



# 2011 Minerals Yearbook

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## NICKEL

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By Peter H. Kuck

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Global consumption of nickel resumed its long-term upward growth in 2011, despite concerns about the European debt crisis and the devastation created in Japan by a tsunami in March. This growth was driven by increased use of stainless steel and superalloys. The use of stainless steel in the construction and household goods sectors, however, was an exception and remained sluggish owing to weak sales of new housing and high rates of unemployment. World mine production reached an alltime high of 1.96 million metric tons (Mt) of contained nickel in 2011, surpassing the previous high of 1.74 Mt in 2007 prior to the recession (table 10). The London Metal Exchange Ltd. (LME) average monthly cash price for nickel metal peaked in February 2011 at \$28,250 per metric ton, but then began an extended decline as new mining projects were commissioned. The LME cash price ended the year at \$18,149 per ton, and averaged \$22,890 per ton for 2011. Daily stocks of nickel metal in LME-sanctioned warehouses reached an alltime high of 166,746 metric tons (t) on February 5, 2010. By yearend 2011, LME stocks had dropped to 90,516 t, a decline of 46% from the alltime high.

Austenitic (nickel-bearing) stainless steel continued to account for more than 60% of global primary nickel consumption (Nickel Institute, 2013). In 2011, world production of all grades of stainless steel increased by 5% to an alltime high of 33.6 Mt from 31.1 Mt in 2010 (International Stainless Steel Forum, 2013a, b). China was the leading producer of austenitic stainless steel, accounting for about 44% of world output, and the leading consumer of primary nickel. The European Union (EU) was the second ranked producer of stainless steel, with a global share of 23%. In 2011, China produced more austenitic stainless steel than the United States, Japan, and all of the countries in the EU combined. On a global basis, nonferrous alloys accounted for about 12% of primary nickel use; electroplating and other surface finishing, 11%; alloy steels other than stainless, 10%; and batteries, catalysts, and specialty chemicals, 7% (Eramet Group, 2012, p. 35–42; Mistry, 2012, p. 7; Vale S.A., 2012c, p. 3–7).

Reported nickel consumption (primary plus secondary) in the United States increased by 8% compared with that of 2010. U.S. apparent consumption of primary nickel was 124,000 t, or about 8% of world consumption. Stainless steel comprised only 42% of U.S. primary consumption, a relatively low percentage compared with similar economically developed countries. The low percentage for the United States was a reflection of the large number of specialty metal industries and a readily available supply of stainless steel scrap. U.S. industry reported melting 89,300 t of nickel contained in scrap, an increase of 9% from 82,000 t (revised) in 2010.

## Legislation and Government Programs

**Recovery Act Projects.**—Since the passage of the American Recovery and Reinvestment Act (Public Law 111–5) in 2009, the U.S. Department of Energy (DOE) has funded a variety of programs designed to encourage more rapid development of renewable energy sources. Some of these programs funded basic or applied research, while others supported large-scale development projects through loan guarantees. Several large-scale development projects, each costing more than \$1 billion and funded by industry with partial government support, were launched in 2011 (U.S. Department of Energy, 2013).

Many of the advanced projects involving power generation have the potential to increase demand for nickel metal and (or) nickel-bearing alloys. Nickel-base superalloys are commonly used to fabricate critical components of steam or gas turbines. Superalloy piping is used to bring hot, corrosive geothermal brines to the surface where the heat can be transferred to a less challenging medium. Solar and geothermal plants accounted for 4% of U.S. renewable energy consumption in 2011. Some of the DOE-supported projects had applications for both transportation and power generation. One example was the development of improved stationary and portable fuel cell power systems (U.S. Energy Information Administration, 2012a, p. 6–8, 278–281).

In fiscal year 2010, Federal agencies implemented nearly 700 renewable energy initiatives that supported 7 different renewable energy sources—bioenergy, geothermal, hydropower, ocean, solar, waste conversion, and wind. The U.S. Government Accountability Office identified 65 of these as solar-related initiatives with obligations totaling \$2.58 billion for fiscal years 2010 and 2011. An additional \$1.32 billion of obligations were committed to batteries and energy storage for 2009 through 2012 (U.S. Government Accountability Office, 2012). Commercial implementation of many of these technologies has the potential to increase the use of nickel-bearing steels and superalloys.

**U.S. Coinage.**—The U.S. Mint increased coin production in 2011 to meet growing demand from a recovering economy, but the Mint was still operating at a reduced level when compared with the period from 2000 through 2007. The nickel-bearing coinage minted in 2011 contained 1,770 t of nickel in the form of either cupronickel or manganese brass alloy. In 2011, the Mint produced a total of 990.2 million Jefferson nickels (25% nickel by weight) and 1,502 million Roosevelt dimes (8.33% nickel), up from 490.6 million nickels and 1,119 million dimes in 2010 (U.S. Mint, undated b). The Jefferson nickels contained a total of 1,238 t of nickel and the Roosevelt dimes contained 284 t.

Minting of 25-cent pieces remained limited despite the improving economy. The U.S. Mint produced 391.2 million commemorative quarters in 2011, up from 347.0 million in 2010, but still far below production levels directly prior to the 2008–09 recession. The different designs on the reverse (tails side) of the quarters promoted the Nation's parks and historical sites. Each coin weighed 5.67 grams (g) and contained 8.33% nickel; thus 185 t of nickel was contained in the five commemorative quarters released in 2011 (U.S. Mint, undated a, b).

In 2011, the U.S. Mint produced 77.56 million Native American dollar coins and 297.36 million Presidential dollar coins. Each dollar coin weighed 8.1 g and contained 2.0% nickel, for a total use of 61 t of nickel (U.S. Mint, undated b, c).

## Production

The United States had no active nickel mines in 2011, although several were under development. Limited quantities of byproduct nickel were recovered at some copper and precious metal refineries.

**Michigan.**—In mid-September, Kennecott Eagle Minerals Co. (a fully owned subsidiary of the Rio Tinto Group) began construction of a \$469 million underground mine near Big Bay on the Upper Peninsula. The Eagle Mine would be the first active nickel mine in the United States since the closure of the Nickel Mountain Mine northwest of Riddle, OR, in 1996. On September 14, the Ingham County Circuit Court gave Kennecott permission to begin excavating a portal and 1.6-kilometer (km)-long underground incline that would lead into the high-grade copper-nickel sulfide deposit. The mine was expected to come online in late 2013. Ore would be trucked from the mine to the renovated Humboldt mill near Champion, where a copper-nickel sulfide concentrate would be produced. The concentrate would then be railed to Ontario, Canada, for smelting. Renovation of the Humboldt mill was expected to cost about \$100 million. The mine was expected to produce an average of 17,300 metric tons per year (t/yr) of nickel and 13,200 t/yr of copper in concentrates during the first 6 years of its life. At yearend 2011, the deposit had 200,000 t of indicated and inferred resources grading 3.48% nickel (Pepin, 2011, 2012; Kennecott Eagle Minerals Co., 2012; Rio Tinto plc, 2012, p. 41, 50, 55).

**Minnesota.**—PolyMet Mining Corp. (Vancouver, British Columbia, Canada) was waiting approval from the State of Minnesota to begin mining the NorthMet deposit. In November 2009, the Minnesota Department of Natural Resources—the State lead agency—released a revised draft environmental impact statement (EIS) for public comment. At the beginning of 2011, a supplemental draft EIS was in progress to better analyze the environmental impacts of the project and to more clearly demonstrate that the PolyMet project would fully comply with State and Federal environmental standards. By February 2012, PolyMet had spent \$40 million on environmental review and permitting activities (PolyMet Mining Corp., 2010; 2012, p. 21).

The NorthMet deposit, a copper, nickel, and platinum-group-element (PGE) deposit at the western end of the Duluth Complex, was estimated to have 249 Mt of proven and probable reserves averaging 0.28% copper and 0.082% nickel. Ore from

the proposed open pit would be shipped to the reconditioned Erie mill near Hoyt Lakes, MN, for processing by flotation. The concentrate would be processed at the Erie site in a new hydrometallurgical plant. The Erie complex was expected to process 32,000 metric tons per day (t/d) of ore. In February 2011, PolyMet revised the design and engineering plan of the hydrometallurgical plant. During phase 1 of the project, the PolyMet plant would produce concentrates containing cobalt, copper, nickel, and precious metals. In phase 2, the nickel concentrate would be processed separately in a dedicated autoclave, leading to the production of high-grade copper concentrates, nickel-cobalt hydroxide, and a precious-metals precipitate. In October 2008, PolyMet formed a strategic alliance with Glencore International AG (Baar, Switzerland), the world's leading commodities trading company. At yearend 2011, Glencore owned 24.1% of PolyMet's common shares in addition to various debentures and warrants. The Swiss trading company agreed to market all of PolyMet's production and had reportedly invested \$118 million in the project by mid-2012 (Newby, 2012, p. 3, 9; PolyMet Mining Corp., 2012, p. 11–14, 22–27).

Duluth Metals Ltd. (Toronto, Ontario, Canada), Teck American Inc. (Spokane, WA), and Twin Metals Minnesota LLC (St. Paul, MN, a subsidiary of Antofagasta Plc and Duluth Metals) continued to actively evaluate disseminated sulfide deposits in the Duluth Complex, with a focus on the Mesaba-Birch Lake-Nokomis area (Minnesota Minerals Coordinating Committee, 2011). Since 2007, Duluth Metals has released several technical reports about the Nokomis deposit that outline the potential of the deposit to support a 40,000 t/d mining operation. The Nokomis deposit is located southeast of Ely, where a zone of copper-nickel-PGE mineralization occurs near the base of the Duluth Intrusive Complex at depths of 130 meters (m) to 1,300 m.

In March, Duluth Metals acquired the principal assets of Franconia Minerals Corp. (Spokane), which included a 70% interest in the neighboring Birch Lake, Maturi, and Spruce Road deposits. These assets were later transferred to Twin Metals, considerably expanding the Twin Metals Project area. Twin Metals retained Bechtel Mining & Metals to prepare a prefeasibility study of the project. Subsequent exploration work has focused on the Nickel Lake macrodiike at the northeastern end of the South Kawishiwi intrusion (Duluth Metals Ltd., 2011; 2012, p. 3–6, 12–16, 31–34, 55; Dundas and others, 2013, p. 5–9).

**Byproduct Smelter and Refinery Production.**—In 2011, Stillwater Mining Co. (Billings, MT) shipped 573 t of nickel in crystalline sulfate, up from 525 t in 2010. Stillwater mined PGEs from the J-M Reef in Montana's Beartooth Mountains. Concentrates from the company's two mills (East Boulder and Nye) 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., 2012, p. 8–12, 52–55).

No ferronickel was produced in the United States in 2011 from either domestic or imported ores. Almost all U.S. ferronickel exports were either re-exports or material upgraded for special purposes. The steel industry accounted for virtually

all the ferronickel consumed in 2011, with more than 97% used in stainless, heat-resistant, or specialty alloy steels.

**Secondary Production.**—The International Metals Reclamation Co. Inc. (INMETCO) operated the only secondary smelter in North America dedicated to recovering chromium and nickel from waste and scrap. The smelter at Ellwood City, PA, produced an iron-based remelt alloy that typically averaged 13% chromium and 12% nickel. Stainless steel producers used the remelt alloy as a substitute for ferrochromium and ferronickel. INMETCO was capable of processing a wide range of nickel-bearing wastes including flue dust, grindings, mill scale, and swarf generated during the manufacturing of stainless steel. The complex also accepted filter cakes, plating solutions, sludges, and spent rechargeable batteries. INMETCO was the only facility in North America thermally processing spent nickel-cadmium batteries. The facility also processed nickel-iron (Edison-type) batteries and nickel-metal hydride batteries. INMETCO was a wholly owned subsidiary of the Horsehead Holding Corp. (Pittsburgh, PA) (Horsehead Holding Corp., 2012, p. 1–6, 12–14, 28).

Gulf Chemical & Metallurgical Corp. (Freeport, TX) [owned by Eramet Group (Paris, France)] was one of a limited number of companies worldwide that processed spent catalysts from petroleum refineries. The Freeport facility treated nickel-molybdenum and cobalt-molybdenum hydrotreating catalysts that had been “poisoned” by nickel and vanadium. Gulf Chemical first roasted and leached the spent catalysts to recover the molybdenum and vanadium. The nickel-and-alumina residue was then converted to a crude, but marketable nickel-cobalt alloy in a direct-current electric arc furnace (EAF). In April, Gulf Chemical launched a \$50 million program designed to improve the environmental performance of the Freeport plant, which had been in operation since 1973 (Gulf Chemical & Metallurgical Corp., 2011).

## Consumption

Apparent primary nickel consumption in the United States increased by 10% to 124,000 t in 2011, from 113,000 t in 2010. The estimated value of apparent primary nickel consumption was \$2.84 billion, an increase from \$2.47 billion in 2010 owing to increased use and a 5% increase in the LME cash price. Apparent primary consumption plus reported secondary consumption in 2011 totaled 214,000 t, an increase of 19,000 t from that in 2010 (table 1).

**Stainless Steel and Low-Alloy Steels.**—In 2011, stainless steel producers accounted for 42% of reported primary nickel consumption in the United States (table 4) and more than 60% of primary consumption in the world. Alloy steels—other than stainless—accounted for an additional 5% of U.S. nickel use. Production of raw stainless steel and heat-resisting steel in the United States totaled 2.07 Mt in 2011, down by 6% from 2.20 Mt in 2010. Nickel-bearing grades accounted for 1.43 Mt, or 69% of total stainless steel production (American Iron and Steel Institute, 2012a, p. 71–73; b).

North American Stainless (NAS) in Ghent, KY, the leading U.S. producer of flat rolled stainless steel, produced 937,000 t of slabs—4% more than that of 2010 (Acerinox, S.A., 2012, p. 60–63).

