Norilsk Nickel International suspended production at Cawse in June and put the operation on care-and-maintenance status in October when the nickel price began to decline (Department of Industry and Resources [Western Australia], 2009, p. 36; OJSC MMC Norilsk Nickel, 2009, p. 61–63, 70–72).

Sulfide Operations.—*Western Australia.*—In 2008, BHP Billiton's Nickel West produced 43,400 t of metal briquettes and powder at Kwinana from concentrates smelted at Kalgoorlie. Kwinana also produced several intermediate products, including cobalt-nickel sulfide, copper sulfide, and ammonium sulfate. Nickel West was the third ranked producer of nickel in concentrate in the world.

The Kalgoorlie smelter produced about 26,600 t of nickel in finished matte for export. About 38% of the concentrate came from the Mount Keith Mine in the Northern Goldfields region. The remaining 62% came from Leinster and third party mines at Kambalda (BHP Billiton, 2009a, p. 11). Nickel West continued to expand its Mount Keith operation and was also reevaluating

the undeveloped Yakabindie deposit, 25 km south of Mount Keith (BHP Billiton, 2009c, p. 76–77).

In 2008, Norilsk Nickel International produced 8,849 t of nickel in concentrates at its Lake Johnston sulfide flotation plant, 125 km southeast of Marvel Loch. The concentrates were produced from ores mined at its nearby Emily Ann and Maggie Hays underground workings or from ores supplied on a toll basis by Western Areas NL. Norilsk Nickel International also operated the Black Swan-Silver Swan mining complex (53 km northeast of Kalgoorlie) and the Waterloo underground mine (35 km south of Leinster). The Waterloo ore was being toll processed at BHP Billiton's Leinster concentrator, and generated 5,814 t of salable nickel in 2008. Norilsk's Harjavalta operations in Finland recovered 14,815 t of salable nickel from Black Swan concentrates. An additional 865 tons of salable nickel was recovered by third parties from Black Swan material. In the fourth quarter, Norilsk put both the Silver Swan and Waterloo on care-and-maintenance status for an indefinite period of time (OJSC MMC Norilsk Nickel, 2009, p. 61–63, 69–70).

Western Areas commissioned its high-grade Flying Fox Mine at Forrestania in late 2008 and was constructing a second high-grade mine, Spotted Quoll, in the district (Department of Industry and Resources [Western Australia], 2009, p. 36).

In November, production was suspended at more than eight other Western Australian mines because of deteriorating nickel prices. This second set of mines included the Beta Hunt and East Alpha mines (Palmary Enterprises Ltd.), the Blair Mine (Australian Mines Ltd.), the recommissioned Carnilya Hill Zone 29 and Miitel mines (Mincor Resources NL), Copernicus Mine (Panoramic Resources Ltd.), Radio Hill Mine (Fox Resources Ltd.), and Widgiemooltha North project (Department of Industry and Resources [Western Australia], 2009, p. 35–37).

Tasmania.—In December 2007, Zinifex Ltd. (Southbank, Victoria), one of the leading zinc mining companies in the world, offered to buy Allegiance Mining NL for $669 million in cash. Allegiance's principal asset was its new Avebury nickel mine near Zeehan. However, Jinchuan Group Ltd., which owned 10.4% of Allegiance, declined to sell its share, triggering a string of offers and counteroffers in the first quarter of 2008. By mid-March, Zinifex had acquired a 51.1% interest in Allegiance and taken control of Avebury (Chambers, 2008). The Avebury mill was commissioned in August and produced 10,381 t of nickel concentrates during the next 3 months. The concentrator was designed to produce about 8,500 t/yr of contained nickel. In the fall, Zinifex merged with Oxiana Ltd. to form OZ Minerals Ltd. (Melbourne, Victoria), but the joint company had difficulties obtaining new financing. In mid-December, OZ Minerals put the Avebury Mine and mill on indefinite care-and-maintenance status (Louthean, 2008; OZ Minerals Ltd., 2008).

Brazil.—Three companies mined nickel ore in Brazil in 2008—Anglo American Brasil Ltda., Cia. de Nickel do Brasil, and Grupo Votorantim. Four major mining and/or metallurgical processing complexes were under construction—the Barro Alto ferronickel smelter and refinery, Goias (Anglo American plc), the Niquelandia ferronickel smelter, Goias (Votorantim Metais), the Onca Puma mining and ferronickel complex, Para (Vale Inco Ltd.), and the Santa Rita Mine, Bahia (Mirabela Nickel Ltd.).

Votorantim Metais was the leading producer of electrolytic nickel in Latin America and operated a nickel-cobalt refinery in Sao Miguel Paulista (Sao Paulo) capable of producing 23,000 t/yr of electrolytic nickel and 1,420 t/yr of electrolytic cobalt. The Sao Miguel Paulista refinery was using intermediate nickel carbonate from the company's operation in Niquelandia for feed. The electrolytic nickel was 99.9% pure and was registered on the LME. Votorantim's sulfide smelter at Fortaleza de Minas (Minas Gerais) produced an estimated 7,240 t of nickel in matte, primarily for export to Finland, down from about 7,560 t (revised) in 2007 (Da Silva, 2009). The matte typically assays 50% to 55% nickel, 7% to 12% copper and 0.14% to 1% cobalt (Votorantim Metais, 2008).

Mirabela Nickel Ltd. (Perth, Australia) planned to commission its Santa Rita Mine near Ipiau, Bahia, in late 2009. When ramp up is completed in 2010, Santa Rita should be able to produce between 18,500 and 27,000 t/yr of nickel in sulfide concentrate. In the summer of 2008, Mirabela signed 5-year offtake agreements with both Norilsk Nickel Harjavalta Oy and Votorantim Metais Niquel S.A. Mirabela would ship 50% of the concentrate produced at Santa Rita to Norilsk Nickel's Harjavalta smelter in Finland for further processing. The remaining 50% would go to the Fortaleza smelter in Minas Gerais. Mirabela's 5-year contract with Votorantim would permit Votorantim to increase the capacity of the Fortaleza operation to 18,000 t/yr of nickel in matte from 6,000 t/yr. In November, Santa Rita had 121 Mt of proven and probable reserves averaging 0.60% nickel (Mirabela Nickel Ltd., 2009, p. 2–8, 14–15).

At yearend, Vale Inco decided to slowdown construction at its Onca Puma mining complex in Para State. The slowdown was an attempt to balance nickel production against declining global demand for the metal. The project was to have come onstream in January 2010, with a capacity of 58,000 t/yr of nickel in ferronickel, but a key environmental permit was still pending (Companhia Vale do Rio Doce, 2009b).

***Canada.*—Manitoba.**—Vale Inco's operations at Thompson produced 28,900 t of refined nickel in 2008 from ores extracted from the Birchtree and Thompson Mines. The company's Manitoba complex was fully integrated and included a 15,000-metric-ton-per-day mill, a smelter capable of producing 1,400 anodes per day, and a refinery undergoing modernization. Feed for the refinery came largely from three sources—concentrates produced onsite at Thompson, concentrates imported from Western Australia, and concentrates shipped from Vale Inco's new mill at Voisey's Bay, Labrador (Companhia Vale do Rio Doce, 2009a, p. 32–36; Minerals and Metals Sector Staff, 2009, p. 38.1–38.2).

In March, the Manitoba government issued an environmental license to Crowflight Minerals Inc., permitting the company to begin production at its Bucko Lake project near Wabowden. Crowflight commissioned the onsite concentrator in September and planned to reach full capacity—4,200 t/yr of nickel in concentrate—by mid-2009. All of the concentrate was to be processed at Xstrata's Falconbridge smelting complex in Ontario. Crowflight shipped its first concentrate to Xstrata in February 2009 (Crowflight Minerals Inc., 2009).

In May, Micon International Ltd. completed a prefeasibility study of the Maskwa deposit for Mustang Minerals Corp. (Toronto, Ontario). The proposed renovated open pit, 140 km northeast of Winnipeg, has 7.1 Mt of proven and probable reserves grading 0.64% nickel and 0.13% copper. An onsite concentrator would produce 4,200 t/yr of nickel in sulfide concentrate grading 10.2% nickel, 2.5% copper, and 0.36% cobalt (Micon International Ltd., 2008, p. 21–22, 66, 146–149).

Newfoundland and Labrador.—The Ovoid Mine at Vale Inco's Voisey's Bay operation extracted 2.39 Mt of ore grading 3.50% nickel and 2.38% copper. The mined tonnage yielded a record 77,500 t of finished nickel, up from 58,900 t in 2007 (Companhia Vale do Rio Doce, 2009a, p. 34–35). Vale Inco shipped the high-grade nickel concentrate produced at Voisey's Bay to Thompson and to Harjavalta, Finland, for smelting and downstream processing. Vale Inco was building a hydrometallurgical refinery at Long Harbour, Newfoundland, as part of the 2002 Voisey's Bay Development Agreement with the Provincial government. Under this agreement and subsequent agreements, the bulk of future concentrates produced at Voisey's Bay would be shipped to Long Harbour for processing after the refinery was commissioned (Voisey's Bay Nickel Co. Ltd., 2006, p. 1–5).

