



2012 Minerals Yearbook

NICKEL

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By Peter H. Kuck

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Global consumption of nickel continued to increase in 2012, despite the prolonged economic crisis that began in 2008 and ongoing concerns about the European debt crisis. This growth was driven by increased use of stainless steel and superalloys, especially in China (International Nickel Study Group, 2013, p. A–6). World production of stainless and heat-resisting steel reached a record high of 35.4 million metric tons (Mt) in 2012, but the growth was uneven, with downturns occurring in the Americas and Eastern Europe (ERAMET Group, 2014, p. 20–28; International Stainless Steel Forum, 2014a). World mine production of nickel reached an alltime high of 2.05 Mt of contained nickel in 2011, surpassing the previous high of 1.65 Mt in 2010 (table 1). World production in 2012 was slightly less than that of 2011. The London Metal Exchange Ltd. (LME) average monthly cash price for nickel metal peaked in February 2012 at \$20,462 per metric ton but then began an extended decline as new mining projects were commissioned. The LME cash price ended the year at \$17,404 per metric ton and averaged \$17,533 per ton for 2012. Daily stocks of nickel metal continued to increase in LME-sanctioned warehouses throughout 2012.

Austenitic (nickel-bearing) stainless steel has accounted for more than 60% of global primary nickel consumption since 2009. China was the leading producer of austenitic stainless steel in 2012, accounting for about 49% of world output, as well as the leading consumer of primary nickel. In 2012, China produced more austenitic stainless steel than the United States, Japan, and all of the countries in the European Union (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, 2014, p. 16–23; Mistry, 2012, p. 7; Nickel Institute, 2015, appendix 3).

Reported nickel consumption (primary plus secondary) in the United States increased by 3% compared with that of 2011. U.S. apparent consumption of primary nickel was 126,000 metric tons (t), or about 8% of world consumption, based on the 1.66 Mt reported by the International Nickel Study Group (INSG). Stainless steel composed only 41% of U.S. primary consumption, a relatively low percentage compared with similar economically developed countries—a reflection of the large number of specialty metal industries and a readily available supply of stainless steel scrap (table 4). U.S. industry reported melting 89,900 t of nickel contained in scrap, an increase of 4% from 86,600 t in 2011 (table 3).

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 and expanded in 2012 (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 recovered using plate-type heat exchangers fabricated from austenitic stainless steel, Incoloy®, or titanium. Solar and geothermal plants together accounted for only 5% of U.S. renewable energy production in 2012, compared with 58% for conventional hydroelectric power stations and 30% for wind farms. Solar power, however, was expected to account for more than one-third of total new power generation projects scheduled for completion in 2014. Other 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, 2014a, p. IF 41–45, Appendix A, A1, A16, and A17; 2014b, p. 5).

U.S. Coinage.—The U.S. Mint increased coin production in 2012 for the third consecutive year to meet growing demand from a recovering economy. However, the Mint was still operating at a reduced level when compared with the period from 2000 through 2007. The nickel-bearing coinage minted in 2012 contained 1,876 t of nickel in the form of either cupronickel or manganese brass alloy. In 2012, the Mint produced a total of 1,024 million Jefferson nickels (25% nickel by weight) and 1,676 million Roosevelt dimes (8.33% nickel), up from 990.2 million nickels and 1,502 million dimes in 2011 (U.S. Mint, undated b). The Jefferson nickels contained a total of 1,280 t of nickel and the Roosevelt dimes contained 317 t.

Minting of quarters increased by 45%. The U.S. Mint produced 568.0 million commemorative quarters in 2012, up from 391.2 million in 2011, but still far below production levels directly prior to the 2008–9 recession. The different designs on the reverse (tail side) of the quarters continued to promote the Nation's parks and historical sites. Five different designs were released in 2012. Each coin weighed 5.67 grams and contained 8.33% nickel, for a total of 268 t of nickel (U.S. Mint, undated a, b).

Production

The United States had only one active nickel mine at yearend 2012—a greenfield operation under construction in Michigan. Several deposits, however, were in varying stages of development in Minnesota. Limited quantities of byproduct nickel were recovered at some copper and precious metal refineries. The refinery recovery data are included with the scrap statistics.

No ferronickel was produced from ores in the United States in 2012. Almost all U.S. ferronickel exports were either re-exports or material upgraded for special purposes. The steel industry accounted for more than 85% of ferronickel consumed in 2012, of which more than 99% was used in stainless, heat-resisting, or specialty alloy steels.

Michigan.—In September 2011, Kennecott Eagle Minerals Co. (a fully owned subsidiary of the Rio Tinto Group) began construction of a \$469 million underground mine in Michigamme Township, near Big Bay on the Upper Peninsula. Most of the development work had been completed by the end of 2012. 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. Redpath Mining USA was responsible for drilling and excavating 3.2 kilometers (km) (2 miles) of tunnels from a portal near Eagle Rock. The deepest part of the mine would be about 240 meters (m) (800 feet) below the surface. At yearend 2012, the Eagle Mine had 5.33 Mt of indicated and inferred resources grading 3.1% nickel, 2.5% copper, and 0.1% cobalt (Pepin, 2011, 2012; Kennecott Eagle Minerals Co., 2012; Rio Tinto Group, 2012, p. 41, 50, 55).

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. At yearend 2012, Rio Tinto was considering selling both the Eagle Mine and the Humboldt mill to Lundin Mining Corp. (Toronto, Ontario, Canada). The transaction price was reportedly \$315 million (Lundin Mining Corp., 2014, p. 12). Lundin was planning to spend an additional \$400 million to bring the Eagle Mine into production by late 2014. Production would be ramped up during the first quarter of 2015 and reach full capacity by mid-2015. 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 (Lundin Mining Corp., 2013; 2014, p. 51).

Minnesota.—PolyMet Mining Corp. (Vancouver, British Columbia, Canada) was waiting for approval from the State of Minnesota to begin mining the NorthMet deposit in St. Louis County near the town of Babbitt. The Minnesota Department of Natural Resources and the U.S. Army Corps of Engineers—the original lead agencies on the project—published a draft Environmental Impact Statement (EIS) for public comment in November 2009. The U.S. Forest Service agreed to participate in the EIS process in June 2010 and was joined by the U.S. Environmental Protection Agency in June 2011. At the beginning of 2013, a supplemental EIS was being drafted. By yearend 2012, PolyMet had spent more than \$20 million on environmental review and permitting activities. Bateman

Engineering Pty Ltd. (Brisbane, Australia) was responsible for process design, detailed engineering, and cost estimates (PolyMet Mining Corp., 2014, p. 13–22).