In October 2010, ThyssenKrupp Stainless USA, LLC began cold rolling stainless steel at its greenfield mill in Calvert, AL. Production initially used material from ThyssenKrupp AG’s stainless mills in Europe. In late 2011, a second Sendzimir cold-rolling mill was added to the Calvert facility. The new Sendzimir mill allowed the facility to begin manufacturing stainless steel flat products in widths of 183 centimeters (72 inches)—a product used to manufacture large storage tanks for the chemical, food processing, and petroleum industries. The Calvert facility was the only stainless steel rolling mill in North America with this capability.

The new cold-rolling operation was part of a much larger steelmaking and processing complex launched in 2007 that was being built in partnership with ThyssenKrupp Steel USA (Calvert, AL). The stainless steel meltshop—still under construction—was designed to produce up to 1 million metric tons per year (Mt/yr) of stainless steel slabs and was expected to be operational as early as December 2012. The meltshop would have a 160-t-capacity EAF, a 180-t-capacity argon oxygen decarburization (AOD) converter, and a continuous caster. Of the \$5.0 billion being spent on the Calvert complex, \$1.4 billion was being invested in the stainless melting and rolling facilities (ThyssenKrupp Stainless USA, LLC, 2010, 2011; ThyssenKrupp Steel USA, [undated]).

**Superalloys and Related Nickel-Based Alloys.**—Of the primary nickel consumed in the United States, approximately 21% was used to make high-performance superalloys and related nickel-based alloys for the aerospace, electric power, and petrochemical industries. Sales to manufacturers of jet aircraft engines and other sectors of the aerospace industry increased in 2011, as Airbus S.A.S. and the Boeing Co. began to ramp up production of legacy single-aisle aircraft, such as the 737 and A320. Shipments of U.S.-manufactured civil jet transport increased to 477 in 2011 from 462 in 2010. On a global basis, Airbus and Boeing, the two leading manufacturers of large jet transport, delivered a total of 1,011 commercial aircrafts in 2011, a 4% increase from the 972 in 2010. U.S. sales of civil aircraft rose from a previous high of \$51.4 billion in 2007 to \$51.7 billion in 2011 in terms of 2005 constant dollars. Sales of superalloys to the defense manufacturing sector also were robust. From 2002 to 2008, U.S. aerospace industry sales for the combined military aircraft, missiles, and space subsectors steadily increased, increasing to \$129 billion from \$91.2 billion. However, sector sales leveled off in 2010 to \$127 billion and declined in 2011 as the U.S. Federal budget came under financial pressure (Aerospace Industries Association, 2012, p. 3–7 and 9–14; EADS N.V., 2012).

Allegheny Technology Industries, Inc. [ATI (Pittsburgh, PA)] was constructing a hot-rolling and processing facility for advanced specialty metals at the company’s existing flat-rolled operations in Brackenridge, PA. The new facility, budgeted at \$1.16 billion, would produce high-quality hot-rolled coils for a variety of metals and alloys, including nickel-based alloys, titanium metal, titanium alloys, zirconium alloys, and select grades of specialty stainless steels. The new facility was designed to produce thinner and wider coils than was possible in the past. The maximum width of the hot bands would be 2 meters (78.62 inches) (Allegheny Technologies Inc., 2012, p. 4, F14–15, F21, F36).



Rolls-Royce plc (London, United Kingdom) signed a long-term sourcing agreement with ATI to ensure an adequate supply of the nickel-based ATI 718Plus® superalloy, which was being manufactured into a variety of jet engine components. Rolls-Royce would be the first jet engine manufacturer to use ATI 718Plus® superalloy for rotating applications, where premium triple-melted material is required. The improved superalloy provides a nominal 55 °C (100 °F) temperature advantage over the traditional 718 alloy, enabling a jet engine of the same design to operate at a higher temperature. General Electric Aviation [an operating unit of General Electric Co. (GE)] had signed a similar sourcing agreement with ATI in 2010 (Allegheny Technologies Inc., 2011).

**Nickel Use in Industrial Gas Turbines and Steam Turbines.**—The U.S. Energy Information Administration (EIA), an agency within DOE, projected that the share of U.S. electric power generation from natural gas would rise to an average of 26.0% in 2015 from an average of 24.8% in 2011. This projection reflected the plentiful supply and relatively low cost of natural gas in North America in 2011. ATI718Plus® and similar superalloys were expected to play an increasingly important role in the manufacturing of these advanced turbines (Allegheny Technologies Inc., 2012, p. 15; U.S. Energy Information Administration, 2012a, p. 3–7, 37–40, 224; 2012b; Gold, 2013).

In November, Siemens Energy commissioned a new \$350 million gas-turbine production plant, adjacent to the company's existing steam turbine-generator plant in Charlotte, NC. For more than a decade, Siemens AG—the parent company in Munich, Germany—had been involved with the development and application of superalloys for large utility gas turbines—both in Europe and in the United States. At yearend 2011, Siemens was evaluating at least four nickel-base superalloys with nominal nickel contents ranging from 59% to 61% for single crystal use in jet engines and turbines. At least five other alloys containing between 49% and 69% nickel were being evaluated by industry for advanced ultrasupercritical turbines. Turbine inlets fabricated from these superalloys would receive steam at temperatures as high as 760 °C (1,400 °F) (Moverare and others, 2011, p. G2–2; Siemens Energy Sector, 2011; Draa, 2012; Schwant, Shen, and Soare, 2013).

Nickel-base superalloys and stainless steel play several important roles in geothermal powerplant operations, including piping made from a nickel-base superalloy or austenitic stainless steel. The U.S. geothermal energy industry continued to make headway in 2011 despite permitting delays, although the steep drop in natural gas prices since 2008 made several proposed geothermal projects financially untenable for the near future.

In March 2012, Energy Source LLC (El Centro, CA) commissioned phase 1 of its Hudson Ranch geothermal powerplant. The 49.9-megawatt (MW) powerplant and chemical complex was near Calipatria on the southeastern edge of the Salton Sea in southern California. Construction of phase 1 began in October 2010 and involved the drilling of three production wells. Production well drilling for phase 2 of the Hudson Ranch project was to have begun in the third quarter of 2012. ThyssenKrupp VDM GmbH (Werdohl, Germany) was supplying brine-resistant pipe fabricated from nickel alloy

625. The Salt River Project, a municipal utility in Arizona, agreed to purchase the entire plant output for the next 30 years (ThyssenKrupp AG, 2011; Trabish, 2012).

In Nevada, Gradient Resources Inc. broke ground for the first phase of its Patua geothermal power project in Churchill County, 61 km east of Reno. Although production well drilling started in 2010, actual construction of the 60-MW generating station did not start until August 2011. The \$300 million powerplant was scheduled to begin commercial operations in September 2013. Five other geothermal powerplants were operating within a 50-km radius of the Patua site (Gradient Resources Inc., 2011; 2012; Chichon, 2012, p. 14–15).

**Nickel-Based Batteries and Hybrid Electric Vehicles.**—U.S. demand for nickel in rechargeable batteries continued to increase. In 2011, many of the hybrid electric vehicles on U.S. highways used nickel-metal hydride (NiMH) batteries. Ford Motor Co., Honda Motor Co., Ltd., and Toyota Motor Corp. have all relied on NiMH batteries because of their proven durability, stability, and safety. The rechargeable battery market remained highly competitive and a variety of lithium-ion and lithium iron phosphate batteries began making inroads against the standard NiMH design (Vandeputte, 2012, p. 10–16).

In 2010, GE spent \$100 million converting a steam turbine assembly facility at Schenectady, NY, to an advanced battery manufacturing facility, and in 2011, began manufacturing the Durathon family of batteries—sodium-metal-halide batteries that contain nickel chloride as a key cell constituent. The advanced battery, originally designed for data centers and backup power, reportedly could store three times more energy than an equivalent conventional lead-acid battery. The Durathon battery was one-half the size of an equivalent lead-acid battery, required almost zero maintenance, and had a life expectancy of about 20 years. The battery was nontoxic, fully recyclable, and was capable of operating at temperatures ranging from -20 °C to 60 °C. GE planned to invest an additional \$70 million in the plant to double its production capacity (General Electric Co., 2012; 2013).

## Stocks

During the second half of 2010, stocks of nickel metal in LME warehouses began to slowly decline from the alltime high of 166,746 t reached in February 2010. By January 1, 2011, LME stocks had decreased to 136,890 t. This level was still quite high compared with inventories held from 2000 through 2007—before the start of the recession. During 2011, LME stocks continued to decrease as production of stainless steel in China increased and the economies of key countries like Brazil and the United States recovered from the economic downturn. LME stocks ended 2011 at 90,516 t. Data collected by the International Nickel Study Group (INSG) (2012, p. A1–A2, A7) indicated that, at yearend 2011, world nickel producers (excluding those in Austria, China, Macedonia, Kosovo, and the Ural region of Russia) held an additional 95,500 t of primary nickel stocks. About 69%, or 65,500 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 31% was class II material, which included

ferronickel, oxide sinter, and East Asian utility nickel. All stocks in LME warehouses were class I. At yearend, U.S. consumer stocks of primary nickel totaled 12,100 t, 8% more than the 11,200 t held at yearend 2010 (tables 1, 5).

## Prices

Nickel prices trended upward between July 2010 and February 2011, driven by the global economic recovery and the resulting increased consumption of the metal. However, actions by hedge funds, institutional investors, and speculators resulted in significant fluctuations in pricing within the general trend. The January 2011 average LME cash price for 99.8%-pure metal was \$25,642 per metric ton (\$11.631 per pound). A high of \$28,249 per ton (\$12.814 per pound) was reached in February, followed by a decline in price. By June, the average monthly price had declined to \$22,349 per ton (\$10.137 per pound) and declined further throughout the summer and fall as the Euro zone crisis started to escalate and the full impact of the tsunami began to be felt in Japan. Owing to the tsunami and an already weak construction market, Japanese production of austenitic stainless steel decreased by 4% to 1.72 Mt in 2011. The monthly average price for December was \$18,149 per ton (\$8.232 per pound), about 29% less than that of January. The average annual LME price was \$22,890 per ton (\$10.383 per pound)—5% more than the 2010 average.

## World Review

The world's leading producer of nickel ore was Norilsk (Russia), followed by Vale S.A. (Brazil and Canada) and the BHP Billiton Group (Australia and United Kingdom). PT Aneka Tambang Tbk. (Indonesia) was in fourth place, producing large tonnages of direct shipping ore for the Chinese nickel pig iron (NPI) industry. Other major producers were Anglo American plc (United Kingdom), Eramet Group (France), Jinchuan Non-ferrous Metals Corp. (JNMC) (China), and Xstrata plc (Switzerland).

According to the International Nickel Study Group, world use of primary nickel was 1.58 Mt in 2011—an alltime high for the second consecutive year—and was 8% greater than the previous high of 1.46 Mt in 2010 (International Nickel Study Group, 2012, p. A-1 and A-5). Global mine production increased by 15% to a record-high 1.96 Mt. Production in eastern Canada increased by 47% after a prolonged labor dispute between Vale and the United Steelworkers was settled in the second half of 2010. Production, however, was still 14% less than the prestrike output of 2008. The dispute had crippled Vale's mining and concentrating operations in Ontario and Labrador.

Global demand continued to be buoyed by the growth of apparent consumption in China, which rose to 685,000 t in 2011 from 348,000 t in 2007. The Chinese stainless steel industry continued to expand and used a record-high 521,000 t of primary nickel in 2011, a 22% increase from the amount consumed in 2010. The Chinese stainless steel industry was the leading consumer of primary nickel. The steel industry of the EU consumed 213,000 t of primary nickel in 2011, while the Japanese steel industry was in third place with 84,000 t (Eramet Group, 2012, p. 33-42). According to the International Stainless

Steel Forum (2013a; b), global stainless steel production increased to 32.1 Mt in 2011 from 31.1 Mt in 2010 and 24.9 Mt in 2009.

**Australia.**—Australia was the fifth-ranked nickel-producing country in the world. Seven companies in Western Australia reported producing salable nickel in 2011. Two of the seven, plus one additional company, trucked sulfide ore to BHP Billiton's concentrator at Kambalda for further processing [Department of Mines and Petroleum (Western Australia), 2011, p. 35-37].

**Laterite Operations.**—The Yabulu refinery of Queensland Nickel Pty. Ltd. processed laterite ores purchased from independent mining operations in Indonesia, New Caledonia, and the Philippines. In 2011, Yabulu produced about 32,000 t of nickel, mostly in the form of compacts (a product similar to rondelles) averaging 98.5% nickel or greater. Other products included nickel carbonate, specialty nickel oxide, and nickel oxide sinter (Queensland Nickel Group, The, 2013, p. 8, 10).

In October, First Quantum Minerals Ltd. recommissioned the idled Ravensthorpe complex in Western Australia, after making \$150 million worth of modifications to the front end of the complex. The Ravensthorpe operation produced 5,666 t of nickel in a mixed nickel-cobalt hydroxide intermediate during ramp up in the fourth quarter. Ravensthorpe achieved commercial production in late December and was expected to produce between 33,000 t/yr and 36,000 t/yr of contained nickel in 2012 (First Quantum Minerals Ltd., 2012, p. 3, 11, 22, 26).

The Murrin Murrin joint venture near Leonora, Western Australia, used sulfuric acid to leach nickel and cobalt from lateritic ores in high temperature, high-pressure autoclaves. The laterite mining and processing operation produced 30,000 t of nickel, an increase of 4% from that produced in 2010. In October, Glencore Investment Pty. Ltd. acquired the 60% interest in Murrin Murrin held by its joint-venture partner, Minara Resources Ltd., and took full control of the operation (Glencore International plc, 2013, p. 46-52, 74).

**Sulfide Operations.**—*Tasmania.*—The Averbury Mine [Minmetals Australia Pty. Ltd. (Melbourne, Victoria)] remained on care-and-maintenance status throughout 2011.