Ontario.—Vale Inco's Ontario Division was the leading nickel producer in the Sudbury district. The division produced 85,300 t of finished nickel in 2008 on an ore-source basis, compared with 70,700 t in 2007 and 82,000 t in 2006. Vale Inco revised its 2006 and 2007 figures to exclude finished nickel produced by the company using feeds purchased from unrelated parties. The division had seven mines operating in 2008, the largest being the Stobie in terms of gross tonnage, followed by the Coleman. Part of the refined nickel was recovered from intermediate nickel oxide at the division's Clydach refinery in the United Kingdom (Companhia Vale do Rio Doce, 2009a, p. 34–35; Minerals and Metals Sector Staff, 2009 p. 32.1–32.3).

Xstrata, Sudbury's other principal producer, mined 1.64 Mt of ore with an average grade of 0.98% nickel and 1.12% copper (Xstrata plc, 2009b, p. 6). Xstrata's smelter at Falconbridge produced 64,906 t of nickel in matte, which was shipped to the company's Nikkelverk operations in Norway for refining. Xstrata's new Nickel Rim South Mine, scheduled to open in 2009, was expected to offset declining production from the Craig, Fraser, and Thayer-Lindsley operations. Xstrata halted all mining operations at Thayer-Lindsley in January 2009 because the mine was an older, higher cost operation in a depressed nickel market and was approaching the end of its productive life (Xstrata plc, 2008c, d).

FNX Mining Co. Inc. continued to extract ore from the Levack Complex on the north rim of the Sudbury Basin. In 2008, the Levack Complex—composed of the Levack and McCreedy West Mines—shipped 848,000 t of nickel ore and 330,000 t of copper-precious metal ore to Vale Inco's Clarabelle mill and other third-party mills. FNX's Podolsky Mine, on the northeastern corner of the rim, shipped 243,000 t of copper-precious metal ore. Most of the copper ores from the footwall deposits carried significant gold, nickel, and PGE credits. Payable nickel metal in 2008 for FNX totaled 5,940 t (FNX Mining Co. Inc., 2009, p. 1–10).

Xstrata mined 954,000 t of ore averaging 1.20% nickel at its Montcalm Mine near Timmins and treated 927,000 t of ore at the company's Kidd mill, where 8,905 t of nickel in concentrate was recovered (Xstrata plc, 2009b, p. 6).

Quebec.—Xstrata's Raglan Mine in northern Quebec produced 25,873 t of nickel in concentrate, which was slightly less than the 26,059 t recovered in 2007 (Xstrata plc, 2009b, p. 6).

Declining nickel prices and tightening credit slowed exploration programs in the Nunavik region immediately surrounding Raglan. In May, the Quebec Ministere du Developpement Durable, de l'Environnement et des Parcs (MDDEP) issued a Certification of Authorization to Canadian Royalties, permitting the company to start construction at its Raglan South (renamed Nunavik) mining site. The Ministry approved port facilities as part of the $465 million project. In August, however, Canadian Royalties stopped work to conserve capital. Canadian Royalties had been evaluating seven deposits in the Raglan South area—Allammaq, Expo, Ivakkak, Mequillon, Mesamax, Puimajug, and TK. Only three—Expo, Ivakkak, Mesamax—were considered in the engineering feasibility study completed by SNC–Lavalin Group Inc. and its team in 2007. Allammaq and Puimajug were discovered after the feasibility study had been launched (Canadian Royalties Inc., 2008, p. 10–15, 19–21; Gazette, The, 2008).

China.—According to the China Nonferrous Metals Industry Association, China produced 129,000 t of electrolytic nickel in 2008, up 6% from 122,000 t in 2007. Electrolytic nickel from Jinchuan Non-ferrous Metals Corp. (JNMC) accounted for 104,600 t, or 81% of the national total. JNMC operated the Yongchang mining complex at Jinchang in Gansu Province. At Jinchang, chalcopyrite-pentlandite ore bodies occur in a 6.5-km long by 500-m wide zone along the base of Longshou Mountain. The two underground mines at Jinchang have 520 Mt of combined proven reserves grading 1.1% nickel. In October, JNMC commissioned a new smelter capable of processing 1.0 Mt/yr of nickel concentrates, equivalent to about 60,000 t/yr of refined nickel. Concentrates imported from Spain, Tasmania, and Western Australia under long-term contracts supplemented local feed (Copper & Nickel Monthly, 2009).

Jilin Jien Nickel Industry Co., Ltd. produced 8,000 t of nickel in salts and matte in 2008 and was dramatically expanding smelting and refining capacity. Jilin Jien had two operations in Jilin Province plus the Siziwngqi Mine in Inner Mongolia. At least five other companies produced primary nickel in China during 2008.

Chinese demand for primary forms of nickel continued to escalate and was estimated to have reached 350,000 t in 2008, which was 8% greater than that of 2007 (Eramet Group, 2010, p. 44). The Chinese stainless steel industry accounted for 64% of the country's primary nickel consumption. China was the world's leading stainless-steel-producing country in 2008, with a crude stainless steel output of 7.09 Mt, 5% less than the 7.49 Mt in 2007. Chinese production of stainless steel fell for the first time in more than a decade. Chinese production of stainless steel had been growing at an average annual rate of 35% since 1998. Four companies—the Baosteel Group, Lianzhong Iron and Steel Co. (LISCO), Taiyuan Iron & Steel (Group) Co., Ltd.

(TISCO), and Zhangjiagang Pohang Stainless Steel Co. Ltd. (ZPSS)—accounted for about 60% of the country's stainless steel meltshop production (Vale Inco Ltd., 2009, p. 4, 18).

Since 2001, China had consumed more stainless steel annually than any other country. China consumed 6.68 Mt of stainless steel in 2008, about 30% of the world total and a tonnage larger than the total consumption of Western Europe. Chinese imports of stainless steel had been declining since 2005 (1.20 Mt in 2008). Exports peaked at 1.26 Mt in 2007 but slipped to 0.897 Mt in 2008 as a result of the global recession (Vale Inco Ltd., 2009, p. 4, 10–11, 18, A37–A38).

China has a large electroplating industry and a number of rechargeable battery manufacturers that use nickel. China's plating industry accounted for about 16% of the country's primary nickel demand in 2008, while battery manufacturers consumed about 5% (Copper & Nickel Monthly, 2009; Eramet Group, 2010, p. 44).

China's stainless steel producers used relatively inexpensive nickeliferous pig iron (NPI), typically grading 4% to 6% nickel, as a substitute for ferronickel and scrap. The NPI helped to offset escalating nickel prices and to counter spot shortages of ferronickel and scrap at a time when new stainless steel meltshop capacity was being added throughout China. In 2007, the nickel content of the pig iron made in electric furnaces was averaging about 12% (Yongqi, 2008). Zhejiang Huaguang Smelting Group Co. Ltd., the leading NPI producer, had production capacity of 1 Mt/yr, recovering iron with a nickel content that varied from 1% to 14%. Huaguang reportedly had long-term contracts to supply 700,000 t/yr of NPI to major Chinese stainless steel producers, including Baosteel, TISCO, and ZPSS. When nickel prices slid dramatically in 2008, several small NPI producers in Fujian, Shandong, and Sichuan Provinces were forced to reduce or suspend production (Interfax-China, 2007; Copper & Nickel Monthly, 2009).

Dominican Republic.—In August, a combination of high oil prices and declining nickel prices forced Falconbridge Dominicana (C por A) (Falcondo) to suspend ferronickel production. Fuel oil was a major expense for Falcondo because the bulk of the oil was used to fire the company's thermal powerplant at Bonao. Falcondo continued to operate the 200-MW powerplant because it provided electricity to the Dominican Republic grid. In December, Xstrata Nickel put the nickel mining and processing part of the complex on extended care-and-maintenance status. Falcondo retained about 500 of its 1,800 employees to operate the powerplant and continue mine rehabilitation and reforestation activities. Xstrata had a feasibility study underway to determine if the powerplant could be converted from oil to a more economical source of energy. Falcondo produced 18,782 t of nickel in ferronickel prior to the shutdown but was capable of producing more than 29,000 t/yr of nickel and had at least 20 years of reserves and/or demonstrated resources (Xstrata plc, 2008a, b; 2009b).

Finland.—At least four companies were actively developing nickel deposits in Finland—First Quantum Minerals Ltd. (Vancouver, Canada), Talvivaara Mining Co. Plc (Espoo), Universal Resources Ltd. (West Perth, Australia), and Vulcan Resources Ltd. (West Perth) (table 14).