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. The deposit is more than 4 km (2.5 miles) in length and extends to a depth of more than 790 m (2,600 feet) at some locations. Ore from the proposed open pit would be shipped to the reconditioned Erie mill near Hoyt Lakes, MN, for beneficiation. The concentrate would be processed at the Erie site in a new hydrometallurgical plant. The Erie complex was expected to process 32,000 tons per day of ore (Desautels and Zurowski, 2012, p. 1–1 to 1–10).

In October 2008, PolyMet formed a strategic alliance with Glencore AG, now a wholly owned subsidiary of GlencoreXstrata plc (Baar, Switzerland). The Swiss trading company has agreed to market all of PolyMet's concentrates, other intermediate products, and metals produced during the first 5 years of the Hoyt Lakes operation. Glencore had reportedly invested \$118 million in the project by yearend 2012 (GlencoreXstrata plc, 2013; Newby, 2012, p. 8–15; Newby and Knudson, 2014, p. 3, 5, 11–14; PolyMet Mining Corp., 2013, p. 17–29; 2014, p. 23–29, 34).

Duluth Metals Ltd. (Toronto, Ontario, Canada), Teck American Inc. (Spokane, WA), and Twin Metals Minnesota LLC (St. Paul, MN, a joint venture 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, 2014).

In December 2012, AMEC E&C Services Inc. delivered a draft National Instrument (NI) 43–101 technical report to Twin Metals. The technical report confirmed earlier claims that the Duluth Complex hosts one of the world's largest undeveloped accumulations of copper-nickel sulfides and PGEs. Measured resources controlled by Twin Metals consist of 1.7 Mt of copper and 540,000 t of nickel, based on a copper cutoff grade of 0.3%. Indicated resources include an additional 5.0 Mt of copper and 1.6 Mt of nickel (Duluth Metals Ltd., 2012a, b, c; 2014, p. 15–20 and 24–35; Dundas and others, 2013, p. 5–9).

Byproduct Smelter and Refinery Production.—In 2012, Stillwater Mining Co. (Billings, MT) shipped 508 t of nickel in crystalline sulfate, down from 573 t in 2011. 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. Spent PGE catalysts were added to the sulfide concentrates to sweeten the smelter feed. The additions were primarily automotive exhaust, petroleum refining, and chemical processing catalysts (Stillwater Mining Co., 2013, p. 7–9, 14, 22–23, 59).

Secondary Production.—The International Metals Reclamation Co. Inc. (INMETCO) operated the only secondary smelter in North America dedicated to processing

chromium- and nickel-containing waste and scrap. The smelter at Ellwood City, PA, produced an iron-base 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 variety of nickel-bearing wastes including flue dust, grindings, mill scale, and swarf generated during the manufacturing of stainless steel. The company also accepted filter cakes, spent solutions, and sludges from the plating industry. INMETCO was the only facility in North America thermally processing spent nickel-cadmium batteries. The facility also processed spent nickel-iron (Edison-type) batteries and nickel-metal hydride (NiMH) batteries. INMETCO was a wholly owned subsidiary of the Horsehead Holding Corp. (Pittsburgh, PA) (Horsehead Holding Corp., 2013, p. 1–4, 12–14, 41–42).

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 associated with polyaromatic rings in the oil. 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-molybdenum alloy in a direct-current electric arc furnace (EAF). In April 2011, 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, 2013, 2014).

Consumption

Apparent primary nickel consumption in the United States was essentially unchanged in 2012 from 126,000 t in 2011. The estimated value of apparent primary nickel consumption was \$2.21 billion, a decrease from \$2.89 billion in 2011 owing largely to a 23% decrease in the LME cash price. Apparent primary consumption plus reported secondary consumption in 2012 totaled 216,000 t, an increase of about 2,700 t from that in 2011 (table 1).

Stainless Steel and Low-Alloy Steels.—In 2012, stainless steel producers accounted for 41% 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 3% of U.S. nickel use. Production of raw stainless steel and heat-resisting steel in the United States totaled 1.98 Mt in 2012, down by 5% from 2.07 Mt in 2011. Nickel-bearing grades accounted for 1.43 Mt, or 72% of total stainless steel production (American Iron and Steel Institute, 2013a, p. 71–73; 2013b). North American Stainless, the Kentucky subsidiary of Acerinox, S.A., was the leading U.S. producer of flat-rolled stainless steel in 2012.

In late 2012, ThyssenKrupp Stainless USA, LLC transferred ownership of its greenfield stainless steel meltshop at Calvert, AL, to Outokumpu USA LLC. The stainless steel meltshop at Calvert was designed to produce up to 1 million metric tons per year (Mt/yr) of stainless steel slabs but was still in the

late stages of commissioning at the beginning of 2013. The meltshop had a 160-t-capacity EAF, a 180-t-capacity argon oxygen decarburization converter, and a continuous caster. Of the \$5.2 billion spent on the entire Calvert complex, \$1.6 billion was invested in the stainless melting and rolling facilities. The facility was the only plant in the United States that was designed to make 72-inch-wide sheet and plate suitable for seamless large tanks and other containers for the transport and petrochemical industries (ThyssenKrupp Stainless USA, LLC, 2010, 2011; ThyssenKrupp Steel USA, undated; Outokumpu Oyj, 2013, p. 1, 17).

Superalloys and Related Nickel-Base Alloys.—Of the primary nickel consumed in the United States in 2012, approximately 24% was used to make high-performance superalloys and related nickel-base alloys, primarily for the aerospace, electric power, and petrochemical industries. Sales of superalloys to manufacturers of jet aircraft engines and other sectors of the aerospace industry increased in 2012, as Airbus S.A.S. and the Boeing Co. ramped up production of legacy single-aisle aircraft, such as the 737 and A320. Shipments of U.S.-manufactured civil jet transport increased to 601 in 2012 from 477 in 2011. At the beginning of 2013, Boeing had an order backlog of 799 for its B-787 Dreamliner. The defense manufacturing sector continued to purchase significant quantities of superalloys as well. From 2003 to 2008, U.S. aerospace industry sales for the combined military aircraft, missiles, and space subsectors steadily grew, increasing to \$132 billion from \$104 billion. However, sector sales leveled off in 2011 at \$129 billion and declined to \$127 billion in 2012 as the U.S. Federal budget came under financial pressure (Boeing Co., The, 2013, p. 26; EADS N.V., 2013, p. iv; Aerospace Industries Association, 2013, p. 4–6, 10–14).

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 from a variety of metals and alloys, including nickel-base 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. Formal commissioning was expected to take place in the first half of 2014 (Allegheny Technologies Inc., 2013, p. 12, 17, 34).