*Western Australia.*—In 2011, Nickel West, a subsidiary of BHP Billiton, produced 44,800 t of metal briquettes and powder at its Kwinana refinery from matte produced at its Kalgoorlie smelter. Kwinana also produced several intermediate products, including ammonium sulfate, cobalt-nickel sulfide, and copper sulfide. The Kalgoorlie smelter produced an additional 52,700 t of nickel in finished matte (68% nickel) for export. About one-third of the concentrate feed for the smelter came from the Mount Keith Mine in the Northern Goldfields region. The other two-thirds came from Nickel West's Perseverance-Cliffs mining operations near Leinster and third party mines at Kambalda (BHP Billiton, 2012, p. 52-57, 81, 121).

Western Areas NL mined 374,000 t of sulfide ore grading 5.0% nickel and containing 18,553 t of recoverable nickel at its Flying Fox underground mine at Forrestania in the fiscal year ending June 30, 2012. The company also extracted 189,000 t of ore grading 4.8% nickel and containing 9,135 t of nickel from the Tim King open pit at its new Spotted Quoll Mine, 6 km south of Flying Fox. In March, Western Areas began developing

the underground portion of the Spotted Quoll ore complex. The new underground workings were reached from a decline constructed in the wall of the Tim King pit. Underground mining started in November 2011 on the 1230 level [Department of Mines and Petroleum (Western Australia), 2011, p. 35–36; Western Areas NL, 2011, p. 2, 8–21].

**Brazil.**—Seven companies mined nickel ore in Brazil—Anglo American Níquel Brasil Ltda., Cia. Nickel do Brasil, Grupo Votorantim, Mineradora Comercial Lillian Ltda., Mirabela Nickel Ltd., Prometalica Mineração Centro Oeste S.A., and Vale S.A.

Construction of two greenfield ferronickel complexes was completed in late 2010. In March 2011, Anglo American Níquel Brasil Limitada poured the first deliverable ferronickel at its \$1.9 billion Barro Alto complex in Goiás State. The new smelter-refinery was scheduled to reach full production in early 2013 and was expected to produce 41,000 t/yr of nickel in ferronickel when ramp up was completed. The plant had two rotary kilns for calcining the raw ore and two 83-MW electric-arc furnaces for final smelting. The Barro Alto complex is approximately 170 km from Anglo American's older, but still active, Codemin mining and smelting complex in Niquelandia. The open pit at Barro Alto, which has been operating since 2004, will continue to supply ore to the Codemin ferronickel plant. In 2011, the Codemin and Barro Alto plants produced 9,500 t and 6,200 t, respectively, of nickel in ferronickel. At yearend 2011, the Barro Alto Mine had 52.2 Mt of proven and probable reserves grading 1.60% nickel and containing 833,000 t of nickel (Anglo American plc, 2012, p. 2, 16–18, 72–75, 178–179).

In March, Vale formally commissioned its Onça Puma smelting complex in Para State and began producing alloy in one of two ferronickel furnaces. The second furnace came online in the second half of 2011. Lateritic ores from the Onça and Puma West pits were being blended to produce a consistent feed for the coal-fired rotary calcination kilns. The processing complex was designed to produce 53,000 t/yr of nickel in ferronickel, but only produced 7,000 t in 2011. Operational issues with both furnaces slowed ramp up. The capital cost of the project was about \$2.84 billion. At yearend 2011, the Onça Puma Mine had 82.9 Mt of proven and probable reserves averaging 1.52% nickel (Vale S.A., 2011; 2012a, p. 20, 36–38, 59; Spinetto, 2012).

Votorantim Metais Níquel S.A. was the leading producer of electrolytic nickel in Latin America and operated a nickel-cobalt refinery in Sao Miguel Paulista, Sao Paulo State, capable of producing 23,000 t/yr of 99.9% pure electrolytic nickel and 1,420 t/yr of electrolytic cobalt. The Sao Miguel Paulista refinery processed intermediate nickel carbonate from the company's operation in Niquelandia. The sulfide smelter of Votorantim Metais at Fortaleza de Minas, Minas Gerais State, produced an estimated 13,400 t of nickel in matte in 2011, primarily for export to Finland, down from 14,308 t in 2010. The matte typically assayed 50% to 55% nickel, 7% to 12% copper, and 0.14% to 1% cobalt [International Nickel Study Group, 2011, p. B–10; Departamento Nacional de Produção Mineral (Brazil), 2012, p. 87–88].

Mirabela Nickel Ltd. (Perth, Western Australia) produced sulfide concentrate at its Santa Rita Mine near Ipiau, Bahia State. Santa Rita had the capacity to produce 27,000 t/yr of nickel in sulfide concentrate. In 2011, Mirabela processed 5.37 Mt of ore grading 0.50% nickel, and produced 15,854 t of nickel in concentrate, an increase from 10,375 t in 2010. Mirabela shipped roughly one-half of the concentrate to Norilsk Nickel's Harjavalta smelter in Finland, and trucked the other one-half 1,350 km to Votorantim's Fortaleza smelter in Minas Gerais. Santa Rita reportedly had 16.7 Mt of proven reserves averaging 0.57% nickel and 143 Mt of probable reserves grading 0.52% nickel (Mirabela Nickel Ltd., 2012, p. 7–10).

**Burma.**—China Nonferrous Metals Mining Group Co. Ltd. (CNMC) and Taiyuan Iron and Steel (Group) Co. Ltd. (TISCO) have been developing a laterite mine and constructing an adjacent ferronickel smelter at Tagaung Tang, near Thabeikkyin in the Mandalay region of Burma. The project was expected to cost between \$790 million and \$900 million. According to the Myanmar Ministry of Mines, the Tagaung Tang Mine was commissioned in March 2011. The mine reportedly had 40 Mt of reserves averaging 2.02% nickel (Thet, 2012, p. 11, 26–29).

**Canada.**—Four Provinces had active nickel mines in 2011—Manitoba, Newfoundland and Labrador, Ontario, and Quebec. In addition, companies were evaluating a variety of nickel deposits in all but two of the remaining nine Provinces or Territories.

**Manitoba.**—Vale Nickel's operations at Thompson produced 25,000 t of refined nickel in 2011 from ores extracted from the Birchtree and Thompson Mines. The Thompson Mine processed 1.18 Mt of ore grading 1.76% nickel, while the Birchtree Mine produced 721,000 t grading 1.36% nickel (Vale S.A., 2012a, p. 35, 37–38).

**Newfoundland and Labrador.**—Vale Nickel extracted 2.37 Mt of ore grading 3.38% nickel and 2.39% copper from its Ovoid Mine near Voisey's Bay that eventually yielded 68,900 t of refined nickel, up from 42,300 t in 2010, but down from a record 77,500 t in 2008. A prolonged labor dispute that began in August 2009 and continued through January 2011 was responsible for the post-2008 decrease in production of finished nickel. Vale has been constructing a hydrometallurgical processing plant at Long Harbour, Newfoundland, since April 2009. The Long Harbour plant was scheduled to begin operation in 2013 using concentrates from Ovoid as feed. In 2011, Vale Nickel shipped the high-grade nickel concentrate produced at Ovoid to Sudbury and Thompson for smelting and downstream processing (Vale S.A., 2012a, p. 35, 37–38; 2012b).

**Ontario.**—Sudbury has been the leading nickel-producing district in Canada since 1883. Vale Canada's Ontario Division produced 59,700 t of refined nickel in 2011 from its own ores, up from 22,400 t in 2010 and 43,600 t in 2009—2 years when output was affected by a prolonged labor strike. The Ontario Division had seven mines operating in 2011. Part of the 59,700 t was recovered from intermediate nickel oxide at the division's Clydach refinery in the United Kingdom. Vale Canada continued to develop its new \$450 million Totten Mine during the strike. In 2011, the partially completed mine produced 28,000 t of ore grading 1.01% copper and 0.97% nickel (Vale S.A., 2012a, p. 33–39).



Xstrata, Sudbury's other principal producer, mined 1,493,000 t of ore with an average grade of 1.46% nickel and 3.23% copper (Xstrata plc, 2012b, p. 1, 7–8). Xstrata's smelter at Falconbridge produced 69,459 t of nickel in matte, which was shipped to the company's Nikkelverk operations in Norway for refining (Xstrata plc, 2012a, p. 60–65; b, p. 7–8).

Quadra FNX Mining Ltd. operated the Levack/Morrison, McCreedy West, and Podolsky Mines, all located within 35 km of Sudbury, and retained the mineral rights to the Kirkwood and Victoria properties. In 2011, the company sold ore containing 4,500 t of payable nickel to Xstrata Nickel. In December, Quadra FNX accepted a takeover offer from KGHM Polska Miedź S.A. (Lublin, Poland). The \$2.9 billion transaction closed in March 2012, and the company was renamed KGHM International Ltd. (KGHM International Ltd., 2012, p. 2, 10–12).

Cliffs Natural Resources Inc. (Cleveland, OH), KWG Resources Inc. (Montreal, Quebec), and Noront Resources Ltd. (Toronto) continued to evaluate a variety of chromium, copper, nickel, PGE, and titanium deposits in the McFaulds Lake District. The district is located in the James Bay Lowlands, north of the Albany River. The district is the site of two massive chromite zones and a variety of nonferrous metal targets in and around a large ultramafic intrusion—the Ring of Fire. At least 30 other companies were active in the area at yearend 2011. The Government of Ontario was working with the mining industry, local communities, and the Matawa First Nations to develop all-weather roads, a possible rail line, and other infrastructure needed to support mining development (Kral, 2013, p. 22, 24).

In March, Noront Resources Ltd. filed plans of its proposed Eagle's Nest project with the Canadian Environmental Assessment Agency and the Province of Ontario. The company subsequently discovered additional nickel, copper, and platinum-group-metal resources at two other sites—"Eagle Two" and "AT-12". Noront was planning to complete a full feasibility study of the Eagle's Nest by October 2012. The sulfide concentrate would be slurried and pumped through a pipeline from the underground mine to Webequie Junction (Ontario Prospector, The, 2010, p. 22–29; Noront Resources Ltd., 2012, p. 1, 4–7, 14–19).

**Quebec.**—Xstrata's Raglan operation in northern Quebec produced 27,274 t of nickel in concentrate, which was 3% less than the 28,237 t recovered in 2010. A fourth underground mine—Kikialik—was being excavated at Raglan and began commercial production in January 2012 (Xstrata plc, 2012b, p. 8).

Royal Nickel Corporation (RNC) (Toronto) was evaluating the Dumont nickel property, about 70 km northwest of Val d'Or. In January 2012, RNC commissioned Ausenco Solutions Canada, Inc. to update the existing prefeasibility study and prepare a NI 43–101-compliant technical report on the property. The nickel mineralization was associated with a 700 m-thick mafic to ultramafic sill. The deposit had 1,070 Mt of probable reserves grading 0.27% nickel, putting Dumont on par with the Voisey's Bay deposit in Labrador (Ausenco Solutions Canada, Inc., 2012, p. 1–1 to 1–16).

**Indonesia.**—The Government of Indonesia warned PT Aneka Tambang Tbk. (Antam) that the company might have to limit

sales of both limonite and saprolite to NPI producers in China and other overseas customers. The Indonesian Government wanted foreign consumers to construct new ferroalloy and (or) NPI facilities in the archipelago. Antam decided to modernize its ferronickel complex at Pomalaa and construct a coal-fired powerplant close to the complex in anticipation of a future Government ban or tax on exports of direct shipping ore. Antam mined 7.96 Mt (wet) of various laterite ores, exceeding its alltime high of 7.11 Mt in 2007. About 80% of the production was direct shipping ore for export—primarily to Australia, China, eastern Europe, and Japan. Antam produced 19,690 t of nickel in ferronickel, an increase of 5% from that in 2010. 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) (PT Aneka Tambang Tbk., 2012, p. 16, 75–80, 98–102, 118–122).

PT Vale Indonesia Tbk. (PTVI) (formerly PT International Nickel Indonesia Tbk.) mined 3.85 Mt of ore averaging 1.95% nickel from its Sorowako concessions on Sulawesi, as measured by the amount of product delivered to the company's smelter from its adjoining dryer kilns. The smelter produced 66,900 t of nickel in matte for export to Japan, down by 12% from that in 2010. In October, PTVI inaugurated its 90-MW Kerebbe hydroelectric power station, raising capacity of the system to 365 MW. Vale had a 59% interest in PTVI (PT Vale Indonesia Tbk., 2012, p. 42, 67–73).

**Japan.**—On March 11, an earthquake with a magnitude of 9.0 struck the northwestern area of the Pacific Ocean, about 70 km east of the Tohoku coast of Honshu. The earthquake triggered a tsunami that devastated the eastern parts of Fukushima, Iwate, and Miyagi Prefectures. The Hachinohe ferronickel plant operated by Pacific Metals Co. in Aomori Prefecture was damaged by the earthquake, resulting in a production loss of some 8,300 t of ferronickel (gross weight). The plant was the largest ferronickel operation in Japan and had a production capacity of 40,000 t/yr (gross weight). Hachinohe was owned by Nippon Steel Corp., Japan's leading stainless steel producer, and Sumikin Stainless Steel Corp., a joint venture of Sumitomo Metal Industries Ltd. and Nippon Steel Corp. Full capacity was restored by the beginning of 2012 (Camus, 2011; Menzie and others, 2011; TEX Report Ltd., The, 2011).

Elsewhere, many bridges and highways were destroyed, disrupting supply chains throughout Honshu. The earthquake damaged the Takahagi warehouse where the central Government had stored emergency stocks of nickel and other strategic metals. Seismic activity toppled, crushed, and ruptured commodity storage containers stacked inside the warehouse. Japan Oil, Gas and Metals National Corp.—the stockpile operator—spent \$1.12 million repairing and upgrading the warehouse to minimize damage from future earthquakes. The tsunami heavily damaged the Fukushima Daiichi nuclear power station. In response to the earthquake, the Government of Japan shut down all 54 of the nuclear power reactors in Japan, disrupting power supplies for steel mills, ferroalloy plants, and base-metal refineries throughout the country (Sheldrick, 2012; Takashi and Koji, 2013).