In April, Talvivaara Mining began extracting ore on a commercial scale at its new Talvivaara Mine near Sotkamo. The Talvivaara deposits are part of the Proterozoic Kainuu belt, a 200 km-long complex of folded quartzites and schists with a maximum width of approximately 40 km. Talvivaara was recovering polymetallic sulfide ore from open pit operations in the Kolmisoppi and Kuusilampi deposits, which the company acquired from Outokumpu Plc in 2004. The principal ore minerals—chalcopyrite, pentlandite, and sphalerite—occur with pyrrhotite and pyrite in black schist. The Kuusilampi deposit had 300 Mt of measured resources grading 0.23% nickel, 0.13% copper, 0.51% zinc, and 0.02% cobalt (Talvivaara Mining Co. Plc., 2009, p. 30).

After 16 years of evaluation and research, Outokumpu decided that the Kuusilampi and Kolmisoppi deposits could not be economically exploited using conventional metal extraction techniques, but that the ores might be amenable to bioheapleaching. Outokumpu turned over all of its research documentation on bioheapleaching to Talvivaara Mining as part of the 2004 Talvivaara purchase agreement and settlement. After 4 more years of testing and evaluation, Talvivaara began bioheapleaching on a commercial scale in July 2008. The company produced its first metal sulfide precipitates from the leach solution in October and delivered its first shipment of mixed nickel-cobalt sulfide to Norilsk Nickel Harjavalta Oy in February 2009 (Talvivaara Mining Co. Plc., 2009, p. 24–27).

Indonesia.—PT Aneka Tambang Tbk. (Antam) cut back production of saprolite ore when purchases from NPI producers in China began to decline as a result of the recession. The state-owned company mined 6.57 Mt (wet) of various laterite ores, down from the alltime high of 7.11 Mt in 2007. More than 80% of the production was direct shipping ore for export—primarily to China, Eastern Europe, and Japan.

Antam also produced 17,566 t of nickel in ferronickel, which included 748 t produced as a part of a tolling agreement with an undisclosed European company. Antam's three smelters at Pomalaa had a combined capacity of 26,000 t/yr of nickel in ferronickel (in the form of ingot and shot averaging 19% to 21% nickel). In 2008, the three ferronickel smelters consumed a total of 1,236,334 t (wet) of high-grade ore. The total consumption figure included 555,016 t (wet) of high-grade ore from the company's Pomalaa and Halmahera Mines and 681,321 t (wet) of ore from the East Pomalaa Mine of PT Inco. Antam did not renew its long-term sourcing agreement with PT Inco when the agreement expired in July and planned to ship additional ore from its Pomalaa Mine in 2009 to make up projected shortages. Approximately 74 t (wet) of high-grade ore was needed to produce 1 t of nickel in ferronickel (PT Aneka Tambang Tbk., 2009, p. 117–120).

In 2007, Antam and BHP Billiton had formed a 50-50 joint venture—the Pearl Nickel project—to evaluate significant laterite resources at Buli, northeast of Weda Bay on Halmahera Island. In November 2008, however, BHP Billiton decided to withdraw from the alliance and transferred ownership of BHP Asia Pacific Nickel Pty Ltd. to Antam. After the transfer, BHP Asia Nickel Pacific Pty. Ltd. was renamed Asia Pacific Nickel Pty. Ltd. BHP Billiton also withdrew from the Gag Island development project (PT Aneka Tambang Tbk., 2009, p. 154).

PT Inco mined 4.68 Mt of ore averaging 2.10% nickel from its Pomalaa and Sorowako concessions on Sulawesi. The production figure represents the amount of product delivered to the company's smelter from its adjoining dryer kilns. The smelter produced 68,300 t of nickel in matte for export to Japan, down from 75,800 t in 2007. Vale Inco has a 61% interest in PT Inco (Companhia Vale do Rio Doce, 2009a, p. 34–35).

Korea, Republic of.—In October, Société de Nickel de Nouvelle-Caledonie et Coree (SNNC) commissioned a ferronickel plant at Gwangyang, close to the stainless steel operations of Pohang Iron and Steel Co. Ltd. (POSCO). SNNC is a joint venture of Société Minière du Sud Pacifique (SMSP) (51%) and POSCO (49%). SMSP has agreed to deliver 1.8 Mt/yr of wet ore to Gwangyang from its mining centers of Boakaine, Kouaoua, Nakety, Ouaco, and Poya—all on the main island of New Caledonia. The Gwangyang pyrometallurgical facility was expected to produce 30,000 t/yr of nickel in ferronickel when full capacity is reached at yearend 2009 (Société Minière du Sud Pacifique, 2010).

New Caledonia.—Société Le Nickel (a subsidiary of Eramet) produced 37,468 t of nickel in ferronickel at its Doniambo smelter. The smelter also produced 13,565 t of nickel in matte, which was shipped to Eramet's Sandouville refinery in France for conversion into LME-grade metal and chemicals (International Nickel Study Group, 2009).

Inco's Goro project was scheduled to begin producing cobalt and nickel by early 2009. The $3.21 billion mining and processing complex was expected to have a production capacity of 60,000 t/yr of nickel in intermediate product (Companhia Vale do Rio Doce, 2009a, p. 35). SMSP and its joint venture partner, Xstrata, were developing the saprolitic portion of the Koniambo laterite deposit near Kone in the Northern Province (Xstrata plc, 2009a, p. 43, 67, 175).

Russia.—About 77% of Norilsk's sales of marketable nickel came from its Russian operations. The remaining 23% was generated by the company's holdings in Australia, Botswana, Finland, and South Africa. Norilsk's operations on the Kola and Taimyr Peninsulas had a combined output of 232,302 t of nickel metal—about 89% of Russia's primary nickel output for the year. Norilsk's two Arctic subsidiaries exported almost all of their nickel production; only about 10,000 t, or less than 5%, was sold to Russian consumers (OJSC MMC Norilsk Nickel, 2009, p. 63–69, 111).

The remaining 11% of Russia's primary nickel output came from independent operations in the central and southern regions of the Ural Mountains—OAO Mechel (Orenburg Oblast'), Rezh Nickel Works JSC (Sverdlovsk Oblast'), and OJSC Ufaleynikel (Chelyabinsk Oblast').

In March, OOO Vostochno-Sayanskaya Nickel (an affiliate of Norilsk Nickel) won at open auction the right to explore and develop the Iisko-Tagulsk copper-nickel-PGE district in Irkutsk Oblast'. Vostochno-Sayanskaya paid $30.7 million for the prospecting and mining license. The license covered 15,900 square kilometers near the towns of Nizhneudinsk and Tulun, more than 350 km northwest of the city of Irkutsk. Norilsk Nickel had been prospecting in the region since 2003 and had been actively evaluating the Kingashskaya district in neighboring Krasnoyarsk Oblast'. Some metal analysts speculated that the Iisko-Tagulsk tract held between $2 billion and $190 billion worth of nickel and associated metals (Helmer, 2008; Interros Corporate News, 2008). The 2008 Krasnoyarsk program focused on the Kingashskoye and newly discovered Verkhnekingashskoye deposits (OJSC MMC Norilsk Nickel, 2009, p. 53).

In March, OAO Mechel (Moscow) publicly announced plans to take over Oriel Resources plc, a London-based mining company developing the Shevchenko nickel deposit in Kazakhstan. Mechel offered $2.20 for each share of Oriel, or about $1.50 billion for the entire company. Mechel owned and operated the Southern Urals ferronickel smelter and the two laterite mines—Buruktal and Sakahara—that supplied the operation. Mechel produced 16,158 t of nickel in low-iron ferronickel in 2008. The bulk of the production was shipped to the ports of Kaliningrad and St. Petersburg for export to the EU. The remainder was used to make stainless steel at Mechel's stainless steel plant at Chelyabinsk (OAO Mechel and Oriel Resources plc, 2008, p. 9–11).

Vietnam.—In late 2007, the Government of Vietnam granted Ban Phuc Nickel Mines LLP (BPNM) an 11-year mining license, permitting the company to begin underground mining of a massive sulfide deposit averaging 2.4% nickel in Son La Province. The bulk of the sulfide mineralization at Ban Phuc is associated with ultramafic-mafic intrusives of Triassic age. The deposit has two distinct types of mineralization—low tonnage veins of massive sulfides intruding hornfels host rock plus low-grade, but high-tonnage, disseminated sulfides in dunite. The bulk of the development work to the end of 2008 had focused on the massive sulfide-bearing veins (Asian Mineral Resources, 2009, p. 27–33).

In 2008, BPNM constructed two portals and excavated more than 900 m of development tunnels. Asian Mineral Resources Ltd. (Toronto), which had a 90% interest in BPNM, had planned to commission the mine and concentrator in mid-2009 but decided to slow work on the project when world nickel prices declined. The Ban Phuc project was placed on care-and-maintenance status in November 2008. Company officials, however, stated that that the mine could be commissioned within 12 months when development was resumed (Asian Minerals Resources, 2010).