General Electric Aviation [an operating unit of General Electric Co. (GE)] and Rolls-Royce plc (London, United Kingdom) both have long-term sourcing agreements with ATI to ensure an adequate supply of the nickel-base ATI 718Plus® superalloy. The advanced superalloy was being manufactured into a variety of jet engine components. ATI also has begun producing Rene 65, a futuristic nickel-base superalloy designed for the aerospace market (Allegheny Technologies Inc., 2013, p. 3–5, 11, F19).

Nickel Use in Industrial Gas Turbines and Steam Turbines.—ATI 718Plus® and similar superalloys were expected to play an increasingly important role in the manufacturing of more efficient, advanced turbines of all types. Conventional nickel-bearing alloys are already being incorporated into

a variety of other critical components at powerplants now under construction.

Siemens Energy was manufacturing gas-turbine and steam-turbine generators at two plants in Charlotte, NC. At yearend 2012, 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). Alcoa Power and Propulsion (a business unit of Alcoa Inc.) and Certified Alloy Products Inc. (a Long Beach, CA, subsidiary of Doncasters Group Ltd.) were also producing high-performance superalloys for aerospace and industrial gas turbines (Moverare and others, 2011, p. G2–2; Schwant and others, 2013).

Nickel-Based Batteries and Hybrid Electric Vehicles.—U.S. demand for nickel in rechargeable batteries continued to increase. In 2012, many of the hybrid electric vehicles on U.S. highways still used NiMH batteries despite recent advances in lithium battery technology. 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 were making inroads against the standard NiMH design (Vandeputte, 2012, p. 10–16).

In 2011, GE 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 is one-half the size of an equivalent lead-acid battery, requires almost zero maintenance, and has a life expectancy of about 20 years. The battery is nontoxic, fully recyclable, and capable of operating at temperatures ranging from -20 °C to 60 °C. GE planned to spend \$70 million to double production capacity at its renovated plant in Schenectady, NY (General Electric Co., 2012, 2013).

Stocks

Stocks of nickel metal in LME warehouses began to slowly build up in early 2012 after temporarily bottoming out at 86,676 t in October 2011. By January 31, LME stocks had risen to 95,598 t. This level was quite high compared with inventories held from 2000 through 2007—before the start of the recession. LME stocks continued to creep upward during the first half of 2012 even though nickel consumption was rising in China and the economies of key countries like Brazil and the United States were recovering from the economic downturn. In July, LME stocks started to rise sharply and ended 2012 at 141,690 t. Data collected by the INSG (2013, p. A1–A2, A7) indicated that, at yearend 2012, world nickel producers (excluding those in Austria, China, Kosovo, Macedonia, and the Ural region of Russia) held an additional 87,400 t of primary nickel stocks. About 73%, or 64,000 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 cathodes, briquets, pellets, powder, and rondelles. The remaining 27% 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 10,200 t, 13% less than the 11,700 t held at yearend 2011 (tables 1, 5).

Prices

Nickel prices decreased in 2012 even though the global economy was slowly recovering. Production from newly commissioned smelters and refineries more than offset increased consumption of the metal. Increased production of nickel pig iron in China weakened demand for imported ferronickel in the world's largest producer of stainless steel. The January 2012 average LME cash price for 99.8%-pure metal was \$19,818 per metric ton (\$8.989 per pound). A high of \$20,462 per ton (\$9.281 per pound) was reached in February, followed by 6 months of declining prices. The average monthly price bottomed out in August at \$15,654 per ton (\$7.100 per pound), but partially recovered in the fall. The monthly average price for December was \$17,404 per ton (\$7.894 per pound), about 12% less than that of January. The average annual LME price was \$17,533 per ton (\$7.953 per pound)—23% less than the 2011 average.

World Review

The world's leading producer of nickel ore was Norilsk (Russia), followed by Vale S.A. (a “national origin” company with headquarters in Brazil and Canada) and the BHP Billiton Group (with headquarters in Australia and United Kingdom). PT Aneka Tambang Tbk. (Indonesia) was in fourth place, producing large tonnages of direct shipping ore (DSO) for China's nickel pig iron (NPI) industry.

According to the INSG, world use of primary nickel was 1.66 Mt in 2012—an alltime high for the third consecutive year—and was 3% greater than the previous high of 1.61 Mt in 2011 (International Nickel Study Group, 2013, p. A–1 and A–6). Global mine production increased by 11% to a record-high 2.18 Mt. Mine production in eastern Canada, however, decreased by 7% even though the prolonged labor dispute between Vale and the United Steelworkers had been settled in late 2010. The dispute had crippled Vale's mining and concentrating operations in Ontario and Labrador for more than a year.

Global demand continued to be buoyed by the growth of apparent consumption in China, which rose to 770,000 t in 2012 from 360,000 t in 2008. China's stainless steel industry continued to expand and used a record-high 607,000 t of primary nickel in 2012, a 17% increase from the amount consumed in 2011. China's stainless steel industry was the leading consumer of primary nickel in the world. The steel industry of the countries of the EU consumed 211,000 t of primary nickel in 2012, while Japan's steel industry was in third place with 78,000 t (ERAMET Group, 2014, p. 16–22). According to the International Stainless Steel Forum (2014a, b),

global stainless steel production increased to a record-high 35.4 Mt in 2012 from 33.6 Mt in 2011 and 31.1 Mt in 2010.

Australia.—Australia was the fifth-ranked nickel-producing country in the world in terms of refinery output but ranked second in mine output. Nine companies in Western Australia reported producing salable nickel in 2012. Three of the nine trucked sulfide ore to BHP Billiton's concentrator at Kambalda for further processing [Department of Mines and Petroleum (Western Australia), 2013, p. 32–34].

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 2012, Yabulu produced about 34,000 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, undated, p. 8, 10).

In October 2011, 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. In 2012—the first full year of commercial operation—the company processed 2.81 Mt of beneficiated ore averaging 1.5% nickel. About 77% of the nickel was recovered, up from 68% in the fourth quarter of 2011. Ravensthorpe produced 32,884 t of nickel contained in a mixed nickel-cobalt hydroxide intermediate in 2012 (First Quantum Minerals Ltd., 2013, p. 11, 30–31, 42).

The Murrin Murrin complex 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 36,400 t of nickel, an increase of 21% from that produced in 2011 and a record high for the complex. In October 2011, Glencore Investment Pty. Ltd., a wholly owned subsidiary of Glencore International plc, acquired the 60% interest in Murrin Murrin held by its joint-venture partner, Minara Resources Ltd., and took full control of the operation. At yearend 2012, Murrin Murrin had 188 Mt of proven and probable reserves, averaging 0.98% nickel and 0.069% cobalt (Glencore International plc, 2013, p. 46–52, 74).