**Madagascar.**—Construction of the \$5.5 billion Ambatovy project was completed in late 2011, with commissioning



scheduled for mid-2012. The mine had been operational since the third quarter of 2010. The refinery was designed to use the Sherritt hydrometallurgical process for recovering nickel and cobalt from lateritic ores. The Ambatovy ore was piped 220 km from the mining area to the processing plant as a water-based slurry. At the processing plant, the ore was leached with hot sulfuric acid in autoclaves to produce a mixed sulfide intermediate of cobalt and nickel. The mixed sulfide intermediate was then dissolved to produce a concentrated solution of cobalt and nickel. In the final stage of the operation, still in ramp up, the cobalt and nickel would be separated by solvent extraction. When fully operational, Ambatovy would be capable of producing 60,000 t/yr of nickel metal briquettes and 5,600 t/yr of cobalt metal briquettes and powder. The complex was expected to be one of the largest lateritic mining, processing, and refining operations in the world (Daigle and others, 2011, p. 152–162; Sherritt International Corp., 2012, p. 2–3, 7, 26, 35–36).

**New Caledonia.**—Société Le Nickel, a subsidiary of Eramet, produced 40,015 t of nickel in ferronickel at its Doniambo smelter. The smelter also produced 13,780 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, 2011; 2012).

At yearend 2011, Vale Nouvelle-Calédonie SAS (VNC) was ramping up production at its new Grand Sud hydrometallurgical plant. Performance testing of the autoclaves began in February 2010, but commissioning of downstream operations was delayed when two solvent extraction columns failed 2 months later. The solvent extraction columns were a critical part of the complex's refining circuit. The mixed hydroxide precipitate circuit in the upstream part of the operation produced 7,374 t of nickel in a hydroxide cake that was shipped to the Yabulu refinery in Queensland for further processing. The \$4.3 billion mining and processing complex was expected to have a production capacity of 60,000 t/yr of nickel in intermediate product. The mine delivered 1.04 Mt of lateritic ore averaging 1.29% nickel to the hydrometallurgical plant. At yearend 2011, VNC had 127 Mt of proven and probable reserves of dry ore grading 1.44% nickel (International Nickel Study Group, 2012; Vale S.A., 2012a, p. 34–38, 59).

Koniambo Nickel SAS was preparing to commission its \$3.5 billion laterite mining and ferronickel project in the North Province of New Caledonia. The project was launched in February 2007. Koniambo Nickel (Kone) is a joint venture of Société Minière du Sud Pacifique (SMSP, 51% equity) and Xstrata plc (49% equity). The first pour of molten metal from Line 1 was scheduled for January 2013. Line 2 could be operational by mid-2013. When fully operational in 2014, the Koniambo smelter would be capable of producing 60,000 t/yr of nickel in ferronickel shot. The nonfriable shot was expected to average 35% nickel, 63% iron, and 0.9% cobalt. At yearend 2011, the Koniambo Mine had 62.5 Mt of proven and probable reserves averaging 2.40% nickel (Usmar, 2011; Xstrata Nickel, 2011; 2012).

**Russia.**—About 80% of Norilsk's sales of marketable nickel came from its Russian operations. The other 20% was generated by the company's holdings in Botswana (3%) and

Finland (17%). Norilsk's Australian subsidiary produced 1,748 t of nickel in concentrate, but shipped the concentrate to Norilsk's Harjavalta refinery in Finland for further processing. Norilsk's operations on the Kola and Taimyr Peninsulas had a combined output of 237,228 t of nickel metal—about 91% of Russia's primary nickel output for the year. Norilsk's Russian subsidiaries exported almost all of their nickel production; only about 12,000 t, or 5%, was sold to Russian consumers (OJSC MMC Norilsk Nickel, 2012, p. 63–71, 88).

AO Mechel (Moscow) owned and operated the Southern Urals ferronickel smelter in Orenburg Oblast' and the two laterite mines—Buruktal and Sakhara—that supplied the operation. Mechel produced 16,901 t of nickel in low-iron ferronickel in 2011, of which an estimated 12,600 t was exported. The remainder was used to make stainless steel at Mechel's stainless steel plant at Chelyabinsk. The bulk of the exported ferronickel was delivered to Outokumpu Rossija Oy, Glencore International AG, A&M Trading, Stratton Metals Ltd., and Donetsk Electrometallurgical Plant (AO Mechel, 2012, p. 117–128).

## Outlook

Nickel consumers in the United States were expected to be dependent on foreign sources of refined metal and ferronickel for at least the next 25 years, even if all four of the current copper-nickel mining projects in the Lake Superior region come to fruition. The ongoing expansion of nickel laterite mining operations in Brazil, Indonesia, New Caledonia, and other tropical countries will help meet the increasing demand for nickel worldwide. The nickel output from Vale's state-of-the-art leach facility in New Caledonia and the company's new Long Harbour plant in Newfoundland is expected to satisfy the mid-term rise in global demand projected after 2015. Long-range forecasts of increasing usage in Asia have encouraged parastatal companies in China to fund the development of greenfield laterite mines in Burma, Indonesia, and Papua New Guinea. European and North American companies were seriously considering funding large-scale laterite projects in Cameroon, Guatemala, the Philippines, and Tanzania. At least two exploration companies were showing renewed interest in the nickel mineralization of Côte d'Ivoire, especially deposits near Biankouma and Yoroudougou, while others were preparing to drill two or three promising structures in southern Greenland.

Sulfide mines approaching the end of their productive lives because of dwindling reserves and high operating costs continue to be replaced. Developments of high-grade sulfide deposits, however, are becoming less frequent because the deposits are harder to find and located farther from shipping routes. These new projects are more costly to finance owing to their remoteness, stricter environmental regulations, and increased technical complexity. 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 bioheap leaching.

Concerns about global warming and associated climate changes, together with high oil prices, have encouraged research, development, and construction in the renewable energy

sector. Many of the older coal-fired plants do not meet current environmental standards, cannot be economically renovated, and are scheduled to be retired. The retrofitting of coal-fired powerplants to reduce carbon dioxide emissions remains a national issue. State-of-the-art powerplants fired by natural gas were expected to replace some of these coal-based facilities.

Global demand for electricity continues to increase and is accelerating as the population of the world increases. To meet demand, utilities will need to build more generating capacity, irrespective of whether the plants operate on fossil fuels, renewable energy (geothermal, solar, or wind), or nuclear fuels (safer, fourth-generation nuclear reactors). All of this capacity would require large tonnages of nickel-bearing stainless steel and superalloys (Wong and Coates, 2010).

Demand for nickel in the transportation sector is also expected to increase. Chinese, European, and North American usage of nickel- and cobalt-base superalloys was expected to escalate between 2013 and 2020, largely because of increasing demand for new jet aircraft that have more-fuel-efficient engines. Boeing forecasts an average growth rate of 5% to 6% per year for global passenger and cargo air traffic between 2011 and 2031. An estimated 33,500 new airplanes would have to be built during the 20-year period to meet demand. Significantly higher gasoline prices could encourage the replacement of conventional automobile steel frames with lighter ones fabricated from stronger stainless steel. The development of renewable energy sources was expected to accelerate research on cost-effective, more advanced batteries, especially for automobiles, telecommunication complexes, and remote power stations. Depending on material choices, this development could either enhance or reduce nickel demand in battery applications (Boeing Co., The, 2012, p. 22–26).

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TABLE 1  
SALIENT NICKEL STATISTICS<sup>1</sup>

(Metric tons of contained nickel unless otherwise specified)

	2007	2008	2009	2010	2011	
<b>United States:</b>						
<b>Secondary recovery from purchased scrap:</b>						
From ferrous scrap	84,600	77,500	72,100	73,300 <sup>r</sup>	80,400	
From nonferrous scrap	9,340	9,250	7,730	8,650 <sup>r</sup>	8,900	
Shipments of purchased scrap <sup>2</sup>	181,000	161,000	152,000	139,000 <sup>r</sup>	133,000	
<b>Exports:</b>						
Primary	13,100	11,600	7,020	12,600	12,400	
Secondary	103,000	94,600	90,000	80,300	64,800	
<b>Imports for consumption:</b>						
Primary	125,000	129,000	99,900	129,000	138,000	
Secondary	16,200	20,100	17,700	23,800	21,300	
<b>Consumption:</b>						
<b>Reported:</b>						
Primary	101,000 <sup>r</sup>	102,000 <sup>r</sup>	83,200 <sup>r</sup>	97,600 <sup>r</sup>	104,000	
Secondary, purchased scrap	94,000	86,700	79,900	82,000 <sup>r</sup>	89,300	
Total	195,000 <sup>r</sup>	189,000 <sup>r</sup>	163,000 <sup>r</sup>	180,000 <sup>r</sup>	193,000	
Apparent, primary	112,000 <sup>r</sup>	115,000	94,100 <sup>r</sup>	113,000	124,000	
Apparent primary plus reported secondary	206,000 <sup>r</sup>	202,000	174,000	195,000 <sup>r</sup>	214,000	
<b>Stocks, yearend:</b>						
Producers and traders	5,690	5,860	5,490	6,240 <sup>p</sup>	6,650 <sup>p</sup>	
Consumer, primary	7,450 <sup>r</sup>	9,380 <sup>r</sup>	8,510 <sup>r</sup>	11,200	12,100	
Consumer, secondary	6,600	6,320	5,520	6,150 <sup>r</sup>	6,610	
Total	19,700	21,600 <sup>r</sup>	19,500 <sup>r</sup>	23,600	25,400	
<b>Price, cash, London Metal Exchange:</b>						
Average annual	dollars per metric ton	37,216	21,104	14,649	21,804	22,890
Average annual	dollars per pound	16.881	9.572	6.645	9.890	10.383
<b>Price, Type 304 stainless steel scrap, gross weight:<sup>3</sup></b>						
Average annual	dollars per metric ton	2,952	2,361	1,462	2,200	2,276
Average annual	dollars per long ton	2,999	2,399	1,486	2,235	2,312
World, mine production	1,740,000 <sup>r</sup>	1,610,000 <sup>r</sup>	1,450,000 <sup>r</sup>	1,710,000 <sup>r</sup>	1,960,000	

<sup>p</sup>Preliminary. <sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; except prices; may not add to totals shown.

<sup>2</sup>Defined as scrap receipts less shipments by consumers plus exports minus imports plus adjustments for consumer stock changes.

<sup>3</sup>Derived from the monthly averages of the consumer buying price in Pittsburgh, PA, as published in American Metal Market (AMM). The price represents Type 304 solids & clips containing 18% to 20% chromium and 8% to 12% nickel.

TABLE 2  
NICKEL RECOVERED FROM PURCHASED SCRAP IN THE UNITED STATES,  
BY KIND OF SCRAP AND FORM OF RECOVERY<sup>1</sup>

(Metric tons of contained nickel)

	2010	2011
<b>Kind of scrap:</b>		
Aluminum-base <sup>2</sup>	1,690	1,950
Copper-base	1,280	1,270
Ferrous-base <sup>3</sup>	73,300 <sup>r</sup>	80,400
Nickel-base	5,680	5,680
Total	82,000 <sup>r</sup>	89,300
<b>Form of recovery:</b>		
Aluminum-base alloys	1,690	1,950
Copper-base alloys	2,080	2,280
Ferrous alloys	74,300 <sup>r</sup>	80,500
Nickel-base alloys	3,920	4,560
Total	82,000 <sup>r</sup>	89,300

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Primarily borings and turnings of wrought alloys, such as 2218, 2618, 4032, and 8280, or special casting alloys, such as 203.0.

<sup>3</sup>Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

TABLE 3  
REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM<sup>1</sup>

(Metric tons of contained nickel)

Form	2010	2011
Primary:		
Metal	83,700 <sup>r</sup>	88,400
Ferronickel	11,400	13,200
Oxide and oxide sinter <sup>2</sup>	214	312
Chemicals	1,270	1,160
Other	1,020	938
Total	97,600 <sup>r</sup>	104,000
Secondary, scrap <sup>3</sup>	82,000 <sup>r</sup>	89,300
Grand total	180,000 <sup>r</sup>	193,000

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes chemical-grade oxide.

<sup>3</sup>Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4  
U.S. CONSUMPTION OF NICKEL, BY USE<sup>1</sup>

(Metric tons of contained nickel)

Use	2011						Secondary (scrap)	Grand total	Grand total in 2010
	Metal	Ferronickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary			
Consumption reported:									
Cast irons <sup>2</sup>	61	--	--	--	3	64	W	64	292 <sup>r</sup>
Chemicals and chemical uses	956	--	W	W	W	956	--	956	919
Electric, magnet, expansion alloys	268	--	--	--	--	268	W	268	212
Electroplating, sales to platers	6,910	--	--	W	W	6,910	--	6,910	7,200
Nickel-copper and copper-nickel alloys	W	--	W	W	16	16	2,090	2,110	3,550 <sup>r</sup>
Other nickel and nickel alloys	18,800	W	4	--	43	18,800	W	18,800	16,000 <sup>r</sup>
Steel:									
Stainless and heat resistant	30,900	12,700	W	--	53	43,600	74,900	119,000	117,000 <sup>r</sup>
Alloys, excludes stainless	5,000	158	--	--	W	5,160	2,690	7,850	1,370 <sup>r</sup>
Superalloys	21,000	W	--	1	526	21,500	W	21,500	20,700
Other <sup>3</sup>	4,580	335	308	1,160	297	6,680	9,620	16,300	12,000 <sup>r</sup>
Total	88,400	13,200	312	1,160	938	104,000	89,300	193,000	180,000 <sup>r</sup>

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Under investigation.