Zambia.—In June, Albidon Ltd. commissioned its new Enterprise Mine located in the southeastern corner of the Munali intrusion. Byrnecut Mining International Ltd. was the principal mining contractor on the Munali project. The underground mine was accessed via a 25-m deep boxcut excavation that led to twin declines. By yearend, the capacity of the mine had been ramped up to 1.2 Mt/yr of sulfide ore. The Enterprise deposit reportedly has 9.1 Mt of indicated and inferred resources averaging 1.23% nickel and 0.2% copper. The Voyager deposit, 600 m north of the Enterprise, reportedly has an additional 1.2 Mt of resources averaging 0.9% nickel and 0.1% copper. The ore from the Enterprise was being fed into a conventional flotation concentrator. By yearend, the circuitry was capable of producing 10,000 t/yr of nickel in concentrate. All of the concentrate was being sold to the Jinchuan smelter in China. The concentrate averaged 13% nickel, 2% copper, and 0.7% cobalt with

significant PGE credits (Albidon Ltd., 2008a, p. 8–11, 16–17, 35; b).

Outlook

U.S. nickel consumers will probably be dependent on foreign sources of refined metal and ferronickel for at least the next 25 years. The ongoing expansion of nickel laterite mining operations in Albania, Australia, Brazil, Cuba, Indonesia, New Caledonia, and the Philippines will help meet the increasing demand for nickel worldwide. The nickel output from Vale Inco's state-of-the-art leach facility at Goro is expected to satisfy the near-term rise in global demand projected for the post-2010 economic recovery. Long-range forecasts of growing usage in Asia have encouraged parastatal companies in China to fund the construction of greenfield laterite mining and leaching complexes in Burma, Papua New Guinea, and Turkey. European and North American companies were seriously considering funding large-scale laterite projects in Cameroon, Côte d'Ivoire, and Guatemala.

Sulfide mines approaching the end of their productive lives owing to dwindling reserves and high operating costs continue to be replaced. But discoveries of high-grade sulfide deposits are becoming less frequent, harder to find, located farther from urban consumers, and more costly to finance. Advances in extraction technology may offer a solution. As a result of advances in bioengineering, large-tonnage, low-grade polymetallic sulfide ore deposits like those at Sotkamo, Finland, previously passed over, are now amenable to bioheapleaching.

European and North American usage of nickel- and cobalt-base superalloys was expected to escalate between 2012 and 2016, largely because of growing demand for new jet aircraft. Three grades of high-performace superalloys—Inconel 718, Inconel 720, and Waspaloy—dominated nickel sales to jet engine manufacturers in 2009. Airbus S.A.S. and The Boeing Co. both have a large backlog of jet-aircraft orders (Boeing Co., The, 2009).

The global economic slowdown in 2008 temporarily reduced consumption of stainless steel and, with it, consumption of nickel. By December 2008, the nickel cash price had fallen below $10,000 per ton but appeared to be bottoming out. The 2008 price collapse had a particularly deleterious effect on stainless steel recycling, slowing collection of scrap. The World Bank and the International Monetary Fund were concerned that the world economy could shrink for the first time since World War II (Faiola, 2009).

Producers and consumers of nickel, however, remained optimistic about the long-term outlook for the metal. National governments of several developed nations, in cooperation with the World Bank, have implemented a variety of economic stimulus programs designed to alleviate unemployment and restore world trade to pre-2008 levels. Many of the proposed stimulus programs were expected to fund long-needed electrical generation, transportation, and other infrastructure projects that would require large tonnages of nickel-bearing stainless steel and superalloys.

Some analysts have predicted that world crude oil production may peak a decade earlier than predicted—perhaps as soon as 2014 (Nashawi, Malallah, and Al-Bisharah, 2010). Nickel was expected to play an important role in the development of several renewable energy sources needed to reduce global greenhouse gas emissions (Wong and Coates, 2010). The burgeoning development of renewable energy sources was expected to accelerate research on cost-effective, more advanced batteries, especially for automobiles and remote power stations. Unprecedented urbanization, especially in Brazil, China, India, Russia, and other emerging nations, should help spur nickel consumption.

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TABLE 1

SALIENT NICKEL STATISTICS[1]

(Metric tons of contained nickel unless otherwise specified)

	2004	2005	2006	2007	2008
United States:					
Secondary recovery from purchased scrap:					
From ferrous scrap	89,100 r	89,700 r	94,000 r	89,700 r	76,100
From nonferrous scrap	10,600	8,820	9,400	9,200 r	9,160
Shipments of purchased scrap[2]	129,000 r	139,000 r	142,000	186,000 r	160,000
Exports:					
Primary	8,000	7,630	8,050	13,100	11,600
Secondary	48,300	55,600	59,300	103,000	94,600
Imports for consumption:					
Primary	136,000	143,000	153,000	125,000	129,000
Secondary	18,800	15,500	20,300	16,200	20,100
Consumption:					
Reported:					
Primary	102,000	100,000	107,000 r	101,000 r	102,000
Secondary, purchased scrap[3]	99,700 r	98,500 r	103,000	98,900 r	85,200
Total	202,000	199,000 r	211,000 r	200,000 r	188,000
Apparent:					
Primary	128,000	135,000	143,000	112,000 r	115,000
Secondary, purchased scrap	71,500 r	57,800 r	64,300 r	6,980 r,[4]	12,500
Total	200,000	193,000 r	208,000 r	119,000 r	128,000
Apparent primary plus reported secondary	228,000 r	234,000 r	247,000 r	211,000	200,000
Stocks, yearend:					
Producers and traders	6,580	5,940	6,450	5,690 r	5,860
Consumer, primary	5,770	6,670	7,590 r	7,350 r	9,150
Consumer, secondary	5,610 r	6,250 r	6,480 r	11,700 r	10,000
Total	18,000 r	18,900 r	20,500 r	24,800 r	25,000
Price, cash, London Metal Exchange:					
Average annual dollars per metric ton	13,823	14,738	24,244	37,216	21,104
Average annual dollars per pound	6.270	6.685	10.997	16.881	9.572
Price, 18/8 stainless steel scrap, gross weight:[5]					
Average annual dollars per metric ton	1,450	1,445	2,057	2,952	2,361
Average annual dollars per long ton	1,473	1,468	2,090	2,999	2,399
World, mine production	1,370,000 r	1,470,000 r	1,570,000 r	1,680,000 r	1,600,000

[r]Revised.

[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]The significant decrease in secondary apparent consumption reflects increased exports of scrap to China and Taiwan.

[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 (AMM). On November 1, 2006, AMM began reporting prices for Type 316 solids and clips and has changed its listing for 18/8 bundles, solids and clips to Type 304 solids and clips.

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)

	2007[r]	2008
Kind of scrap:		
Aluminum-base[2]	2,580	2,130
Copper-base	1,730	1,610
Ferrous-base[3]	89,700	76,100
Nickel-base	4,890	5,420
Total	98,900	85,200
Form of recovery:		
Aluminum-base alloys	2,580	2,130
Copper-base alloys	2,680	2,520
Ferrous alloys	90,300	76,100
Nickel-base alloys	3,350	4,470
Total	98,900	85,200

[r]Revised.

[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	2007	2008
Primary:		
Metal	87,100 r	88,600
Ferronickel	11,000	11,300
Oxide and oxide sinter[2]	133	273
Chemicals	1,510	774
Other	1,100 r	1,360
Total	101,000 r	102,000
Secondary, scrap[3]	98,900 r	85,200
Grand total	200,000 r	188,000

[r]Revised.

[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	2008								Grand total in 2007
	Metal	Ferronickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)	Grand total	
Consumption, reported:									
Cast irons[2]	61	W	W	--	W	61	163	224	212
Chemicals and chemical uses	488	--	W	356	--	844	--	844	2,880
Electric, magnet, expansion alloys	188	--	--	--	--	188	W	188	154
Electroplating, sales to platers	9,010	--	--	W	W	9,030	W	9,030	10,300
Nickel-copper and copper-nickel alloys	2,120	--	W	--	16	2,140	2,760	4,890	5,720
Other nickel and nickel alloys	17,800	W	W	--	70	17,900	3,580	21,500	17,900
Steel:									
Stainless and heat resistant	27,200	10,200	W	W	182	37,500	75,300	113,000	127,000
Alloys, excludes stainless	6,470	W	--	W	W	6,470	612	7,080	7,130
Superalloys	21,800	W	W	W	606	22,400	192	22,600	22,000
Other[3]	3,420	1,150	273	401	484	5,730	2,590	8,320	6,660
Total	88,600	11,300	273	774	1,360	102,000	85,200	188,000	200,000
Consumption, apparent	XX	XX	XX	XX	XX	115,000	12,500	128,000	119,000 r

[r]Revised. 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]Under investigation.