Sulfide Operations.—The Avebury Mine [MMG Ltd. (Southbank, Victoria)] in Tasmania remained on care-and-maintenance status throughout 2012. MMG's major shareholder was China Minmetals Nonferrous Metals Co. Ltd. (Beijing, China).

In 2012, Nickel West, a subsidiary of BHP Billiton, produced 56,100 t of metal briquettes and powder at its Kwinana refinery in Western Australia 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 48,100 t of nickel in finished matte (68% nickel) or concentrate for export. The company reduced matte production in the fourth quarter so that scheduled maintenance could be performed at both Kalgoorlie and Kwinana. 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, 2013, p. 79–80, 90, 136).

Western Areas NL mined 348,000 t of sulfide ore grading 4.9% nickel and containing 17,037 t of recoverable nickel at its Flying Fox underground mine at Forrestania in the fiscal year ending June 30, 2013. The company also extracted 207,000 t of ore grading 5.1% nickel and containing 10,602 t of nickel from its new Spotted Quoll Mine, 6 km south of Flying Fox (Western Areas NL, 2013, p. 2, 5, 8–13).

Poseidon Nickel Ltd. (Subiaco, Western Australia) was preparing to recommission the Mt. Windarra underground mine in the North Eastern Goldfields district, 260 km northeast of Kalgoorlie. The mine had been in operation from 1974 to 1993. Poseidon spent most of 2011 dewatering the underground workings so that the haulage shaft could be refurbished. The nickel sulfide mineralization is associated with 10- to 45-m-thick, metamorphosed flows of olivine peridotite. The Windarra deposit has 3.9 Mt of indicated resources and inferred resources grading 1.61% nickel. Poseidon has also been drilling the Cerberus deposit about 10 km southeast of the Mt. Windarra workings (Poseidon Nickel Ltd., 2013a, p. 24–39; 2013b).

The following five companies also mined nickel sulfide ores in Western Australia during 2012: GlencoreXstrata Nickel Australasia Pty. Ltd. (Cosmos, Sinclair), Independence Group NL (Long), Mincor Resources NL (Mittel, Carnilya Hill), Norilsk Nickel Australia (Lake Johnston), and Panoramic Resources Ltd. (Lanfranchi Tramways) [Department of Mines and Petroleum (Western Australia), 2013, p. 32–34].

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

In March 2011, Anglo American Níquel Brasil Limitada poured the first deliverable ferronickel at its \$1.9 billion Barro Alto mining and smelting complex in Goiás State. The new smelter-refinery produced 21,600 t of nickel in ferronickel in 2012, more than triple the output of 6,200 t in 2011. Barro Alto also continued to supply ore to the Codemin ferronickel plant in Niquelandia for blending. In 2012, Codemin produced 9,600 t of nickel in ferronickel, slightly more than the 9,500 t of 2011. At yearend 2012, the Barro Alto Mine had 46.8 Mt of proven and probable reserves of saprolite averaging 1.61% nickel. These figures equated to 754,000 t of nickel. Niquelandia had an equivalent 4.9 Mt of ore averaging 1.34% nickel (Anglo American plc, 2013, p. 80–89).

In June 2012, Vale S.A. suspended operations at its Onça Puma smelting complex in Para State after both ferronickel furnaces developed problems and were damaged during ramp up. The \$2.84 billion mining and smelting complex, commissioned in March 2011, produced about 6,000 t of nickel in ferronickel prior to the June shutdown. The company decided to rebuild one of the damaged furnaces at an estimated cost of \$188 million and planned to resume ramp up of the rebuilt furnace in the fourth quarter of 2013. With only one furnace operating, the complex would have a nominal capacity of 25,000 t/yr of nickel in ferronickel. At yearend 2012, the Onça Puma Mine had 82.4 Mt of proven and probable reserves

averaging 1.52% nickel (Vale S.A., 2011; 2013, p. 16, 21, 40–42, 64, F–29; 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 refinery produced 21,437 t of electrolytic nickel in 2012, up from 20,521 t in 2011. The sulfide smelter of Votorantim Metais at Fortaleza de Minas, Minas Gerais State, produced 14,345 t of nickel in matte in 2012, primarily for export to Finland, up from 13,703 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, 2014, p. B–5 and B–6; Departamento Nacional de Produção Mineral (Brazil), 2014, p. 96–97].

Mirabela Nickel Ltd. (Perth, Western Australia, Australia) produced sulfide concentrate at its Santa Rita Mine near Ipiau, Bahia State. In 2012, Mirabela produced 19,253 t of nickel in concentrate, an increase from 15,854 t in 2011. Mirabela shipped about 44% of the concentrate to Norilsk Nickel's Harjavalta smelter in Finland, and trucked the other 56% 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., 2013, p. 7–10).

Burma.—The Tagaung Taung (Dagongshan) ferronickel smelter was in the final stage of construction in north-central Burma. The nickel laterite mine and adjacent smelter are in the Sagaing/Mandalay Region, less than 200 km from the Chinese border. The rotary kiln electric furnace (RKEF) facility was designed to produce 25,000 t/yr of nickel-in-ferronickel pellets. The 72-megavolt-ampere electric furnace was successfully tapped on March 5, 2013, as part of a trial run. According to the Myanmar Ministry of Mines, the Tagaung Taung strip mine was commissioned in March 2011 and had 40 Mt of reserves averaging 2.02% nickel (Metallurgical Corporation of China, Ltd., 2013).

Canada.—Four Provinces had active nickel mines in 2012—Manitoba, Newfoundland and Labrador, Ontario, and Quebec. In addition, companies were evaluating a variety of nickel deposits in all but two of the other six Provinces and three Territories.

Manitoba.—Vale Canada's operations at Thompson produced 24,200 t of refined nickel in 2012 from ores extracted from the Birchtree and Thompson Mines. The Thompson Mine processed 1.16 Mt of ore grading 1.86% nickel, while the Birchtree Mine produced 643,000 t of ore grading 1.34% nickel (Vale S.A., 2013, p. 37, 41–42). The Thompson operation was also smelting concentrates shipped from Vale's mining operation near Voisey's Bay in northern Labrador.

Newfoundland and Labrador.—Vale Newfoundland & Labrador Ltd. extracted 2.35 Mt of ore grading 3.11% nickel and 1.94% copper from its Ovoid Mine near Voisey's Bay that eventually yielded 61,900 t of refined nickel, down from 68,900 t in 2011, but significantly more than the 42,300 t in 2010 when a prolonged labor dispute affected production.