<sup>3</sup>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<sup>1</sup>

(Metric tons of contained nickel)

Form	2010	2011
Primary:		
Metal	8,340 <sup>r</sup>	8,600
Ferronickel	819 <sup>r</sup>	989
Oxide and oxide sinter	84 <sup>r</sup>	88
Chemicals	1,840	2,340
Other	85 <sup>r</sup>	106
Total	11,200	12,100
Secondary, scrap	6,150 <sup>r</sup>	6,610
Grand total	17,300	18,700

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.



TABLE 6  
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS<sup>1</sup>

Class	2010		2011	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
<b>Primary:</b>				
Unwrought:				
Cathodes, pellets, briquets, shot	1,310	\$28,300	914	\$22,400
Ferronickel	31 <sup>r</sup>	1,280	23	630
Powder and flakes	1,530	67,000	1,500	61,500
Metallurgical-grade oxide <sup>2</sup>	5,440	33,000	4,590	31,600
Chemicals: <sup>2</sup>				
Catalysts	2,920	184,000	3,560	244,000
Salts <sup>3</sup>	1,410	31,100	1,840	30,900
Total	12,600	345,000	12,400	391,000
<b>Secondary:<sup>2</sup></b>				
Stainless steel scrap	70,300	936,000	49,200	958,000
Waste and scrap	10,000	95,000	15,600	128,000
Total	80,300	1,030,000	64,800	1,090,000
Grand total	93,000	1,380,000	77,200	1,480,000
<b>Wrought, not alloyed:</b>				
Bars, rods, profiles, wire	305	7,960	253	7,520
Sheets, strip, foil	548	17,000	436	15,200
Tubes and pipes	1,050	10,400	202	7,240
Total	1,900	35,400	891	30,000
<b>Alloyed, gross weight:</b>				
Unwrought alloyed ingot	4,510	108,000	6,480	170,000
Bars, rods, profiles, wire	15,200	507,000	18,600	675,000
Sheets, strip, foil	9,270	282,000	14,300	503,000
Tubes and pipes	2,300	99,200	2,370	120,000
Other alloyed articles	3,250	324,000	3,530	370,000
Total	34,500	1,320,000	45,300	1,840,000

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>The nickel contents are as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; and sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.

<sup>3</sup>Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 7  
U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY<sup>1</sup>

(Metric tons of contained nickel)<sup>2</sup>

Country	2011							Total in 2010	Wrought nickel in 2011 <sup>4</sup>	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide <sup>3</sup>	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	(5)	4	--	(5)	1,410	3	10	1,430	663	4
Belgium	--	10	--	29	58	346	355	798	532	3
Brazil	39	108	--	--	--	--	77	224	395	67
Canada	34	188	11	2,470	8,510	1,610	1,450	14,300	10,600	128
China	--	290	--	21	94	10,600	448	11,400	7,000	104
Colombia	66	20	--	--	--	(5)	9	95	101	40
Finland	--	--	--	--	--	3,090	1	3,090	3,210	(5)
France	--	3	1	--	85	5	18	112	86	11
Germany	(5)	195	6	129	1,670	75	362	2,440	906	59
India	85	74	--	2	37	1,770	373	2,340	2,270	12
Italy	--	5	--	(5)	--	233	74	312	66	3
Japan	(5)	63	(5)	1,870	860	3,530	119	6,430	10,900	4
Korea, Republic of	1	73	--	(5)	8	5,870	60	6,010	10,700	40
Mexico	626	46	--	14	12	44	141	883	1,690	88
Netherlands	18	1	5	3	1,350	1,400	83	2,860	1,330	1
South Africa	--	10	--	6	5	(5)	36	57	18	1
Spain	--	(5)	--	--	--	722	1	723	993	1
Sweden	--	29	--	1	205	212	1	448	344	2
Taiwan	24	34	--	(5)	55	15,100	107	15,300	34,100	35
Thailand	2	75	--	--	--	1,050	33	1,160	324	1
United Kingdom	(5)	56	--	2	1,170	106	79	1,410	1,200	41
Other	19	218	--	48	121	3,470	1,560	5,430	5,570	246
Total	914	1,500	23	4,590	15,600	49,200	5,400	77,200	93,000	891

-- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>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, sesquioxide, and hydroxide, 65%; chlorides, 25%; and sulfate, 22%. Other salts and various catalysts are assumed to be 22% nickel.

<sup>3</sup>Chemical-grade oxide is included in the "Chemicals" category.

<sup>4</sup>Excluded from "2011, total."

<sup>5</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8  
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY CLASS<sup>1</sup>

Class	2010		2011	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
<b>Primary:</b>				
Unwrought:				
Cathodes, pellets, briquets, shot	110,000	\$2,320,000	117,000	\$2,770,000
Ferronickel	9,420	186,000	11,700	269,000
Powder and flakes	6,290	163,000	6,530	191,000
Metallurgical-grade oxide <sup>2</sup>	79 <sup>r</sup>	1,610	451	7,850
Chemicals: <sup>2</sup>				
Catalysts	1,690	85,500	1,770	105,000
Salts <sup>3</sup>	1,440	33,000	979	21,400
Total	129,000	2,790,000	138,000	3,370,000
<b>Secondary:<sup>2</sup></b>				
Stainless steel scrap	14,600	305,000	12,700	295,000
Waste and scrap	9,130	167,000	8,600	189,000
Total	23,800	472,000	21,300	484,000
Grand total	153,000	3,260,000	159,000	3,850,000
<b>Wrought, not alloyed:</b>				
Bars, rods, profiles, wire	248	8,360	301	11,300
Sheets, strip, foil	340	9,810	422	16,200
Tubes and pipes	89	2,960	104	4,160
Total	677	21,100	827	31,700
<b>Alloyed, gross weight:</b>				
Unwrought alloyed ingot	6,860	135,000	7,780	185,000
Bars, rods, profiles, wire	8,540	210,000	10,300	331,000
Sheets, strip, foil	2,570	57,700	3,890	108,000
Tubes and pipes	1,680	64,000	1,640	89,900
Other alloyed articles	1,830	98,900	2,210	125,000
Total	21,500	565,000	25,800	840,000

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>The nickel contents are as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%. Waste and scrap is assumed to be 50% nickel; and stainless steel scrap, 7.5% nickel.

<sup>3</sup>Excludes nickel carbonate.

Source: U.S. Census Bureau.



TABLE 9  
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY<sup>1</sup>

(Metric tons of contained nickel)<sup>2</sup>

Country	2011							Total in 2010	Wrought nickel in 2011 <sup>4</sup>	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide <sup>3</sup>	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	18,500	683	--	311	109	--	--	19,600	17,000	--
Belgium	--	115	--	2	6	1	236	360	381	--
Brazil	3,670	--	630	--	66	27	--	4,390	3,550	--
Canada	48,900	2,730	288	28	1,300	7,020	91	60,400	29,500	1
Colombia	--	--	3,010	--	--	1	--	3,010	5,230	--
Dominican Republic	--	--	3,560	--	--	17	--	3,580	27	--
Finland	8,920	130	--	--	--	--	113	9,160	6,270	--
France	880	2	--	--	1,170	19	352	2,420	2,800	229
Germany	--	120	--	--	581	2	413	1,120	2,260	357
Indonesia	--	--	116	--	--	--	--	116	549	--
Israel	--	20	--	--	154	30	--	204	249	(5)
Italy	--	11	--	(5)	93	--	(5)	104	158	(5)
Japan	276	206	--	16	578	12	93	1,180	1,790	19
Mexico	--	(5)	--	--	996	4,940	18	5,960	6,000	(5)
Netherlands <sup>6</sup>	30	--	10	--	69	3	415	527	669 <sup>r</sup>	1
New Caledonia	--	--	3,570	--	--	--	--	3,570	3,530	--
Norway	12,100	--	--	--	--	--	--	12,100	25,000	--
Russia	21,000	1,350	--	--	93	--	(5)	22,400	33,800	--
South Africa	567	472	6	--	--	--	(5)	1,050	814	--
Spain	--	--	--	--	46	--	4	50	83	--
Taiwan	--	--	--	--	114	110	10	234	394	(5)
United Kingdom	311	568	--	93	2,120	160	131	3,380	6,870	51
Zimbabwe	324	--	--	--	--	--	--	324	762	--
Other	1,170	124	478	1	1,110	357	878	4,110	5,070	167
Total	117,000	6,530	11,700	451	8,600	12,700	2,750	159,000	153,000	827

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>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; and stainless steel scrap, 7.5% nickel.

<sup>3</sup>Primarily oxide, rondelles, and sinter.

<sup>4</sup>Excluded from "2011, total."

<sup>5</sup>Less than ½ unit.

<sup>6</sup>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<sup>1</sup>

(Metric tons of contained nickel)

Country and products <sup>2</sup>	2007	2008	2009	2010	2011
Albania, laterite ore <sup>c</sup>	3,700	3,500	3,500	3,500	3,500
Australia, ores and concentrate <sup>3</sup>	184,900	199,200	165,000	168,500 <sup>r</sup>	215,000 <sup>p</sup>
Botswana, ore milled <sup>c</sup>	27,600	28,940 <sup>4</sup>	28,595 <sup>4</sup>	28,000	26,000
Brazil, ore	58,317	67,116	41,059	108,983	109,000 <sup>c,p</sup>
Burma, ore <sup>c</sup>	10	10	10	10	800 <sup>5</sup>
Canada, concentrate	254,915	259,651	136,594	158,376	219,612
China <sup>c</sup>	67,000	79,500	84,800	79,600 <sup>r</sup>	89,800 <sup>p</sup>
Colombia, laterite ore <sup>c</sup>	75,864 <sup>4</sup>	64,200 <sup>4</sup>	79,900	76,200	76,000
Cuba:					
Recoverable laterite <sup>c</sup> :					
Limonitic	38,600	40,300	42,800	43,300	44,300
Serpentinic	65,600	56,300	49,700	50,700	53,200
Total	104,000	96,600	92,500	94,000	97,500
Oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor	(6)	(6)	(6)	(6)	(6)
Dominican Republic, laterite ore	47,125	31,300	-- <sup>r</sup>	--	21,693
Finland, concentrate <sup>7</sup>	3,465 <sup>r</sup>	4,303	4,400 <sup>e</sup>	11,286 <sup>r,p</sup>	18,300 <sup>e</sup>
Greece, laterite ore	21,190	18,646	10,203	16,345	21,710
Indonesia, laterite ore <sup>c</sup>	229,200 <sup>4</sup>	219,300	202,800	235,800	290,000
Kazakhstan, laterite ore <sup>c</sup>	200	500	500	500	500
Kosovo, laterite ore	1,820	3,660 <sup>8</sup>	10,500 <sup>8</sup>	9,080 <sup>8</sup>	7,700 <sup>8</sup>
Macedonia, ferronickel produced <sup>9</sup>	15,321	15,026	12,000	14,413 <sup>r</sup>	17,292
Madagascar, laterite ore	--	--	--	2,000 <sup>r,e</sup>	5,900 <sup>e</sup>
Morocco, nickel sulfate <sup>c</sup>	80	100	100	100	100
New Caledonia, ore	125,364	102,583	92,570	129,894 <sup>r</sup>	131,071
Norway, concentrate	246 <sup>r</sup>	377	336	350	339
Papua New Guinea, ore	--	--	--	--	(10)
Philippines:					
Ore	136,000 <sup>r</sup>	75,000 <sup>r</sup>	144,000 <sup>r</sup>	204,000 <sup>r</sup>	241,000 <sup>e</sup>
Concentrate <sup>11</sup>	16,300 <sup>r</sup>	9,000 <sup>r</sup>	17,300 <sup>r</sup>	29,000 <sup>r</sup>	29,000 <sup>e</sup>
Total	152,300 <sup>r</sup>	84,000 <sup>r</sup>	161,300 <sup>r</sup>	233,000 <sup>r</sup>	270,000 <sup>e</sup>
Russia, marketable mine production:					
Laterite ore <sup>12</sup>	45,687	36,804	32,298	41,184	41,777
Sulfide concentrate <sup>13</sup>	234,083	229,765	229,493	228,093	225,616
Total	279,770	266,569	261,791	269,277	267,393
South Africa, concentrate	37,163 <sup>r</sup>	31,675	34,605	39,960	39,810 <sup>p</sup>
Spain, concentrate	6,772	8,136	8,029	6,296	-- <sup>14</sup>
Turkey, laterite ore <sup>c</sup>	500 <sup>r</sup>	500 <sup>r</sup>	100 <sup>r</sup>	400 <sup>r</sup>	400
Ukraine, laterite ore <sup>c</sup>	12,000	8,000	--	--	--
Venezuela, laterite ore	18,900	13,000	13,200	11,400	19,500
Zambia, concentrate <sup>15</sup>	--	751	280 <sup>e</sup>	2,809	2,868
Zimbabwe, concentrate	8,582	6,354	4,858	6,200	8,000 <sup>e</sup>
Grand total	1,740,000 <sup>r</sup>	1,610,000 <sup>r</sup>	1,450,000 <sup>r</sup>	1,710,000 <sup>r</sup>	1,960,000
Of which:					
Concentrate <sup>16</sup>	562,000 <sup>r</sup>	550,000 <sup>r</sup>	436,000	482,000 <sup>r</sup>	544,000
Ore and ore milled	347,000 <sup>r</sup>	274,000 <sup>r</sup>	306,000 <sup>r</sup>	471,000 <sup>r</sup>	508,000
Laterite ore	560,000 <sup>r</sup>	496,000 <sup>r</sup>	446,000 <sup>r</sup>	490,000 <sup>r</sup>	586,000
Ferronickel produced	15,300	15,000	12,000	14,400 <sup>r</sup>	17,300
Nickel sulfate <sup>c</sup>	80	100	100	100	100
Unspecified and (or) undifferentiated	252,000 <sup>r</sup>	279,000 <sup>r</sup>	250,000 <sup>r</sup>	248,000 <sup>r</sup>	305,000

<sup>c</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>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 April 16, 2013.