[3]Includes batteries, catalysts, ceramics, coinage, other alloys containing nickel, and data indicated by symbol W.

TABLE 5

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

(Metric tons of contained nickel)

Form	2007[r]	2008
Primary:		
Metal	5,570	6,880
Ferronickel	845	741
Oxide and oxide sinter	144	49
Chemicals	699	1,390
Other	98	91
Total	7,350	9,150
Secondary, scrap[2]	11,700	10,000
Grand total	19,100	19,200

[r]Revised.

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

[2]New statistical series created to compensate for previously underreported data for cupronickel stocks.

TABLE 6

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

Class	2007 Quantity (metric tons of contained nickel)	2007 Value (thousands)	2008 Quantity (metric tons of contained nickel)	2008 Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	841	$30,300	1,380	$32,500
Ferronickel	14	408	1	113
Powder and flakes	986	48,400	1,190	55,200
Metallurgical-grade oxide	5,350	17,200	4,140	14,900
Chemicals:				
Catalysts	2,980	205,000	2,650	205,000
Salts[3]	2,940	54,100	2,260	37,800
Total	13,100	356,000	11,600	345,000
Secondary:				
Stainless steel scrap	66,100	1,620,000	75,100	1,190,000
Waste and scrap	36,800	302,000	19,500	150,000
Total	103,000	1,920,000	94,600	1,340,000
Grand total	116,000	2,280,000	106,000	1,680,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	565	14,800	360	11,900
Sheets, strip, foil	581	22,300	799	27,300
Tubes and pipes	444	4,500	544	6,320
Total	1,590	41,600	1,700	45,500
Alloyed, gross weight:				
Unwrought alloyed ingot	6,990	188,000	7,520	213,000
Bars, rods, profiles, wire	16,900	698,000	20,000	762,000
Sheets, strip, foil	6,040	254,000	7,670	310,000
Tubes and pipes	2,630	116,000	2,770	151,000
Other alloyed articles	2,970	197,000	4,120	295,000
Total	35,500	1,450,000	42,100	1,730,000

[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 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.

Source: U.S. Census Bureau.

TABLE 7

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

(Metric tons of contained nickel)[2]

Country	2008								Total in 2007	Wrought nickel in 2008[4]
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical-grade oxide[3]	Waste and scrap	Stainless steel scrap	Chemicals	Total		
Australia	--	6	--	--	416	31	22	475	354	5
Belgium	--	20	--	6	323	247	156	752	495	4
Brazil	172	30	--	--	266	26	82	576	162	13
Canada	34	95	(5)	4,000	10,200	1,730	1,350	17,400	29,500	295
China	23	51	--	6	162	6,950	362	7,560	12,600	127
Colombia	32	19	--	--	--	(5)	9	60	516	45
Finland	--	--	--	--	--	4,210	--	4,210	2,700	--
France	(5)	6	--	2	18	168	56	250	166	19
Germany	9	251	--	89	603	36	182	1,170	1,900	57
India	(5)	11	--	--	12	6,010	153	6,180	7,320	9
Italy	1	7	--	--	--	274	18	300	74	5
Japan	20	96	--	3	6,340	6,990	125	13,600	17,600	42
Korea, Republic of	--	55	(5)	1	128	9,310	138	9,630	4,820	125
Mexico	1,020	52	--	1	(5)	5	201	1,280	1,350	74
Netherlands	--	1	--	--	230	1,380	204	1,820	1,140	13
South Africa	--	2	--	6	7	--	54	69	54	2
Spain	--	1	--	--	--	990	5	996	3,960	2
Sweden	--	1	--	--	336	44	41	422	696	2
Taiwan	4	95	--	--	73	23,900	193	24,300	20,500	12
Thailand	--	65	--	--	--	2,270	38	2,380	941	102
United Kingdom	1	104	--	--	384	185	269	943	1,060	61
Other	65	218	--	28	2	10,300	1,240	11,900	8,200 r	687
Total	1,380	1,190	1	4,140	19,500	75,100	4,900	106,000	116,000	1,700

[r]Revised. -- 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 "2008, 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	2007 Quantity (metric tons of contained nickel)[2]	2007 Value (thousands)	2008 Quantity (metric tons of contained nickel)[2]	2008 Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	101,000	$3,850,000	107,000	$2,550,000
Ferronickel	13,500	529,000	11,000	272,000
Powder and flakes	6,400	242,000	6,040	184,000
Metallurgical-grade oxide	530	19,000	1,340	32,000
Chemicals:				
Catalysts	1,030	77,400	1,800	115,000
Salts[3]	2,280	67,300	1,960	45,100
Total	125,000	4,780,000	129,000	3,200,000
Secondary:				
Stainless steel scrap	8,830	198,000	10,500	217,000
Waste and scrap	7,410	152,000	9,590	210,000
Total	16,200	349,000	20,100	427,000
Grand total	141,000	5,130,000	149,000	3,630,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	327	14,300	250	10,500
Sheets, strip, foil	417	17,900	464	15,100
Tubes and pipes	188	4,730	221	7,360
Total	932	36,900	935	32,900
Alloyed, gross weight:				
Unwrought alloyed ingot	4,180	105,000	4,440	117,000
Bars, rods, profiles, wire	11,200	442,000	10,600	328,000
Sheets, strip, foil	3,620	148,000	3,350	124,000
Tubes and pipes	2,770	85,200	2,460	77,300
Other alloyed articles	2,400	91,400	2,810	99,200
Total	24,100	871,000	23,600	745,000

[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 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.

Source: U.S. Census Bureau.

TABLE 9

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

(Metric tons of contained nickel)[2]

	2008									
Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical-grade oxide[3]	Waste and scrap	Stainless steel scrap	Chemicals	Total	Total in 2007	Wrought nickel in 2008[4]
Australia	15,200	423	--	968	76	7	--	16,600	12,400	7
Austria	--	2	--	--	14	--	--	16	7	43
Belgium	--	162	--	--	65	3	198	428	307	--
Brazil	160	2	--	--	39	(5)	3	204	1,150	96
Canada	56,400	3,880	--	348	2,410	7,030	133	70,200	63,200	98
Chile	--	--	--	--	--	2	--	2	9	--
China	--	12	--	--	202	2	487	703	356	29
Colombia	--	--	2,830	--	9	32	--	2,870	3,540	(5)
Dominican Republic	--	--	5,630	--	--	14	--	5,640	8,120	--
Finland	2,610	24	--	--	--	--	642	3,270	4,130	--
France	468	(5)	--	--	1,260	--	352	2,080	1,240	216
Germany	21	135	--	--	649	110	484	1,400	1,280	278
Japan	--	177	131	1	356	43	666	1,370	887	75
Mexico	--	--	--	--	469	2,780	28	3,270	2,760	(5)
Netherlands[6]	5	4	2	--	18	--	343	372	365	1
New Caledonia	--	--	2,050	--	--	--	--	2,050	1,880	--
Norway	9,950	--	--	--	63	--	--	10,000	11,400	3
Russia	20,300	589	335	--	9	--	--	21,200	21,200	--
South Africa	98	395	--	--	3	--	2	498	746	--
United Kingdom	703	232	3	18	2,370	79	161	3,570	2,950	25
Venezuela	--	--	--	--	12	14	--	26	11	--
Zimbabwe	667	--	--	--	--	--	--	667	743	--
Other	154	6	9	8	1,570	382	260	2,390	2,050	64
Total	107,000	6,040	11,000	1,340	9,590	10,500	3,760	149,000	141,000	935

-- 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%; and sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

[3]Primarily oxide, rondelles, and sinter.