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 2012, Vale Nickel shipped the high-grade nickel concentrate produced at Ovoid to Sudbury, Ontario, and Thompson, Manitoba, for smelting and downstream processing (Fluor Corp., 2014; Vale S.A., 2013, p. 37–38, 41–42).

Ontario.—Sudbury has been the leading nickel-producing district in Canada since 1883. Vale Canada's Ontario Division produced 65,500 t of refined nickel in 2012 from its own ores, up from 59,700 t in 2011 and 22,400 t in 2010 (the final year of a prolonged labor strike). The Ontario Division had eight mines operating in 2012. Part of the 65,500 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 and after the strike. In 2012, the partially completed mine produced 6,000 t of ore grading 2.37% copper and 1.15% nickel (Vale S.A., 2013, p. 37–42).

Xstrata, Sudbury's other principal producer, mined 1,480,000 t of ore with an average grade of 1.61% nickel and 3.71% copper (Xstrata plc, 2013b, p. 1, 8–9). Xstrata's smelter at Falconbridge produced 72,526 t of nickel in matte, which was shipped to the company's Nikkelverk operations in Norway for refining (Xstrata plc, 2013a, p. 16; 2013b, p. 8–9).

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 2012, the company sold ore containing 4,760 t of payable nickel. The Morrison Mine produced 2,770 t, or 58% of the 4,760 t. Another 1,600 t (34%) came from McCreedy West. In March, KGHM Polska Miedz S.A. (Lubin, Poland) bought Quadra FNX for \$2.9 billion. The company was renamed KGHM International Ltd. and ceased to be a publicly traded company on March 29 (KGHM International Ltd., 2013, p. 2, 7, 9, 11–13, 22).

Noront Resources Ltd. (Toronto) continued to evaluate a cluster of copper-nickel-PGE deposits in the McFaulds Lake district of northern Ontario. The district is located in the James Bay Lowlands and is the site of two massive chromite zones associated with a large ultramafic intrusion—the Ring of Fire. 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). Mineral development in the Ring of Fire region could generate more than \$25 billion for the Province of Ontario by 2047 (Ontario Chamber of Commerce, 2014). Since 2001, significant deposits of gold, vanadium, and zinc have been discovered in the region in addition to the chromium, copper, and nickel. At the present time, the nearest rail line and ore transport point is roughly 330 km away in Nakina, northeast of Lake Nipigon.

In March 2011, Noront 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 PGE resources at two other sites—"Eagle Two" and "AT-12." In October 2012,

Noront completed a full feasibility study of the Eagle's Nest—a komatiitic deposit (that is, a sulfide deposit interpreted to have formed in a dynamic lava channel or magma conduit). The sulfide concentrate would be slurried and pumped through a pipeline from the underground mine to Webequie Junction (Ontario Prospector, The, 2010, p. 22–24, 26, 28–29; Noront Resources Ltd., 2012a, p. 1, 3–8, 14–21; 2012b).

Quebec.—Xstrata's Raglan operation in northern Quebec produced 28,613 t of nickel in concentrate, which was 5% more than the 27,274 t recovered in 2011. A fourth underground mine—Kikialik—was being excavated at Raglan and began commercial production in January 2012 (Xstrata plc, 2013b, p. 8).

Royal Nickel Corporation (RNC) (Toronto, Ontario) 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, near the town of Amos, had 1,177 Mt of proven and 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). Once in operation, the mine could produce nickel for over 30 years. The existence of excellent infrastructure should make construction and operation of the processing facilities easier. Environmental management would be simplified because the mine would have minimal amounts of acid-generating sulfides in the waste rock and tailings (Ausenco Solutions Canada, Inc., 2012, p. 5–1 to 5–2, 7–1 to 7–24).

China.—China's NPI industry has grown rapidly since 2006. During the last 6 years, the bulk of China's production has shifted from traditional blast furnaces and relatively small-scale electric furnaces to much more efficient RKEF facilities. Because the output of China's nickel mines lags far behind domestic demand at the present, the NPI industry has consumed significant tonnages of lateritic DSOs from Indonesia and the Philippines, and to a lesser extent, New Caledonia. The Government of Indonesia was concerned about the increasing exports of DSO to China and was preparing to introduce a law banning the export of unprocessed ores in an effort to stimulate construction of RKEF operations, ferronickel smelters, and similar downstream processing facilities in the archipelago. PT Indoferro (Jakarta, Indonesia) was constructing a NPI facility at Cilegon on the island of Java (see "Indonesia").

According to the China Nonferrous Metals Industry Association, China produced 308,000 t of nickel contained in NPI in 2012, up from 254,300 t in 2011 (Nickel Monthly, 2013, p. 5). NPI from Nei Mongol Autonomous Region, Jiangsu Province, and Liaoning Province typically contain 10% to 15% nickel, compared with only 4% to 8% at some operations in Shandong and Shanxi Provinces. At least 10 greenfield NPI plants were in varying stages of construction at yearend 2012. One of these was the 600,000-t/yr NPI project of the Fujian Haihe Industry Co., which started up two 30,000-kilovolt-ampere (KVA) furnaces in May. Four 60,000-KVA furnaces were to be constructed in Phase 2 of the project (Nickel Monthly, 2012, p. 9–10).

Greenland.—At the end of 2011, the Geological Survey of Denmark and Greenland announced the discovery of the oldest-known meteorite impact site in the world, near the town of Maniitsoq. The Maniitsoq area, 160 km north of Nuuk, is underlain by highly deformed and metamorphosed gneisses of Archean age. North American Nickel Inc. (NAN) [Vancouver, British Columbia, Canada] was granted a license to explore a 75-km-long by 15-km-wide, curvilinear belt of younger, relatively undeformed norite intrusions that appear to be related to the 3.0-billion-year-old impact site. Most of the nickel-copper sulfide mineralization discovered to date has been associated with this norite belt, which geologists now refer to as the Greenland Norite Belt (GNB) (Garde and McDonald, 2012; Garde and others, 2013; North American Nickel Inc., 2012).

In November 2012, NAN discovered significant copper, nickel, and cobalt sulfide mineralization within the GNB at Imiak Hill. In early December, NAN announced the discovery of a second zone of significant sulfide mineralization—at Spotty Hill, only 1.5 km from Imiak Hill. The discovery hole at Spotty Hill revealed 124 m of disseminated sulfides grading 0.81% nickel, 0.21% copper, and 0.03% cobalt, and included zones of near-massive sulfides (North American Nickel Inc., 2012). Ports in this part of Greenland are ice-free all year, allowing concentrate to be shipped in both summer and winter to processing plants such as Vale's new hydrometallurgical operation in Newfoundland.