<sup>3</sup>Australian Bureau of Agricultural and Resource Economics (ABARE) data for mines in Western Australia and Tasmania.

<sup>4</sup>Reported figure.

TABLE 10—Continued  
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY<sup>1</sup>

<sup>5</sup>The new Tagaung Tang Mine is a joint project of the China Nonferrous Metal Mining Group (CNMC), Taiyuan Iron & Steel, and the Government of Burma. The joint venture officially began recovering laterite ore on March 27, 2011.

<sup>6</sup>The Government of Cuba reported 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 estimated to be 1.2% for granular and powdered oxide, 1.2% for oxide sinter, 7.6% for sulfide precipitate, and 33% for leach ammoniacal precipitate. The total contained weight of nickel intermediates processed in Cuba from domestic ores was, in metric tons, as follows: 2007—73,934; 2008—67,265; 2009—63,000 (revised estimate); 2010—71,000 (revised estimate); and 2011—71,000 (estimated). The nickel intermediates included oxide, oxide sinter, oxide powder, sulfide, and ammoniacal liquor.

<sup>7</sup>The gross weight of concentrates processed in Finland from domestic ores was, in metric tons, as follows: 2007—44,824; 2008—43,038; 2009—43,000 (estimated); 2010—40,800 (estimated); and 2011—not available.

<sup>8</sup>On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

<sup>9</sup>Cunico Resources Group extracts nickel ore from its open pit Rzanovo Mine and transports the ore by conveyor to its FeNi Industries pyrometallurgical facility in Kavadarci. At the Kavadarci plant, the Rzanovo ore is blended with higher grade imported ores from Albania, Indonesia, New Caledonia, and Turkey to optimize production.

<sup>10</sup>At yearend 2011 the Ramu nickel and cobalt project was undergoing commissioning. Beneficiated ore from the Kurumbukari Mine was to be piped to the treatment plant at Basamuk for leaching in autoclaves.

<sup>11</sup>Nickel content of concentrate produced at Rio Tuba in 2007–11 by Coral Bay Nickel Corp.

<sup>12</sup>Nickel content of ore mined in the Ural Mountains region.

<sup>13</sup>Nickel content of concentrate produced on the Kola and Taimyr Peninsulas.

<sup>14</sup>In December 2010, Rio Narcea Recursos, S.A. suspended production at its Aguablanca open pit mine after heavy rainfall caused a major slope failure on the main access ramp. Mining resumed in August 2011, but milling operations did not restart until the third quarter of 2012.

<sup>15</sup>Albidon Limited concentrates were shipped to Jinchuan, China. First production was in June 2008. The concentrate produced in 2010 averaged 8.39% nickel. The Munali Mine was on care-and-maintenance status from March to December 2009 until ramp-up problems were resolved and world nickel prices recovered.

<sup>16</sup>Includes “Russia, sulfide concentrate.”

TABLE 11  
NICKEL: WORLD PRODUCTION OF INTERMEDIATE PRODUCTS FOR EXPORT, BY COUNTRY<sup>1,2</sup>

(Metric tons of contained nickel)

Country	2007	2008	2009	2010	2011 <sup>e</sup>
<b>Matte:</b>					
Australia <sup>3</sup>	41,612	31,085	35,441	76,290	51,100 <sup>p</sup>
Botswana	22,844	28,940	29,616	29,000 <sup>e</sup>	29,000 <sup>e</sup>
Brazil <sup>4</sup>	3,401	8,328	8,518	14,308	11,200 <sup>p</sup>
Canada <sup>5</sup>	73,922	76,908	68,972	70,127	73,724 <sup>6</sup>
China <sup>7</sup>	1,980	3,240	--	1	--
Indonesia <sup>8</sup>	77,928	73,356	68,228	77,186	67,800 <sup>p</sup>
New Caledonia	14,842	13,564	13,902	13,917	13,780 <sup>6</sup>
Russia <sup>9</sup>	670	600	240	206	25 <sup>p</sup>
Zimbabwe <sup>10</sup>	1,600 <sup>e</sup>	1,583 <sup>r</sup>	1,613 <sup>r</sup>	3,131 <sup>r</sup>	3,481 <sup>6</sup>
<b>Total</b>	<b>239,000</b>	<b>238,000</b>	<b>227,000</b>	<b>284,000<sup>r</sup></b>	<b>250,000</b>
<b>Other:</b>					
<b>Cuba:<sup>11</sup></b>					
Sulfide precipitate	30,553 <sup>r</sup>	32,102 <sup>r</sup>	33,860 <sup>r</sup>	34,202 <sup>r</sup>	34,829 <sup>p,6</sup>
Ammoniacial liquor precipitate <sup>c</sup>	2,907 <sup>6</sup>	322 <sup>6</sup>	300	300	300
<b>Total</b>	<b>33,460<sup>r</sup></b>	<b>32,424<sup>r</sup></b>	<b>34,200<sup>r,e</sup></b>	<b>34,500<sup>r,e</sup></b>	<b>35,100</b>
New Caledonia, nickel hydroxide cake	--	--	--	222	7,568 <sup>6,12</sup>
<b>Grand total, other</b>	<b>33,500</b>	<b>32,400</b>	<b>34,200<sup>r,e</sup></b>	<b>34,700<sup>r,e</sup></b>	<b>42,700</b>

<sup>e</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through April 16, 2013. Data represent nickel content of matte and other intermediate materials produced.

<sup>2</sup>World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>3</sup>Nickel content of reported exports. Figures exclude toll-refined material. Total matte production on a contained nickel basis, in metric tons, was as follows: 2007—46,600 (revised); 2008—31,100 (revised); 2009—27,500 (revised); 2010—59,200 (revised); and 2011—52,700 (estimated). Sources: Australian Bureau of Statistics; International Nickel Study Group.

<sup>4</sup>Represents the output of the Fortaleza smelter. All of the Fortaleza matte is shipped to Finland for further processing.

<sup>5</sup>Nickel content of reported exports. Matte from the smelter at Falconbridge typically assays 55% nickel.

<sup>6</sup>Reported figure.

<sup>7</sup>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: 2007—105,000; 2008—114,000; 2009—120,000; 2010—125,000; and 2011—145,000.

<sup>8</sup>Represents the nickel output of the Soroako smelter. The Soroako matte is shipped to Japan for further processing and contains on average 78% nickel.

<sup>9</sup>Primarily exports to China. Sources: International Nickel Study Group; United Nations Statistics Division.

<sup>10</sup>Zimplats material shipped to the Impala Refinery at Springs, South Africa. Sales volume in matte.

<sup>11</sup>Corrected to remove coproduct cobalt.

<sup>12</sup>Derived from both limonitic laterite and saprolitic laterite ores.



TABLE 12  
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT<sup>1,2</sup>

(Metric tons of contained nickel)

Country and product <sup>3</sup>	2007	2008	2009	2010	2011
<b>Australia:</b>					
Metal	100,300	89,500	123,200	92,200 <sup>r</sup>	97,700 <sup>e</sup>
Unspecified <sup>4</sup>	14,200	19,400	8,000	9,390 <sup>r</sup>	12,600 <sup>e</sup>
Total	114,500	108,900	131,200	101,590 <sup>r</sup>	110,000 <sup>e</sup>
<b>Austria, ferronickel and ferronickel molybdenum<sup>c</sup></b>	900	800	700	600	600
<b>Brazil:<sup>5</sup></b>					
Ferronickel	9,918	7,136 <sup>r</sup>	9,427	8,465	21,700 <sup>p</sup>
Metal	21,635	18,530	16,598	19,111	19,150 <sup>p</sup>
Total	31,553	25,666 <sup>r</sup>	26,025	27,576	40,850 <sup>p</sup>
<b>Canada, unspecified<sup>6</sup></b>	153,647	167,732	116,909	105,413	142,445
<b>China:<sup>7</sup></b>					
Ferronickel and high nickel pig iron	84,500	70,900	100,000	150,000	160,000
Metal	116,000	129,000	165,000	159,000 <sup>r</sup>	185,000
Chemicals and unspecified <sup>e</sup>	6,000 <sup>s</sup>	8,000 <sup>s</sup>	8,000	8,500	8,500
Total <sup>c</sup>	206,500 <sup>s</sup>	207,900 <sup>s</sup>	273,000	318,000 <sup>r</sup>	354,000
<b>Colombia, ferronickel</b>	49,314	41,636	51,802	49,443	37,817
<b>Cuba, oxide sinter and oxides<sup>e,9</sup></b>	39,911 <sup>s</sup>	34,478 <sup>s</sup>	32,800	34,000	34,000
<b>Dominican Republic, ferronickel</b>	29,130	18,782	--	--	13,498
<b>Finland:<sup>10</sup></b>					
Metal	49,758	36,181	41,848	43,900 <sup>r,e</sup>	43,300 <sup>e</sup>
Chemicals and unspecified	5,206	6,855	5,000	5,260 <sup>r,e</sup>	5,220 <sup>e</sup>
Total	54,964	43,036	46,848	49,200 <sup>r,e</sup>	48,500 <sup>e</sup>
<b>France:<sup>e</sup></b>					
Metal	11,200	11,400	12,000 <sup>s</sup>	10,800	11,700
Chemicals	2,020	1,840	1,960	2,080	2,040
Total <sup>11</sup>	13,200	13,200	14,000	12,900	13,700
<b>Greece, ferronickel</b>	18,670	16,650	8,269	13,975	18,528
<b>India:<sup>12</sup></b>					
Ferronickel	(13)	(13)	(13)	(13)	(13)
Ferronickel magnesium	52	93	88	90	90 <sup>e</sup>
Nickel sulfate	(14)	(14)	(14)	(14)	(14)
Total	52	93	88	90	90 <sup>e</sup>
<b>Indonesia, ferronickel</b>	18,532	17,566	12,550	18,688	19,690
<b>Japan:</b>					
Ferronickel	68,346	59,259	54,491	64,349	63,210
Metal	30,402	34,861	29,351	40,228	41,290
Oxide sinter	60,151	61,753 <sup>r</sup>	58,808 <sup>r</sup>	59,011 <sup>r</sup>	50,437
Chemicals	2,270	2,333	1,669	2,497	2,383
Total	161,169	158,206 <sup>r</sup>	144,319 <sup>r</sup>	166,085 <sup>r</sup>	157,320
<b>Korea, Republic of:</b>					
Ferronickel	--	2,506	21,609	20,965	19,011
Metal	(15)	(15)	(15)	(15)	(15)
Total	(15)	2,506	21,609	20,965	19,011
<b>Kosovo, ferronickel<sup>c</sup></b>	800	5,600 <sup>16</sup>	6,360 <sup>16</sup>	7,000	15,700
<b>Macedonia, ferronickel</b>	15,321	15,026	12,000	14,413 <sup>r</sup>	17,292
<b>Morocco, chemicals<sup>e</sup></b>	125	125	125	125	125
<b>New Caledonia, ferronickel</b>	44,954	37,467	38,230	39,802	40,015
<b>Norway, metal</b>	87,590	88,741	88,577	92,185	92,427
<b>Poland, chemicals<sup>e,17</sup></b>	475	475	400 <sup>r</sup>	400 <sup>r</sup>	400
<b>Russia:</b>					
Ferronickel					
High-nickel	17,111	16,158	15,565	16,799	16,899 <sup>p</sup>
Other <sup>18</sup>	4,690	4,905	5,125	5,330	5,360 <sup>e</sup>
Metal	248,363	242,409	239,269	245,543	246,725 <sup>p</sup>
Oxide sinter	235	--	--	--	-- <sup>e</sup>
Chemicals <sup>c</sup>	3,100	2,900	2,700	2,700	2,700
Total <sup>c</sup>	273,000	266,000	263,000	270,000	272,000

See footnotes at end of table.

TABLE 12—Continued  
 NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT<sup>1,2</sup>

(Metric tons of contained nickel)

Country and product <sup>3</sup>	2007	2008	2009	2010	2011
South Africa:					
Ferronickel, high-nickel	5,000	4,300	800	780	800 <sup>c</sup>
Metal	39,800	32,300	36,500	35,700 <sup>c</sup>	36,000 <sup>c</sup>
Chemicals <sup>c,19</sup>	6,610	4,450	4,850	4,790	4,800
Total <sup>c</sup>	51,400	41,100	42,200	41,300	41,600
Taiwan, metal	(15)	(15)	(15)	(15)	(15)
Ukraine, ferronickel <sup>20</sup>	14,211	16,224	12,392	12,400 <sup>c</sup>	12,400 <sup>c</sup>
United Kingdom, metal <sup>21</sup>	34,064	40,800 <sup>r</sup>	17,800 <sup>r</sup>	31,650 <sup>r</sup>	37,400
Venezuela, ferronickel <sup>5</sup>	15,700	10,900	10,400	11,700	13,400
Zimbabwe, metal: <sup>c</sup>					
Refined from domestic nickel ore	4,500	3,400	--	--	--
Toll refined from imported nickel feed <sup>22</sup>	9,500	10,300	6,000	4,064 <sup>8</sup>	3,500
Total	14,000	13,700	6,000	4,064 <sup>8</sup>	3,500
Grand total	1,440,000	1,390,000	1,380,000 <sup>r</sup>	1,440,000 <sup>r</sup>	1,560,000
Of which:					
Ferronickel, including ferronickel magnesium, ferronickel molybdenum, and high nickel pig iron	397,000	346,000 <sup>r</sup>	360,000	435,000 <sup>r</sup>	476,000
Metal	753,000	737,000 <sup>r</sup>	776,000 <sup>r</sup>	774,000 <sup>r</sup>	814,000
Oxide sinter	100,000	96,000 <sup>r</sup>	92,000 <sup>r</sup>	93,000	84,000
Chemicals, including nickel sulfate	14,600	12,100	11,700 <sup>r</sup>	12,600 <sup>r</sup>	12,400
Unspecified	179,000	202,000	138,000	129,000 <sup>r</sup>	169,000

<sup>c</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Table includes data available through April 16, 2013.