[4]Excluded from "2008, 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]

(Metric tons of contained nickel)

Country and products[2]	2004	2005	2006	2007	2008
Albania, laterite ore[e]	600	1,000	1,400	600	800
Australia, ores and concentrate[3]	186,800 r	188,900 r	185,000 r	184,900 r	199,200
Botswana, ore milled	35,163	39,305	38,000 e	38,000 e	38,000 e
Brazil, ore	44,928 r	74,198	82,492	58,317	58,500 p
Burma, ore[e]	10	10	10	10	10
Canada, concentrate	186,694	199,932	232,948	254,915 r	259,588 p
China[e, 4]	75,600	72,700	82,100	67,000 r	72,000
Colombia, laterite ore	75,032	89,031	94,105	99,500 r	99,000 e
Cuba, oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor[5]	71,945	73,753	73,371 r	73,934 r	67,265
Dominican Republic, laterite ore	46,000	53,124	47,516	47,125	31,300
Finland, concentrate[6]	3,700	3,386	2,985	3,635	3,600 e
Greece, laterite ore	21,700	23,210	21,670	21,190	21,100 e
Indonesia, laterite ore	136,000	135,000	157,000	229,000	192,600
Kazakhstan, laterite ore	--	193	200 e	200 e	500 e
Kosovo, laterite ore	--	--	--	2,072 7	10,486 7
Macedonia, ferronickel produced[8]	5,300	8,141	10,942	15,321	15,026
Morocco, nickel sulfate	130	199 e	80	100	100 e
New Caledonia, ore	118,279	111,939	102,986	125,364 r	102,583
Norway, concentrate	181	342	320	240	250
Philippines:					
Ore	16,973	26,636 r	64,705 r	81,288 r	73,333
Concentrate[9]	--	4,081	8,242	10,079	10,562
Total	16,973	30,717 r	72,947 r	91,367 r	83,895
Russia, marketable mine production:					
Laterite ore[10]	33,227	34,419	37,754	45,690	36,807
Sulfide concentrate[11]	235,318	242,758	239,231	234,083	230,000
Total	268,545	277,177	276,985	279,773	266,807
South Africa, concentrate	39,851	42,392	41,599	37,917 r	31,675 p
Spain, concentrate	-- r	5,398	6,336	6,340 r	6,350
Turkey, laterite ore[e, 12]	40	1,000 r	1,500 r	-- r	--
Ukraine, laterite ore[e]	6,000 r	6,000	12,000	12,000	8,000
Venezuela, laterite ore[e]	20,468 13	20,000	20,000	20,000	20,000
Zambia, concentrate	--	--	--	--	751 p
Zimbabwe, concentrate	9,776	8,556	8,825	7,100 e	6,354 p
Grand total	1,370,000 r	1,470,000 r	1,570,000 r	1,680,000 r	1,600,000
Of which:					
Concentrate[14]	476,000 r	507,000 r	540,000 r	554,000 r	549,000
Ore and ore milled	215,000 r	252,000 r	288,000 r	303,000 r	272,000
Laterite ore	339,000 r	362,000 r	393,000	477,000 r	421,000
Ferronickel produced	5,300	8,140	10,900	15,300	15,000
Nickel sulfate	130	199 e	80	100	100 e
Unspecified and/or undifferentiated	334,000 r	335,000 r	340,000 r	326,000 r	338,000

[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. North Korea may have an active nickel mine, but information is inadequate to make reliable estimates of output. Table includes data available through July 31, 2009.

[3]Australian Bureau of Agricultural and Resource Economics (ABARE) data for mines in Western Australia and Tasmania.

[4]In 2005, China began importing significant tonnages of lateritic ores from the Philippines to make nickel pig iron. This material was supplemented by higher-grade lateritic ores from Indonesia and New Caledonia in 2006–08.

[5]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%

TABLE 10—Continued

NICKEL: WORLD MINE PRODUCTION, BY COUNTRY[1]

for granular and powdered oxide, 1.21% for oxide sinter, 7.56% for sulfide precipitate, and 33% for leach ammoniacal precipitate.

[6]The gross weight of concentrates processed in Finland from domestic ores was, in metric tons, as follows: 2004—45,914; 2005—39,854; 2006—40,000 (estimated); 2007—41,000 (estimated); and 2008—40,000 (estimated).

[7]On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[8]Includes production from imported ores.

[9]Nickel content of concentrate produced at Rio Tuba in 2005–08 by Coral Bay Nickel Corp.

[10]Nickel content of ore mined in the Ural Mountains region.

[11]Nickel content of concentrate produced on the Kola and Taimyr Peninsulas.

[12]European Nickel PLC began large scale heap-leaching trials at its Caldag laterite operation in October 2004. In 2006, the company began shipping laterite ore to the ferronickel smelter of Larco General Mining and Metallurgical Company SA in Greece.

[13]Reported figure.

[14]Includes "Russia, sulfide concentrate."

TABLE 11

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

(Metric tons of contained nickel)

Country	2004	2005	2006	2007	2008
Matte:					
Australia[3]	32,256	44,536	39,561	41,612	31,085
Botswana	22,292	28,212	26,762	22,844	23,000 [e]
Brazil[4]	5,950 [r]	6,005	5,416	3,401 [r]	3,500 [p]
Canada[5]	61,115	59,722	56,628	73,922	68,972 [p]
China[6]	20	26	758	1,980	3,240
Indonesia[7]	81,120	77,471	72,782	77,928	72,385
New Caledonia	12,164	12,838	13,655	13,860 [r]	13,565
Russia[8]	599	700	1,300	670 [e]	600 [e]
Zimbabwe[e, 9]	1,400	1,400	1,600	1,400	2,000 [e]
Total	217,000 [r]	231,000	218,000	238,000 [r]	218,000
Other, Cuba:[10]					
Sulfide precipitate	30,999	32,354	30,967 [r]	31,116 [r]	32,465
Ammoniacal liquor precipitate	2,121	2,278	3,283 [r]	2,907 [r]	322
Total	33,120	34,632	34,250 [r]	34,023 [r]	32,787

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

[1]Table includes data available through July 31, 2009. Data represent nickel content of matte and other intermediate materials produced.

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

[3]Figures exclude toll-refined material.

[4]Represents the output of the Fortaleza smelter, which is shipped to Finland for further processing.

[5]Nickel content of reported exports.

[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: 2004—74,000; 2005—83,500; 2006—99,800; 2007—105,000; and 2008—110,000.

[7]Represents the nickel output of the Soroako smelter, which is shipped to Japan for further processing.

[8]Primarily exports to China. Sources: International Nickel Study Group; United Nations Statistics Division.

[9]Zimplats material shipped to Impala Refinery in South Africa.

[10]Corrected to remove coproduct cobalt.

TABLE 12

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

(Metric tons of contained nickel)

Country and product[3]	2004	2005	2006	2007	2008
Australia:					
Metal	112,400	112,600	105,100	100,300	89,500
Unspecified[4]	10,200	9,700	11,400	14,000	15,000
Total	122,600	122,300	116,500	114,300	104,500
Austria, ferronickel and ferronickel molybdenum[e]	1,300 r	1,000 r	900 r	900 r	1,000
Brazil:[5]					
Ferronickel	6,409 r	9,596	9,814	9,918	9,950 p
Metal	19,742	20,714	21,339	21,635	21,650 p
Total	26,151 r	30,310	31,153	31,553	31,600 p
Canada, unspecified[6]	151,518	139,683	146,899 r	153,647 r	167,732 p
China:[7]					
Ferronickel and high nickel pig iron	--	2,900	31,000	84,500	70,900 p
Metal	75,800	95,100	102,000	116,000	129,000 p
Chemicals and unspecified[e]	4,500	5,000	5,000	6,000 [8]	8,000 p, [8]
Total	80,300	103,000	138,000	206,500	207,900 p
Colombia, ferronickel	48,818	52,749	51,137	49,312 r	41,636 p
Cuba, oxide sinter and oxides[9]	38,824	39,121	39,121 r	39,911 r	34,478
Dominican Republic, ferronickel	29,477	28,668	29,675	29,130	18,782
Finland:[10]					
Metal	40,088	34,709	42,299	49,700 r, [E]	46,000 p
Chemicals and unspecified	9,492	4,450	5,170	5,200 r, [E]	5,000 p
Total	49,580	39,159	47,469	54,900 r, [E]	51,000 p
France:					
Metal	10,200	10,500	11,400	11,200	11,500 e
Chemicals[e]	2,000	2,000	2,000	2,000	2,000
Total[11]	12,200	12,500	13,400	13,200	13,500 p
Greece, ferronickel	18,115	19,235	17,740	18,670 r	16,650 p
Indonesia, ferronickel	7,945	7,338	14,474	18,533	19,000 p
Japan:					
Ferronickel	73,655	76,390	66,668	68,346	70,000 e
Metal	32,769	29,399	29,254	30,402	35,307
Oxide sinter	60,300	56,700	53,877	60,151	60,000 e
Chemicals	2,082	2,208	2,531	2,270	2,295
Total	168,806	164,697	152,330	161,169	167,602
Korea, Republic of:					
Ferronickel	--	--	--	--	2,506 p
Metal	(12)	(12)	(12)	(12)	(12)
Total	(12)	(12)	(12)	(12)	2,506 p
Kosovo, ferronickel	--	--	--	800 [13]	7,100 [13]
Macedonia, ferronickel	5,300	8,141	10,942	15,321	15,026
Morocco, chemicals[e]	130	130	125	125	125
New Caledonia, ferronickel	43,016	46,738	48,723	44,954	37,467
Norway, metal	71,410	84,886	81,974	87,590 r	88,741
Poland, chemicals[14]	483	453	465	475 e	475 e
Russia:					
Ferronickel	12,700	12,600	14,436 r	17,111 r	16,158
Metal	244,358 r	249,479 r	255,045 r	248,363 r	242,409
Oxide sinter	3,805	4,075	2,713	235	--
Chemicals[e]	3,000	3,200 r	3,500	3,100 r	2,900
Total	263,863 r	269,354 r	275,694 r	268,809 r	261,467
South Africa:					
Metal	39,900 r	42,400 r	41,800 r	34,400 r	31,000 e
Chemicals[e, 15]	7,170	7,400	7,600	6,800	6,800
Total	47,070 r	49,800 r	49,400 r	41,200 r	37,800 e
Taiwan, metal	(12)	(12)	(12)	(12)	(12)

See footnotes at end of table.