Guatemala.—In September 2011, HudBay Minerals Inc. (Toronto, Ontario, Canada) sold its 98.2% interest in the Fenix ferronickel project, west of El Estor, to the Solway Investment Group Ltd. (Larnaca, Cyprus) for \$140 million in cash at closing. Solway also agreed to pay HudBay up to \$30 million over time at key milestones as the project progressed. The Government of Guatemala owns the remaining 1.8%. HudBay originally took over the Fenix project in August 2008 when it acquired Skye Resources Inc. The Fenix operation had been on care-and-maintenance status since 1980 and includes a brownfield laterite mine and a processing plant on the north shore of Lake Izabal (Hudbay Minerals Inc., 2012, p. 4; Kosich, 2011).

The Fenix project has 36.1 Mt of mineral reserves averaging 1.86% nickel and should be capable of producing 25,000 t/yr of nickel in ferronickel when the first phase of modernization and upgrading is completed in mid-2014. The upgraded ferronickel plant would employ technology similar to that used by BHP Billiton at Cerro Matoso in Colombia and by Solway at its wholly owned Pobusky ferronickel plant in Ukraine. Production over the 27-plus year project life is projected to be 600,000 t of nickel in ferronickel (Solway Investment Group Ltd., 2014).

Solway also applied for a permit, through its subsidiary Compañía Guatemalteca De Níquel S.A., to mine direct shipping ores in the Montufar area southeast of Lake Izabal. After minimal processing, the Montufar ores could be trucked to the Port of Santo Tomas on the Gulf of Honduras for export (Solway Investment Group Ltd., 2014).

Indonesia.—In May, the Government of Indonesia reminded PT Aneka Tambang Tbk. (Antam) and other companies mining nickel laterites that new quotas would be introduced soon as part of a comprehensive national policy to sharply limit exports of all

DSOs. The Government wanted foreign consumers to construct state-of-the-art ferroalloy and NPI facilities in the archipelago. However, a shortage of hydroelectric powerplants and other renewable-energy-based utilities limited the number of sites suitable for greenfield electric-furnace-based smelters (Jensen and Supriatna, 2012).

At some point, an outright ban on unprocessed raw materials would take effect. [The new regulations, originally enacted in 2009 as Law No. 4, eventually came into force on January 12, 2014. The ban halted all sales of Indonesian DSO to ferronickel and NPI producers in China, Japan, Ukraine, and other overseas customers. The ban also applied to bauxite and chromite (Els, 2014).] In 2012, Indonesia exported 48.4 Mt of nickel ore, of which 43.1 Mt went to China (International Nickel Study Group, 2014, p. B–20).

Antam decided to modernize its ferronickel complex at Pomalaa and construct two 30-megawatt (MW) coal-fired powerplants close to the complex in anticipation of the imminent ban and tax on exports of DSO. Antam mined 9.43 Mt (wet) of various laterite ores, exceeding its alltime high of 7.96 Mt in 2011. About 86% of the production in 2012 was DSO for export—primarily to Australia, China, Eastern Europe, and Japan. Antam produced 18,372 t of nickel in ferronickel, a decrease of 7% from that in 2011. Approximately 75 to 85 wet metric tons of high-grade nickel ore averaging 1.8% nickel were needed to produce 1 t of nickel contained in ferronickel. 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., 2013, p. 30–34, 58–61, 89–91, 98–101, 105–108, 139–143, 165, 218–219).

PT Vale Indonesia Tbk. (PTVI) (formerly PT International Nickel Indonesia Tbk.) mined 3.68 Mt of ore averaging 2.02% 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 70,717 t of nickel in matte for export to Japan in 2012, up by 6% from that in 2011. In October 2011, PTVI inaugurated its 90-MW Karebbe hydroelectric power station, raising capacity of the 275-MW system to 365 MW. The cost savings generated by using Karebbe's hydropower helped to offset the short-term decline in nickel prices. Vale Canada had a 59% interest in PTVI. The next largest shareholder was Sumitomo Metal Mining Co. Ltd., with a 20% interest (PT Vale Indonesia Tbk., 2013, p. 1, 15, 30, 50).

Ibris Nickel Pte. Ltd. (Singapore) and smaller, locally owned mining companies, like PT Mobi Jaya Persada (Dampala, Sulawesi), were especially concerned about the controversial export ban. Ibris, the third-largest nickel mining company in Indonesia in terms of ore extraction, employed about 1,400 workers at its 2-Mt/yr mine in North Konawe, Southeast Sulawesi. All of the North Konawe ore production was being exported in 2012 (Jensen, 2014).

ERAMET was still planning to invest \$1.5 billion in a nickel mining and hydrometallurgical processing complex at Weda Bay on Halmahera Island, North Maluku. PT Weda Bay Nickel (WBN) (Jakarta, Indonesia) was a joint venture of ERAMET (60%), Mitsubishi Corp. (27%), Antam (10%), and Pacific Metals Co. (3%). In May, contractors for WBN completed the

required Environmental, Social, and Health Impact Assessment. The baseline and impact study was carried out to meet the requirements of international financing institutions. At the end of 2012, WBN was removing lateritic ore from proposed infrastructure construction sites and stockpiling the ore for future processing. The hydrometallurgical plant proposed for Phase 1 of the project was to have an initial design capacity of 35,000 t/yr of nickel (ERAMET Group, 2013, p. 5, 11, 21, 25, 38, and 51).

Madagascar.—The \$5.5 billion Ambatovy mining and hydrometallurgical complex was commissioned in the third quarter of 2012. The ore was leached with hot sulfuric acid in autoclaves to produce a mixed sulfide intermediate of cobalt and nickel. Ambatovy produced 8,972 t of nickel and cobalt in mixed sulfides in 2012. In September, the refinery in Toamasina began commercial production of finished nickel metal and cobalt. The cobalt and nickel were separated from one another by solvent extraction. The greenfield refinery produced 5,695 t of nickel metal briquettes and 493 t of cobalt metal briquettes and powder from the mixed sulfides. When fully operational, Ambatovy would be capable of producing 60,000 t/yr of nickel metal and 5,600 t/yr of cobalt metal. The complex was expected to be one of the largest lateritic mining, processing, and refining operations in the world (Sherritt International Corp., 2013, p. 4–7, 28, 34–35).