<sup>3</sup>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.

<sup>4</sup>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.

<sup>5</sup>Brazil produced nickel carbonate (an intermediate product for metal production), in metric tons: 2007—20,796; 2008—18,580; 2009—16,766; 2010—30,161 (revised preliminary number); and 2011—30,200 (estimated). Companhia Brasileira de Metalurgia e Mineração (CBMM) produced nickel niobium for sale to the superalloys industry.

<sup>6</sup>Nickel contained in products of smelters and refineries in forms that 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 15.

<sup>7</sup>Preliminary figures for ferronickel and chemicals were derived from data published by Beijing Antaika 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 2007–11, China also produced nickeliferous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

<sup>8</sup>Reported figure.

<sup>9</sup>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.

<sup>10</sup>Most of the production is extracted from imported raw materials.

<sup>11</sup>Reported by Eramet for Sandouville. Excludes secondary production from spent rechargeable batteries.

<sup>12</sup>India's fiscal year ending March 31 of that year stated.

<sup>13</sup>Vidarbha Nickel Pvt. Ltd. of Nagpur, Maharashtra State, has been producing ferronickel from spent nickel catalysts, but no production data were available. The ferronickel typically contains 47% to 50% nickel.

<sup>14</sup>In India, nickel sulfate was produced as a byproduct at the Ghatsila copper smelter in Jharkhand State. The facility, part of Hindustan Copper Ltd., is capable of producing 390 tons (gross weight) per year of nickel sulfate, but no production figures have been reported since 2005. The copper anode slime typically contains 0.4% to 0.8% nickel in addition to 4% to 10% silver.

<sup>15</sup>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: 2007—27,675; 2008—28,653; 2009—20,900 (estimated); 2010—22,000 (estimated); and 2011—21,000 (estimated). Taiwan: 2007—11,000 (estimated); 2008—11,000 (estimated); 2009—11,000 (estimated); 2010—11,000 (estimated); and 2011—10,000 (estimated).

<sup>16</sup>On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

<sup>17</sup>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.

<sup>18</sup>Includes ferronickel chromium and Ni-resist cast iron.

TABLE 12—Continued  
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT<sup>1,2</sup>

<sup>19</sup>Includes nickel sulfate plus exported metal in concentrate.

<sup>20</sup>May include nickel in remelt alloys derived from scrap.

<sup>21</sup>Tonnages include nickel contents of chemicals.

<sup>22</sup>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 2016

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2011	Brazil (Pará)	Onca-Puma <sup>3</sup>	1.73	110,000	53,000	Ferronickel.
		Vale Nickel	1.76	59,000		
2011	New Caledonia (Southern)	Vale Nouvelle-Calédonie (formerly Goro) <sup>4</sup>	1.34	96,000	60,000	Nickel-cobalt hydroxide, initially. Nickel oxide, later.
		Vale Nickel, Société de Participation Minière du Sud Calédonien S.A.S., and SUMIC	2.01	24,000		
		Netherlands Nickel B.V. (a joint venture of Sumitomo Metal Mining Co., Ltd. and Mitsui & Co., Ltd.)	1.70	83,000		
2011	Australia (Western Australia)	Ravensthorpe (restart) <sup>5</sup>	0.73	120,000	39,000	Nickel-cobalt hydroxide.
		First Quantum Minerals Ltd.	0.58	150,000		
			0.53	110,000		
2011	Burma (Thabeikkyin, Mandalay)	Tagaung Taung <sup>6</sup> China Nonferrous Metals Mining Group Co., Ltd. (CNMC), Government of Burma, and Taiyuan Iron and Steel (Group) Co., Ltd. (TISCO)	2.02	40,000	22,000	Ferronickel.
2012	Madagascar (Moramanga)	Ambatovy (Ambatovy and Analamay deposits)	1.05	84,000 <sup>7</sup>	60,000	Nickel metal powder and briquettes.
		Sherritt International Corp. (40%), Korea Resources Corp. (27.5%), Sumitomo Corp. (27.5%), and SNC-Lavalin Inc. (5%)	0.84	22,000		
			1.08	29,000		
2012	Papua New Guinea (Madang)	Ramu	0.93	42,000	31,000	Nickel-cobalt hydroxide.
		Metallurgical Group Corp. of China Ltd. consortium (85%), <sup>8</sup> Highlands Pacific Ltd. (8.56%), and Mineral Resources Development Co. (6.44%)	1.07	30,000		
			1.04	71,000		
2012	Philippines (Surigao del Norte and Surigao del Sur)	Adlay-Cagdianao-Tandawa	1.61	5,800	20,000	Direct shipping ore.
		Surigao Integrated Resources Corp. (assignment from CTP Construction and Mining Corp.) and Shenzhou Mining Group Corp.	1.58	13,000		
2012	Philippines (Zambales)	Acoje and Zambales—Stage 1	0.96	16,000 <sup>9</sup>	24,000	Do.
		David M. Consunji, Inc. (DMCI) Holdings, Inc., ENK PLC (formerly European Nickel PLC), <sup>10</sup> and Montemina Resource Corp. (MRC) <sup>12</sup>	0.93	22,000 <sup>9</sup>		
			1.22	18,000 <sup>11</sup>		
			1.08	4,800 <sup>11</sup>		
	1.18	24,000 <sup>13</sup>				
2013	New Caledonia (Northern)	Koniambo (sapolite ores)/North Plant	2.54	21,000	60,000	Ferronickel.
		Société Minière du Sud Pacifique S.A. (51%)	2.45	54,000		
		and Xstrata Nickel (49%)	2.50	83,000		
2013	Philippines (Surigao del Norte and Surigao del Sur)	Taganito mine and hydrometallurgical processing plant	1.14	83,000 <sup>14</sup>	30,000	Nickel-cobalt sulfide.
		Mine ownership—Nickel Asia Corp. (65%), Pacific Metals Co., Ltd. (33.5%), and Sōjitsu Kabushiki-gaisha (SOJITZ) Corporation (1.5%) Hydrometallurgical processing plant ownership—Sumitomo Metal Mining Co., Ltd. (62.5%), Nickel Asia Corp. (22.5%), and Mitsui & Co., Ltd. (15%)	0.95	360 <sup>14</sup>		
2014	Australia (Tasmania)	Barnes Hill, Mount Vulcan, and Scott's Hill	1.01	2,500	4,000	Cathode.
		Proto Resources & Investments Ltd. <sup>15</sup> and Metals Finance Ltd.	0.93	300		

See footnotes at end of table.

TABLE 13—Continued  
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Philippines (Romblon)	Romblon (Sibuyan Island)—Bato, Binaya-an, and Taclobo Pelican Resources Ltd.	1.56	7,300	9,000	Direct shipping ore.
2015	Australia (Queensland)	Marlborough (Coorumburra, Slopeaway, and Whereat) <sup>16</sup> —Stage 1 Gladstone Pacific Nickel Ltd.	0.99 0.91 0.70	12,000 43,000 70,000	63,000	Metal.
2015	Australia (Queensland)	NORNICO-Greenvale (Bell Creek, Greenvale, Kokomo, Lucknow, and Minnamoolka deposits) Metallica Minerals Ltd.	0.96 0.77 0.70	14,000 29,000 6,000	10,000	Metal.
2015	Cuba (Holguin)	Las Camariocas-Yamaguey Quality Cuba S.A. (Ferroniquel S.A.)	1.32	110,000	21,000	Ferronickel.
2015	Indonesia (Southeast Sulawesi, PT Antam (Persero) Tbk North Konawe regency)	Mandiodo	2.00 1.49	6,500 <sup>17</sup> 48,000 <sup>18</sup>	12,000	Nickel pig iron.
2015	Do.	North Konawe Jilin Horoc Non-Ferrous Metal Group Co., Ltd., PT Billy Indonesia, and Government of Southeast Sulawesi	1.50	100,000	20,000	Ferronickel.
2016	Australia (Queensland)	Lucky Break (Circular Laterite and Dingo Dam) Metallica Minerals Ltd. (50%) and Metals Finance Ltd. (50%)	0.82 0.82 0.75	590,000 48,000 490,000	730	Nickel carbonate. Cathode, later.
2016	Australia (Western Australia)	Mt. Thirsty (north-northwest of Norseman) Barra Resources Ltd. (50%) and Fission Energy Ltd. (50%)	0.60 0.51	17,000 15,000	9,000	Nickel-cobalt sulfide.
2016	Do.	NiWest (Eucalyptus, Hepi, Mt. Kilkenny, and Wanbanna) GME Resources Ltd.	1.04 0.99 0.96	34,000 22,000 19,000	30,000	Do.
2016	Australia (junction of the Western Australian, South Australian, and Northern Territory borders)	Wingellina Metals X Ltd.	1.00 0.97 0.97	69,000 99,000 16,000	40,000	Nickel-cobalt hydroxide.
2016	Cameroon (East Province)	Mada and Nkamouna Geovic Cameroon PLC. (60%) and National Investment Corp. (40%)	0.68 0.67 0.19 0.59 0.58	60,000 <sup>19</sup> 21,000 <sup>19</sup> 20,000 <sup>19</sup> 40,000 <sup>20</sup> 180,000 <sup>20</sup>	3,200	Cobalt-nickel sulfide.
2016	New Caledonia (Nakety-Bogota)	Nakety-Bogota <sup>21</sup> Société Gestion—Exploitation des Mines de Nickel (GEMINI S.A.), Société Minière Georges Montagnat S.A., and Société des Mines de la Tontouta (Ballande Group)	1.47 1.50	88,000 <sup>22</sup> 140,000 <sup>23</sup>	52,000	Ore.
2016	Philippines (Agusan del Norte)	Agata (includes Bolobolo-Karihatag and Agata South) Mindoro Resources Ltd.	1.00 1.16 0.95 1.18 0.80 1.11	250 <sup>9</sup> 540 <sup>11</sup> 13,000 <sup>9</sup> 29,000 <sup>11</sup> 680 <sup>9</sup> 1,700 <sup>11</sup>	7,500 14,000	Phase I, direct shipping ore. Phase 2, nickel-cobalt hydroxide.
2016	Philippines (Mindoro Oriental)	Mindoro I/Sablayan (Buraboy, Kisluyan, and Shabo areas) Aglubang Mining Corp. (local partner) and Intex Resources ASA	0.85 0.86 0.77	17,000 210,000 91,000	53,000	Metal.

See footnotes at end of table.



TABLE 13—Continued  
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2016	Philippines (Zambales)	Acoje and Zambales—Stage 2 David M. Consunji, Inc. (DMCI) Holdings, Inc., ENK PLC (formerly European Nickel PLC), <sup>10</sup> and Montemina Resource Corp. (MRC) <sup>12</sup>	1.12	30,800 <sup>24</sup>	24,000	Nickel-cobalt hydroxide.
2016	Tanzania (Northern/Lake Victoria)	Dutwa (Ngasamo Hill and Wamangola) African Eagle Resources plc	0.92 0.93 0.81	110,000 <sup>25</sup> 100,000 <sup>26</sup> 5,400 <sup>27</sup>	27,000	Nickel-cobalt hydroxide or sulfide.
2016	Turkey (Manisa)	Çaldağ Çaldağ Nikel Madencilik San. ve Tic. A.Ş., a subsidiary of OreMine Madencilik (OreMine Resources) San. ve Tic. A.Ş.	1.13	33,000	21,000	Nickel-cobalt hydroxide.

Do. Ditto.

<sup>1</sup>Company names reflect organizational structure as of April 16, 2013. BHP Billiton Group is a dual listed company comprising BHP Billiton Ltd. and BHP Billiton Plc. Vale Nickel is a wholly owned subsidiary of Vale S.A. (formerly Companhia Vale do Rio Doce).

<sup>2</sup>Gross weight, dry. “Estimated resources” are rounded to no more than two significant digits and represent measured, indicated, and (or) inferred resources depending on the project. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

<sup>3</sup>On March 4, 2011, Vale S.A. produced the first metal from line 1 of its two ferronickel production lines. Line 2 was scheduled to start production in the second half of 2011. The first shipment of 1,078 metric tons of ferronickel containing 385 metric tons of nickel, was made on May 11 from the Port of Itaqui.

<sup>4</sup>Vale Nouvelle-Calédonie began producing intermediate nickel hydroxide cake in mid-2011 for export to Australia.

<sup>5</sup>The Ravensthorpe nickel mine achieved commercial production on December 28, 2011. Total production for 2011 was 5,666 metric tons of contained nickel in mixed hydroxide precipitate.

<sup>6</sup>The new Tagaung Tang Mine is a joint project of the China Nonferrous Metal Mining Group (CNMC), Taiyuan Iron & Steel, and the Government of Burma. The joint venture officially began recovering laterite ore on March 27, 2011.

<sup>7</sup>Data represent mineral resources of only the Ambatovy deposits. Significant additional resources are associated with the Analamay deposits, northeast of the Ambatovy mine area.

<sup>8</sup>The Chinese consortium is owned by Metallurgical Corporation of China Ltd. (61%), Jinchuan Group Ltd. (13%), Jilin Jien Nickel Industry Co., Ltd. (13%), and Jiuquan Iron & Steel Group Co., Ltd. (13%).

<sup>9</sup>Limonite.

<sup>10</sup>In June 2010, European Nickel PLC and Rusina Mining NL merged to form ENK PLC.

<sup>11</sup>Saprolite.

<sup>12</sup>Montemina Resource Corp. (MRC) has a 60% interest in the Zambales (laterite) part of the project.

<sup>13</sup>Zambales—laterite.

<sup>14</sup>Dry metric tons of limonite. Figures exclude saprolite resources.

<sup>15</sup>Proto Resources & Investments Ltd. was also evaluating the Waite Kauri North laterite deposit near Leonora in Western Australia.