TABLE 12—Continued

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

(Metric tons of contained nickel)

Country and product[3]	2004	2005	2006	2007	2008
Ukraine, ferronickel[e, 16]	12,000	14,000	18,000	18,000	18,800
United Kingdom, metal	38,606	37,127	36,770	34,064	34,000 [e]
Venezuela, ferronickel	17,400	16,900 [e]	16,600	16,500 [e]	16,500 [e]
Zimbabwe, metal:[e]					
Refined from domestic nickel ore	9,700	7,500	5,510 [8]	4,500	3,400
Toll refined from imported nickel ore[17]	6,000	5,700	9,000	9,500	10,300
Total	15,700	13,200	14,510 [8]	14,000	13,700
Grand total	1,270,000 [r]	1,300,000 [r]	1,350,000 [r]	1,430,000 [r]	1,410,000
Of which:					
Ferronickel	275,000 [r]	292,000 [r]	298,000 [r]	307,000 [r]	290,000
Metal	701,000 [r]	730,000 [r]	741,000 [r]	748,000 [r]	743,000
Oxide sinter	103,000	99,900	95,700	100,000 [r]	94,500
Chemicals	14,900 [r]	15,400 [r]	16,200 [r]	14,800 [r]	14,600
Unspecified	177,000 [r]	163,000 [r]	200,000 [r]	264,000 [r]	268,000

[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]Table includes data available through July 31, 2009.

[3]In addition to the countries listed, North Korea is thought 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 11.

[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 for metal production), in metric tons: 2004—19,897 (revised); 2005—21,116; 2006—21,630; 2007—20,796 (revised); and 2008—20,800 (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 12.

[7]Preliminary figures for ferronickel and chemicals were derived from data published by Beijing Antaike Information Development Co. Ltd. Figures for electrolytic and other class I nickel are based on data provided by the China Nonferrous Metals Industry Association and the International Nickel Study Group. In 2006–08, China also produced nickeliferous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

[8]Reported figure.

[9]Cuba also produces nickel sulfide and ammoniacal liquor precipitate, but because they are used as feed material elsewhere, they are not included to avoid double counting. More information can be found in table 11.

[10]Most of the production is extracted from imported raw materials.

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

[12]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: 2004—27,200; 2005—26,300; 2006—28,085 (revised); 2007—28,675 (revised); and 2008—28,653. Taiwan: 2004–08—11,000 (estimated).

[13]On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[14]Nickel content of nickel sulfate. 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.

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

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

[17]Previously published as “Other, metal.” Data represent production from matte imported from Botswana and nickel sulfate imported from South Africa.

TABLE 13
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2014

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2008/2011[r]	Australia (Western Australia)	Ravensthorpe[3]	0.73	107,000	39,000	Nickel-cobalt hydroxide.
		BHP Billiton Group (2008)/First Quantum Minerals Ltd. (2009)	0.58	120,000		
2010	Brazil (Para)	Onca-Puma	1.72	110,000	58,000	Ferronickel.
		Mineração Onça Puma	0.75	314,000		
		Vale Inco				
2010	New Caledonia (Southern)	Goro	1.34	96,000	60,000	Nickel oxide.
		Vale Inco Nouvelle-Calédonie S.A.S.	2.01	24,000		
		Vale Inco, Société de Participation Minière du Sud Calédonien S.A.S. and Sumitomo consortium	1.70	83,000		
2011	Australia (Queensland)	Lucky Break	NA	NA	1,600	Nickel-cobalt carbonate.
		Metallica Minerals Ltd. and Metals Finance Corp.				
2011[r]	Brazil (Goias)	Barro Alto	1.64	13,000	36,000	Ferronickel.
		Anglo American plc	1.81	27,000		
2011	Cameroon (East Province)	Nkamouna and Mada	0.69	55,000	2,100	Nickel oxide.
		Geovic Cameroon PLC.	0.66	6,600		
			0.47	26,000		
2011	Indonesia (Sulawesi)	Morowali	1.50	NA	7,500	Ore.
		PT Sinosteel Indonesia Mining				
2011	Madagascar	Ambatovy (Ambatovy and Analamay deposits)	1.12	44,000	60,000	Nickel metal powder and briquettes.[r]
		Sherritt International Corp., Sumitomo Corp., South Korean consortium, and SNC-Lavalin Group Inc.	0.99	81,000		
2011	Papua New Guinea (Madang)	Ramu	0.91	76,000	33,000	Nickel-cobalt hydroxide.[r]
		China Metallurgical Group Corp. consortium, Highlands Pacific Ltd., Mineral Resources Development Co., and Mineral Resources Madang Ltd.	1.01	67,000		
2011	Philippines (Davao Oriental)	Pujada—Mati	1.30	200,000	50,000	Nickel-cobalt intermediate.
		Hallmark Mining Corp., Austral-Asia Link Mining Corp., and BHP Billiton Group				
2011[r]	Turkey (Manisa)	Caldag	1.14	33,000	21,000	Nickel-cobalt hydroxide.
		European Nickel PLC and Jiangxi Rare Earth and Rare Metals Tungsten Group Co., Ltd.				
2012[r]	Burma (Thabeikkyin)	Tagaung Taung	2.02	40,000	22,000	Ferronickel.
		China Nonferrous Metals Mining Group Co., Ltd. and Government of Burma				
2012	China (Yunnan)	Yuanjiang	0.91	430,000	NA	Nickel-cobalt intermediate.
		Sino-Platinum Metals Co.				
2012	Philippines (Surigao del Norte and Surigao del Sur)	Adlay-Cagdianao-Tandawa	1.61	5,800	5,000	Ore.
		CTP Construction and Mining Corp.	1.58	13,000		
2012	Philippines (Surigao del Norte)	Agata	1.25	3,300	7,500	Ore initially.
		Mindoro Resources Inc.	1.23	1,800		
2013	Australia (Western Australia)	Jump-up Dam, Boyce Creek, and Aubils	1.01	22,000	5,000	Nickel-cobalt sulfide.[r]
		Heron Resources Ltd. and Ningbo Shanshan Co. Ltd.	0.79	53,000		
2013	Indonesia (Halmahera Island)	Weda Bay (Santa Monica, Pintu, and Boki Mokot deposits)	1.45	154,000	60,000	NA.[r, 4]
		PT Weda Bay Nickel (Eramet Group and Mitsubishi Corp.) and PT Aneka Tambang	1.53	123,000		
2013[r]	Kazakhstan (Kostanai Oblast)	Shevchenko	0.85	21,000	15,700	Ferronickel or nickel-cobalt hydroxide.[r]
		Oriel Resources plc[5]	0.77	83,000		
			0.84	32,000		

See footnotes at end of table.

TABLE 13—Continued
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2014

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2013	New Caledonia (Northern)	Koniambo	2.40	63,000	60,000	Ferronickel.
		Xstrata Nickel and Soc. Miniere du Sud Pacifique S.A.	2.45	54,000		
			2.20	156,000		
2014[r]	Albania	Devolli and Kokogllave	1.20	36,000	15,000	Nickel-cobalt hydroxide.[r]
		Balkan Resources Inc. and European Nickel PLC	1.20	30,000		
2014[r]	Australia (Queensland)	Marlborough (Slopeaway, Coorumburra, and Whereat)[6]	0.99	12,000	65,000	Metal.
			0.91	43,000		
		Gladstone Pacific Nickel Ltd.	0.88	16,000		
2014	Do.	Nornico (Bell Creek, Minnamoolka, and Kokomo deposits)	0.73	36,000	10,000	Nickel-cobalt intermediate.
		Metallica Minerals Ltd.				
2014	Australia (Western Australia)	GME Resources Ltd.	1.18	19,000	30,000	Metal.
			1.14	8,500		
			1.13	3,700		
2014	Do.	Kalgoorlie and North Kalgoorlie—Ghost Rocks, Goongarrie, and Kalpini	1.20	100,000	36,000	Nickel-cobalt hydroxide.
			0.83	225,000		
		Heron Resources Ltd. and Vale Inco				
2014	Brazil (Para)	Vermelho	1.25	124,000	46,000	Metal or oxide.
		Vale Inco	0.80	148,000		
2014[r]	Guatemala (Izabal)	Fenix saprolite (pyrometallurgical process)[r]	1.81 [r]	8,700 [r]	22,700 [r]	Ferronickel.[r]
		Skye Resources Inc.,[7] Vale Inco, and BHP Billiton Group[r]	1.58 [r]	33,000 [r]		
			1.76 [r]	44,000 [r]		
2014	Indonesia (Sulawesi)	Sorowako and Bahodopi mines	1.87	48,000	22,000	Leachate precipitate.
		PT International Nickel Indonesia TBK				
2014	Philippines (Mindoro Oriental)	Mindoro/Sablayan (Kisluyan, Buraboy, and Shabo areas)	0.94	73,000	60,000	Nickel-cobalt sulfide.
		Aglubang Mining Corp.	0.95	47,000		
		Intex Resources ASA	0.88	88,000		
2014[r]	Philippines (Surigao del Norte and Surigao del Sur)	Taganito[r]	(8)	(8)	30,000 [r]	Do.[r]
		Sumitomo Metal Mining Co. Ltd. and Nickel Asia Corp.[r]				
2014	Philippines (Zambales)	Acoje and Zambales	1.13	49,000	17,000	Ore initially.
		DMCI Holdings, Inc., Rusina Mining NL, and European Nickel PLC	1.18	24,000		Leachate precipitate.