New Caledonia.—Société Le Nickel, a subsidiary of ERAMET, produced 43,030 t of nickel in ferronickel at its Doniambo smelter. The smelter also produced 13,417 t of nickel in matte, which was shipped to ERAMET's Sandouville refinery in France for conversion into LME-grade metal and chemicals (Direction de l'Industrie, des Mines et de l'Energie (DIMENC), 2014, p. 2; International Nickel Study Group, 2013, p. B–48; 2014, p. B–27).

At yearend 2012, Vale Nouvelle-Calédonie SAS (VNC) was ramping up production at its new Grand Sud hydrometallurgical complex. The Grand Sud complex was using a high-pressure acid leach process to treat both limonitic and saprolitic ores. The hydrometallurgical plant produced 3,191 t of nickel in nickel hydroxide cake averaging 16% nickel in addition to 2,111 t of nickel in nickel oxide averaging 78% nickel. The mixed hydroxide precipitate, produced in the upstream part of the operation, was shipped to the Yabulu refinery in Queensland for further processing. The nickel oxide, however, was sent to Vale's refinery at Dalian, China, for conversion into utility nickel. In 2012, the mine delivered 1.18 Mt of lateritic ore averaging 1.27% nickel to the hydrometallurgical plant. At yearend 2012, VNC had 123 Mt of proven and probable reserves of dry ore grading 1.44% nickel. The \$4.3 billion mining and processing complex was expected to have a production capacity of 57,000 t/yr of nickel in nickel oxide and nickel hydroxide cake when fully operational in 2016 (Direction de l'Industrie, des Mines et de l'Energie (DIMENC), 2014; Vale S.A., 2013, p. 22, 39–42, 55, 64, F–52).

In 2006, Koniambo Nickel SAS began constructing a mining complex and ferronickel smelter in the North Province near the port of Vavouto. The \$6.3 billion project was a joint venture of Société Minière du Sud Pacifique and Xstrata Nickel (now part of GlencoreXstrata). A 12-km-long overland conveyor system

was built to haul saprolitic ore from the nearby Koniambo Massif to the smelter site. Commercial production of ferronickel was scheduled to begin in April 2013. The smelter had a design capacity of 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 2012, the Koniambo Mine had 62.5 Mt of proven and probable reserves averaging 2.40% nickel (Swanepoel, 2013; Koniambo Nickel SAS, 2014; Xstrata Nickel, 2012).

Papua New Guinea.—In February, Metallurgical Corporation of China, Ltd. (MCC) started commissioning the Ramu project near Madang. The \$2.1 billion nickel-cobalt project was a joint venture of a Chinese consortium led by MCC (85%), the Government of Papua New Guinea and local landowners (6%), and Highlands Pacific Ltd. (9%). The ore was being slurried and piped 135 km from the mine on the Kurumbukari Plateau, across the Ramu River, to the Basamuk processing plant on the Rai Coast. The Basamuk plant was designed to produce 78,000 t/yr (dry) of mixed nickel-cobalt hydroxide containing 31,200 t of nickel and 3,300 t of cobalt. During rampup in 2012, the Ramu project produced 13,777 t (dry) of mixed hydroxide containing 5,283 t of nickel and 469 t of cobalt (Highlands Pacific Ltd., 2014, p. 10–11).

Russia.—About 78% of Norilsk's sales of marketable nickel came from its operations in Russia. The other 22% was generated by the company's holdings in Finland (18%) and Botswana (4%). Norilsk's Australian subsidiary produced 8,975 t of nickel in concentrate from ore mined at Lake Johnston 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 233,632 t of nickel metal—about 92% of Russia's primary nickel output for the year. Norilsk's Russian subsidiaries exported almost all of their nickel production; only about 9,000 t, or 4%, was sold to Russian consumers and other buyers in the Commonwealth of Independent States (OJSC MMC Norilsk Nickel, 2013, p. 60–67, 74–75).

OAO Mechel (Moscow) owned and operated the Southern Urals ferronickel smelter in Orenburg Oblast' plus the two laterite mines—Buruktal and Sakhara—that supplied the operation. Mechel produced only 9,782 t of nickel in low-iron ferronickel in 2012, of which an estimated 8,700 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 Stratton Metal Resources Ltd., Outokumpu Rossija Oy, A&M Trading, Glencore International AG (a Swiss operating subsidiary of Glencore), and MBR Metals Oü. In December, Mechel halted its nickel mining and processing operations for an extended period of time because of the continued decline in demand for nickel on global markets and the corresponding weakening in the LME price of nickel (OAO Mechel, 2013, p. 116–124).

In early 2012, the owners of Highmetals KDS (Moscow) met with officials of both Chelyabinsk Oblast' and Sverdlovsk Oblast' to discuss how to best restructure JSC Ufaleynickel and PA Rezhnikel. The two companies needed to modernize their production facilities in order to remain competitive. Highmetals reportedly acquired the two companies at the end of 2011 from

OOO Industrial and Metallurgical Holding Management Co. Prior to the crisis, Ufaleynickel had been producing 14,000 to 16,000 t/yr of either nickel metal granules or nickel oxides (Interfax, 2012).

In mid-2012, Ural Mining and Metallurgical Co. (UMMC) moved forward with its plan to develop the Elkinskoe copper-nickel deposit in the Novokhopersky district of Voronezhskaya Oblast'. The Russian State Committee on Mineral Resources gave UMMC permission to begin developing the deposit provided that the company completed a satisfactory geologic evaluation of the surrounding area beforehand. In May, UMMC was the winning bidder of a tender put forward by the Oblast', in which Norilsk Nickel also participated. The neighboring Yelanskoye deposit apparently will be held in reserve (OJSC MMC Norilsk Nickel, 2011; Rusmininfo Ltd., 2012).

Venezuela.—In November 2012, the Government of Venezuela refused to renew the mining concessions and operating permits held by Minera Loma de Níquel C.A., and took control of the laterite mining and ferronickel operation. The Government had already cancelled 13 of Loma de Níquel's concessions. Petróleos de Venezuela S.A., the parastatal oil company, was given responsibility for the operation. Anglo American plc had a 91.4% stake in Loma de Níquel prior to the takeover. The smelter processed 767,400 t of ore grading 1.40% nickel and produced 8,100 t of nickel in ferronickel before mining was halted in September (Anglo American plc, 2013, p. 81–82, 88; León, 2012).

Outlook

Nickel consumers in the United States are 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, Guatemala, Indonesia, New Caledonia, the Philippines, 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 2016. 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 are seriously considering funding large-scale laterite projects in Cameroon, the Philippines, and Tanzania. At least two exploration companies are showing renewed interest in the nickel mineralization of Côte d'Ivoire, especially deposits near Biankouma and Yoroudougou.