<sup>16</sup>The Marlborough ores would be supplemented with ores from the mines of Société des Mines de la Tontouta and Société Minière Georges Montagnat in New Caledonia.

<sup>17</sup>Probable resources of nickel in saprolite.

<sup>18</sup>Measured, plus indicated, resources of nickel in limonite.

<sup>19</sup>Nkamouna deposit.

<sup>20</sup>Mada deposit—first datum is indicated resources; and second is inferred resources.

<sup>21</sup>Ore would be shipped to Queensland for blending with ores from the Marlborough project and subsequent processing.

<sup>22</sup>Nakety.

<sup>23</sup>Bogota.

<sup>24</sup>Acoje only.

<sup>25</sup>Dutwa (Ngasamo Hill and Wamangola)—combined indicated and inferred resources.

<sup>26</sup>Dutwa (Ngasamo Hill and Wamangola)—total indicated resources.

<sup>27</sup>Dutwa (Ngasamo Hill and Wamangola)—total inferred resources.

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

TABLE 14  
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2010	Australia (Western Australia)	Kambalda (North and South) [Burnett,	4.00	440	1,500	Concentrate.
		Cameron, Camilya Hill, Durkin, Gellatly,	3.80	2,500		
		Mariners, McMahon/Ken, Miitel, Otter	3.50	980		
		Juan, Redross, Stockwell, and Wannaway]				
		Mincor Resources NL <sup>3</sup>				
2011	Do.	Lanfranchi (Cruikshank, Deacon, Gigantus,	3.66	350	1,500	Do.
		Helmut South, Helmut South ext., John,	3.75	400		
		Lanfranchi, Martin, McCornish, Schmitz,	2.14	330		
		and Winner)				
		Panoramic Resources Ltd.				
2011	Do.	Spotted Quoll Underground—Stage I	4.10	1,700	10,000	Do.
		Western Areas NL				
2011	Canada (Manitoba)	Bucko Lake [on temporary care-and-	1.45	3,700	5,000	Do.
		maintenance status between October 2010	1.52	2,800		
		and April 2011 (restart)]	1.34	5,500		
		CaNickel Mining Ltd.				
2012	Australia (Western Australia)	Cosmic Boy and Diggers <sup>4</sup>	1.46 <sup>5</sup>	2,100	7,000	Do.
		Western Areas NL	2.40 <sup>6</sup>	380		
			1.00 <sup>7</sup>	10,000		
2012	Do.	Sinclair (underground) <sup>8</sup>	3.88	100	5,500	Do.
		Xstrata Nickel Australasia	2.50	830		
			2.10	710		
2012	Canada (Quebec)	Raglan-Kikialik	3.10	1,800	24,000	Do.
		Xstrata Nickel				
2012	Finland (Lappi)	Kevitsa	0.29	89,000	11,000	Do.
		First Quantum Minerals Ltd.	0.32	150,000		
			0.29	35,000		
2012	Finland (Pohiois)	Outokumpu Copper (Kytlylahti mine and	0.17	620	450	Cobalt-nickel concentrate.
		Luikonlahti mill)	0.20	7,500		
		Altona Mining Ltd. <sup>9</sup>	0.18	310		
2013	Australia (Western Australia)	Radio Hill (conventional heap leaching)	0.61 <sup>10</sup>	2,000	7,400	Nickel-copper concentrate.
		Fox Resources Ltd.	0.42 <sup>10</sup>	2,000		
2013	Canada (Ontario)	Fraser Morgan	1.94	4,400	6,000	Ore.
		Xstrata Nickel	1.81	2,400		
			1.70	1,800		
2013	Do.	Hart	1.40	1,500	9,000	Concentrate.
		Liberty Mines Inc. [Jilin Jien Nickel Industry Co., Ltd. (60%)]				
2013	Do.	Totten (plus new Clarabelle mill addition)	1.33	8,400	8,200	Do.
		Vale Nickel				
2013	Canada (Quebec)	Nunavik (South Raglan) [Allammaq, Expo,	0.93	560	6,800	Do.
		Ivakkak, Mequillon, Mesamax, Puimajuq	0.93	21,000		
		and TK deposits]	0.73	5,200		
		Jilin Jien Nickel Industry Co., Ltd. <sup>11</sup>				
2013	China (Xinjiang Autonomous region/East Tianshan)	Tula'ergen	1.10	100,000	3,000	Do.
		Xinjiang Hami Hexin Mining Ltd.				
2013	United States (Michigan)	Eagle	3.47	3,600	17,000	Do.
		Kennecott Minerals Co. (Rio Tinto Group)	3.16	500		
2014	Canada (Manitoba)	Makwa (formerly Maskwa)	0.54	9,900	3,700	Do.
		Mustang Minerals Corp. <sup>12</sup>				

See footnotes at end of table.

TABLE 14—Continued  
 NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Canada (Manitoba)	Minago	0.56	11,000	11,000	Concentrate.
		Victory Nickel Inc.	0.51	43,000		
			0.53	15,000		
2014	Canada (Ontario)	Hart	1.40	2,200	9,000	Do.
		Liberty Mines Inc. [Jilin Jien Nickel Industry Co., Ltd. (60%)]	1.26	320		
2014	Canada (Sudbury)	Copper Cliff Deep Vale Nickel	NA	130,000	NA	Do.
2014	China (Gansu)	Heishan Jinchuan Group Co., Ltd.	0.60	23,000	5,000	Do.
2014	Finland (Oulu)	Kuhmo (Arola, Hietaharju, Peura-aho, Sika-aho, and Vaara) Altona Mining Ltd. <sup>9</sup> and Polar Mining Oy	0.55 <sup>13</sup>	6,000	3,000	Do.
2014	United States (Minnesota)	NorthMet	0.08	580,000	7,100	Concentrate, initially. Byproduct nickel-cobalt hydroxide, later.
		PolyMet Mining Corp. and Glencore International AG	0.08	230,000		
2015	Australia (Western Australia)	Mt. Windarra Poseidon Nickel Ltd.	1.24 1.72	910 3,000	7,000	Concentrate.
2015	Do.	New Morning/Daybreak Western Areas NL	3.70 <sup>14</sup>	320	3,000	Ore.
			3.50 <sup>14</sup>	93		
			0.90 <sup>15</sup>	1,100		
			0.90 <sup>15</sup>	660		
2015	Canada (Ontario)	Onaping Depth	2.67	15,000	10,000	Do.
		Xstrata Nickel	3.60	1,200		
2015	Russia (Amur)	Kun-Manie (Ikensoe, Maly Krumkon, and Vodorazdelny) Amur Minerals Corp.	0.61	3,700	16,000	Concentrate.
			0.48	48,000		
			0.54	17,000		
2015	Tanzania (Kagera region)	Kabanga Barrick Gold Corp. (50%) and Xstrata Nickel (50%)	2.49	14,000	40,000	Do.
			2.72	23,000		
			2.60	21,000		
2015	Tanzania (Nachingwea region)	Nachingwea Regional Exploration Project, including Ntaka Hill Nickel Sulphide Project Continental Nickel Ltd. (75%) and IMX Resources Ltd. (25%) <sup>16</sup>	1.21	13,000	25,000	Do.
			1.71	28,000		
			1.14	130,000		
2015	Vietnam (Son La)	Ban Phuc Asian Mineral Resources Ltd. and Son La Mechanical Engineering JSC	2.68 <sup>14</sup>	1,700	6,400	Do.
			1.94 <sup>14</sup>	170		
			0.59 <sup>15</sup>	13,000		
			0.56 <sup>15</sup>	7,400		
2016	Australia (Western Australia)	Sherlock Bay Australasian Resources Ltd.	0.38	9,600	8,500	Bioreachate precipitate.
			0.39	9,400		
			0.44	6,400		
2016	Do.	Sholl (A1, B1, B2) [bacterial heap leaching] Fox Resources Ltd. and Jinchuan Group Ltd.	0.47 <sup>17</sup>	1,300	3,000	Nickel-cobalt-copper sulfide precipitate.
			0.43 <sup>18</sup>	1,900		
			0.59 <sup>19</sup>	2,300		
			0.51 <sup>19</sup>	3,500		
2016	Botswana (Selebi-Phikwe region)	Dikoloti Discovery Metals Ltd. and Japan Oil, Gas and Metals National Corp.	0.70	4,100	2,000	Nickel-cobalt sulfide.
2016	Canada (British Columbia)	Turnagain Hard Creek Nickel Corp.	0.18	59,000	24,000	Concentrate.
			0.16	430,000		
			0.15	560,000		

See footnotes at end of table.

TABLE 14—Continued  
 NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2016	Canada (Ontario)	Eagle's Nest-McFaulds Lake	2.08	5,400	NA	Do.
		Noront Resources Ltd. and Baosteel Resources International Co., Ltd.	1.50	5,600		
			1.10	9,000		
2016	Canada (Ontario)	Kenbridge (open pit) Canadian Arrow Mines Ltd.	0.42	45,000	3,900	Concentrate.
2016	Do.	Victoria	1.23	480,000 <sup>20</sup>	NA	Ore.
		KGHM Polska Miedz S.A. (KGHM International) <sup>22</sup>	1.37	400,000 <sup>21</sup>		
2016	Canada (Quebec)	Dumont	0.29	360,000	49,000	Ferronickel.
		Royal Nickel Corp.	0.27	1,100,000		
			0.26	510,000		
2016	Do.	Raglan-Qakimajung Xstrata Nickel	4.52	2,500	11,000	Concentrate.
2016	Canada (Yukon Territory)	Wellgreen	0.38	290,000	10,000	Do.
		Prophecy Platinum Corp. (formerly Pacific Coast Nickel Corp.)	0.69	14,000		
2016	Russia (Kola Peninsula)	Vuruchuaivench MMC Norilsk Nickel-Kola MMC	0.23	17,500	NA	Metal.
2016	Russia (Taimyr Peninsula)	Maslovsky	0.33	220,000	18,000	Do.
		MMC Norilsk Nickel-Polar Division				
2016	South Africa (Mpumalanga and Limpopo)	Sheba's Ridge	0.20	80,000	24,000	Do.
		Aquarius Platinum Ltd. (39%), Anglo Platinum Ltd. (35%), and Industrial Development Corp. of South Africa (26%)	0.18	97,000		
			0.19	430,000		
2016	United States (Minnesota)	Nokomis/Maturi Extension	0.20 <sup>23</sup>	550,000	19,000	Byproduct nickel-cobalt sulfide or hydroxide.
		Birch Lake, Maturi, Spruce Road	0.21 <sup>23</sup>	270,000		
		Twin Metals Minnesota LLC <sup>24</sup> [Duluth Metals Ltd. (60%) and Antofagasta PLC (40%)]	0.17 <sup>25</sup>	180,000		
			0.16 <sup>25</sup>	40,000		
			0.25 <sup>26</sup>	120,000		
		0.21 <sup>27</sup>	120,000			

Do. Ditto. NA Not available.

<sup>1</sup>Company names reflect organizational structure as of April 16, 2013. BHP Billiton Group is a dual listed company comprising BHP Billiton Ltd. and BHP Billiton Plc. Vale Nickel is a wholly owned subsidiary of Vale S.A.

<sup>2</sup>Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits and represent measured, indicated, and (or) inferred resources depending on the project. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

<sup>3</sup>Mincor Resources NL restarted several mines and development projects in mid-2010 after an 18-month hiatus during the global financial crisis.

<sup>4</sup>Includes Diggers Rocks, Diggers South, Purple Haze, and Seagull resources.

<sup>5</sup>Diggers areas—probable ore reserves.

<sup>6</sup>Cosmic Boy area—indicated resources.

<sup>7</sup>Diggers areas—indicated resources.

<sup>8</sup>The Sinclair deposit remains open at depth.

<sup>9</sup>Altona Mining Ltd. was created when Universal Resources Ltd. merged with Vulcan Resources Ltd. in February 2010.

<sup>10</sup>Radio Hill deposit—indicated and inferred resources.

<sup>11</sup>On March 22, 2012, Jilin Jien Nickel Industry Co., Ltd. purchased 95.62% of the outstanding shares of Goldbrook Ventures Inc. In May 2012, the company acquired the remaining shares (4.38%) of Goldbrook Ventures Inc. This acquisition gave Jilin Jien Nickel Industry Co., Ltd. 100% control of the Nunavik project.

<sup>12</sup>Mustang Minerals Corp. was also evaluating the potential of resources at the nearby Mayville property.

<sup>13</sup>Kuhmo project area—total indicated and inferred resources.

<sup>14</sup>Massive sulfides.

<sup>15</sup>Disseminated sulfides.

<sup>16</sup>Continental Resources Ltd. and IMX Resources are in the process of merging to simplify development of the Ntaka Hill Nickel Project.

<sup>17</sup>Sholl B2 deposit—indicated and inferred resources.



TABLE 14—Continued  
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

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<sup>18</sup>Sholl A1 deposit—inferred resources.

<sup>19</sup>Sholl B1 deposit—inferred resources.

<sup>20</sup>Victoria project area—indicated resources.

<sup>21</sup>Victoria project area—inferred resources.

<sup>22</sup>KGHM Polska Miedź S.A. (KGHM International) acquired Quadra FNX Mining Ltd. on February 20, 2012, and took over management of the Victoria project on March 5, 2012.

<sup>23</sup>Nokomis deposit—indicated and inferred resources.

<sup>24</sup>In March 2011, Twin Metals Minnesota LLC (TMM) acquired Franconia Minerals Corp., doubling the project's mineral and land assets.

<sup>25</sup>Birch Lake deposit—indicated and inferred resources.

<sup>26</sup>Maturi deposit resource.

<sup>27</sup>Spruce Road open pit resource.

Sources: Australian Mines Atlas 2011; Canadian Minerals Yearbook 2010; company annual reports, presentations, and press releases; CRU International, Ltd., and the International Nickel Study Group.