[r]Revised. Do. Ditto. NA Not available.

[1]Company names reflect organizational structure as of July 31, 2009. BHP Billiton Group is a dual listed company comprising BHP Billiton Limited and BHP Billiton Plc. Vale Inco is a wholly owned subsidiary of Companhia Vale do Rio Doce.

[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]Ramp up was halted in January 2009 owing to rising costs and technical difficulties.

[4]Proprietary process currently under development by Centre de Recherche de Trappes (France).

[5]OAO Mechel completed its takeover of Oriel Resources plc on September 19, 2008.

[6]The Marlborough ores would be supplemented with ores from the mines of Societe des Mines de la Tontouta and Societe Miniere Georges Montagnat in New Caledonia.

[7]HudBay Minerals Inc. acquired Skye Resources Inc. in August 2008.

[8]Nickel Asia Corp. could provide ore from several mine sites on Mindanao Island.

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

TABLE 14
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2014

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2008	Australia	Avebury[3]	1.16	3,300	8,500	Concentrate.
	(Tasmania)	Oz Minerals Ltd.	0.97	13,000		
2008	Australia	Sinclair	2.77	1,200	5,500	Do.
	(Western Australia)	Jubilee Mines NL[4]				
2008	Canada	Podolsky[r]	0.75	6,700	3,300	Ore.
	(Ontario)	FNX Mining Co., Inc.	0.30	3,200		
			0.15	4,900		
2008	Finland	Talvivaara (Kuusilampi and Kolmisoppi)	0.27	336,000	33,000	Bioleachate precipitate.
	(Oulu)	Talvivaara Mining Co. Ltd.	0.27	78,000		(Nickel-cobalt sulfide).[r]
2008/2010[r, 5]	Zambia	Munali (Enterprise deposit)	1.23	6,700	8,500	Concentrate.
		Albidon Ltd.	1.40	1,300		
2009	Brazil	Santa Rita	0.61	74,000	26,000	Do.
	(Bahia)	Mirabela Nickel Ltd.				
2009[r]	Canada	Bucko Lake (Wabowden)	1.84	2,400	4,200	Do.
	(Manitoba)	Crowflight Minerals Inc.and Xstrata plc	2.01	100		
			2.23	1,200		
2009	Canada	Nickel Rim South	1.65	2,800	18,000	Do.
	(Ontario)	Xstrata Nickel	1.48	2,500		
			1.57	5,200		
2010	Australia	Lounge Lizard[6]	4.60	1,100	2,000	Do.
	(Western Australia)	Kagara Ltd. and Western Areas NL				
2010	Do.	Spotted Quoll	5.20	390	10,000	Do.
		Western Areas NL	6.30	1,200		
			6.00	790		
2010	Canada	Fraser Morgan	1.85	3,300	7,500	Do.
	(Ontario)	Xstrata Nickel	1.69	1,600		
			1.80	2,100		
2010	Do.	McWatters	0.70	870	3,000	Ore.
		Liberty Mines Inc.[7]	1.50	1,390		
2010	United States	NorthMet	0.08	250,000	7,100	Concentrate initially.[r]
	(Minnesota)	PolyMet Mining Corp.	0.08	330,000		Byproduct nickel-cobalt hydroxide.[r]
2011[8]	Canada	Shakespeare	0.33	12,000	4,100	Ore initially.
	(Ontario)	Ursa Major Minerals Inc.	0.37	1,800		Concentrate.
			0.37	700		
2011	Do.	Totten[9]	0.74	6,000	8,200	Concentrate.
		Vale Inco	0.75	550		
2011	Finland	Kylylahti copper-cobalt	0.20	600	1,400	Zinc-cobalt-copper-nickel concentrate.
	(Pohiois)	Vulcan Resources Ltd.	0.20	6,300		
			0.22	900		
2011	Vietnam	Ban Phuc	2.40	1,010	4,000	Concentrate.
	(Son La)	Asian Mineral Resources Ltd. and Son La Mechanical Engineering JSC	2.77	220		
2012	Australia	Cosmic Boy and Diggers South	1.50	3,000	7,000	Do.
	(Western Australia)	Western Areas NL	0.74	4,800		
2012[r]	Do.	Prospero	5.95	1,300	10,000	Do.
		Jubilee Mines NL[4]				
2012	Do.	Sherlock Bay	0.49	33,000	8,500	Bioleachate precipitate.
		Australasian Resources Ltd.				
2012	Finland	Kevitsa	0.30	110,000	15,000	Concentrate.
	(Lappi)	First Quantum Minerals Ltd.				

See footnotes at end of table.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2014

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2012	Russia (Amur)	Kun-Manie (Vodorazdelny, Ikensoe, Maly Krumkon, and Falcon) Amur Minerals Corp.	0.61 0.48 0.54	3,700 48,000 17,000	16,000	Concentrate.
2012	South Africa (Mpumalanga)	Sheba's Ridge Ridge Mining plc and Anglo Platinum Ltd.	0.18 0.18 0.17	409,000 313,000 53,000	23,700	Matte.
2012[r]	United States (Michigan)	Eagle Kennecott Minerals Co.	3.47 3.16	3,600 500	27,000	Concentrate.
2012[r]	Zimbabwe	Hunters Road Bindura Nickel Corp.	0.56 0.50	29,000 7,000	2,000	Do.
2013	Canada (Quebec)	Nunavik/South Raglan (Allammaq, Mesamax, Mequillon, Expo, Ivakkak, and TK deposits) Canadian Royalties Inc.	0.91 0.87	16,000 720	6,800	Do.
2014	Australia (Western Australia)	New Morning/Daybreak Western Areas NL	1.40	2,100	3,000	Do.
2014	Canada (Manitoba)	Maskwa Mustang Minerals Corp.	0.77 0.59 0.40	590 9,500 830	4,200	Do.
2014	Do.	Minago Victory Nickel Inc.	0.59 0.50 0.53	10,000 39,000 44,000	9,000	Do.
2014	China (Gansu)	Heishan Jinchuan Group Ltd.	0.50	30,000	NA	Do.
2014[r]	Finland (Oulu)	Kuhmo (Peura-aho, Hietaharju, Vaara) Vulcan Resources Ltd. and Polar Mining Oy	0.38	7,700	3,000	Nickel-cobalt hydroxide.
2014[r]	Tanzania (Kagera region)	Kabanga Barrick Gold Corp. and Xstrata Nickel	2.64 2.70	23,000 29,000	30,000	Concentrate.
2014[r]	United States (Minnesota)	Birch Lake, Maturi, Spruce Road Franconia Minerals Corp.	0.19 0.26 0.14	100,000 83,000 28,000	8,600	Byproduct nickel-cobalt hydroxide.[r]

[r]Revised. Do. Ditto. NA Not available.

[1]Company names reflect organizational structure as of July 31, 2009. BHP Billiton Group is a dual listed company comprising BHP Billiton Limited and BHP Billiton Plc. Vale Inco is a wholly owned subsidiary of Companhia Vale do Rio Doce.

[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]The Avebury Mine was placed on care and maintenance in February 2009 owing to low nickel prices.

[4]Acquired by Xstrata Nickel in February 2008.

[5]Low nickel prices forced Albidon Ltd. to place the Munali project on care-and-maintenance status in March 2009.

[6]The Lounge Lizard deposit was to be developed as part of Western Areas NL's Flying Fox underground operation.

[7]Jilin Jien Nickel Industry Co. Ltd. (China) acquired 51% of Liberty Mines in April 2009.

[8]Test shipments of ore were made in 2008.

[9]The original Totten Mine was closed in 1972.

[10]New resource estimate in progress.

Sources: Canadian Minerals Yearbook 2007, 2008; company annual reports, presentations, and press releases; and CRU International, Ltd.