Sulfide mines approaching the end of their productive lives because of dwindling reserves and high operating costs continue to be replaced. Exploration for nickel sulfides is underway in several parts of the Arctic including the Far North of Alaska and the northern Territories of Canada (especially Baffin Island, other parts of Nunavut, and the Yukon). North American Nickel has launched an aggressive exploration program at its Maniitsoq property in southwestern Greenland, following the discovery of high-grade pentlandite-chalcopyrite mineralization

at Imiak Hill. Developments of high-grade sulfide deposits like Imiak Hill, however, are becoming less frequent because the deposits are harder to find and located farther from traditional 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, previously passed over large-tonnage, low-grade polymetallic sulfide ore deposits like those at Sotkamo, Finland, 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 are 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. Demand for electricity in the United States is expected to increase by at least 29% between 2012 and 2040. 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 (U.S. Energy Information Administration, 2014a, p. MT-16 to MT-23).

Demand for nickel in the transportation sector is also expected to increase. Chinese, European, and North American usage of nickel- and cobalt-base superalloys is 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 4% to 5% per year for global passenger and cargo air traffic between 2013 and 2033. An estimated 36,800 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 is 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, 2013, p. 24–29; Tinseth, 2014, p. 10–26).

References Cited

- Aerospace Industries Association, 2013, 2013 year-end review and forecast: Arlington, VA, Aerospace Industries Association, December, 19 p.
- Allegheny Technologies Inc., 2013, Annual report and 10-K wrap—2012: Pittsburgh, PA, Allegheny Technologies Inc., 23 p. and F91 p.
- American Iron and Steel Institute, 2013a, 2012 annual statistical report: Washington, DC, American Iron and Steel Institute, 122 p.
- American Iron and Steel Institute, 2013b, Quarterly production of stainless and heat resisting steel (AIS 104)—Fourth quarter 2012: Washington, DC, American Iron and Steel Institute, 2 p.
- Anglo American plc, 2013, Nickel, *in* Fact Book 2012/13: London, United Kingdom, Anglo American plc, p. 80–89.
- Ausenco Solutions Canada, Inc., 2012, Technical report on the Dumont project, Launay and Trecession Townships, Quebec, Canada: Vancouver, British Columbia, Canada, Ausenco Solutions Canada, Inc., June 22, 377 p.
- BHP Billiton, 2013, Form 20-F for the fiscal year ended 30 June 2013: U.S. Securities and Exchange Commission, 356 p. plus appendices.
- Boeing Co., The, 2013, Form 10-K for the fiscal year ended December 31, 2012: U.S. Securities and Exchange Commission, 121 p. plus exhibits.
- Departamento Nacional de Produção Mineral (Brazil), 2014, Sumario mineral—2013 [Portuguese]: Brasília, Brazil, Departamento Nacional de Produção Mineral, July, v. 33, 137 p. (Accessed August 20, 2014, at <http://www.dnpm.gov.br/conteudo.asp?IDSecao=68&IDPagina=3165>.)
- Department of Mines and Petroleum (Western Australia), 2013, Western Australian mineral and petroleum statistics digest—2012–13: East Perth, Western Australia, Australia, Department of Mines and Petroleum (Western Australia), 77 p.
- Desautels, Pierre, and Zurowski, Gordon, 2012, Updated NI 43–101 technical report on the NorthMet deposit, Minnesota, USA: Barrie, Ontario, Canada, AGP Mining Consultants, Inc., October 12, 1072 p. (Accessed May 7, 2014, via <http://www.polymetmining.com>.)
- Direction de l'Industrie, des Mines et de l'Energie (DIMENC), 2014, Productions et exportations—Minieres & metallurgiques (Décembre 2013): Noumea, New Caledonia, DIMENC, January 31, 3 p.
- Duluth Metals Ltd., 2012a, Duluth Metals announces an updated mineral resource estimate confirming large increases to Twin Metals contained metal, grade and indicated tonnage: Toronto, Ontario, Canada, Duluth Metals Ltd. press release, December 4. (Accessed May 6, 2014, via <http://www.duluthmetals.com/s/NewsReleases.asp>.)
- Duluth Metals Ltd., 2012b, Duluth Metals announces commencement of drilling at Nickel Lake Macrodike: Toronto, Ontario, Canada, Duluth Metals Ltd. press release, September 24. (Accessed May 6, 2014, via <http://www.duluthmetals.com/s/NewsReleases.asp>.)
- Duluth Metals Ltd., 2012c, Duluth Metals announces Twin Metals frame-of-reference for Bechtel led pre-feasibility study Toronto, Ontario, Canada, Duluth Metals Ltd. press release, March 21. (Accessed May 6, 2014, via <http://www.duluthmetals.com/s/NewsReleases.asp>.)
- Duluth Metals Ltd., 2014, Annual information form for the financial year ended December 31, 2013: Toronto, Ontario, Canada, Duluth Metals Ltd., March 21, 71 p. plus 1 appendix. (Accessed August 13, 2014, at <http://www.duluthmetals.com/i/pdf/2013-AIF.pdf>.)
- Dundas, Christopher, Baker, Vern, Osborne, Kelly, Peterson, Dean, Dee, Marvin, and Blake, H.J., 2013, Duluth Metals—Investing in hard assets—Copper, nickel and PGMs in the United States: Toronto, Ontario, Canada, Duluth Metals Ltd. corporate presentation, March, 28 p. (Accessed March 8, 2013, at http://www.duluthmetals.com/i/pdf/DM_Presentation.pdf.)
- EADS N.V., 2013, 2012 annual report: Leiden, Netherlands, EADS N.V., 56 p.
- Els, Frik, 2014, Indonesia ban rocks nickel market: mining.com, January 12. (Accessed January 13, 2014, at <http://www.mining.com/indonesia-ban-rocks-nickel-market-29788/>.)
- ERAMET Group, 2013, 2012 annual report: Paris, France, ERAMET Group, 61 p.
- ERAMET Group, 2014, Nickel outlook—March 2014: Paris, France, ERAMET Group, 28 p.
- First Quantum Minerals Ltd., 2013, 2012 annual report: Vancouver, British Columbia, Canada, First Quantum Minerals Ltd., 92 p.
- Fluor Corp., 2014, Projects—Vale Long Harbour nickel processing plant: Irving, TX, Fluor Corp. (Accessed August 21, 2014, at <http://www.fluor.com/canada/projects/projectinfopage.aspx?prjid=258>.)
- Garde, A.A., and McDonald, Iain, 2012, The remains of a gigantic, three-billion year-old meteorite impact discovered in Greenland: Copenhagen, Denmark, Geological Survey of Denmark and Greenland press release, June 28, 2 p. (Accessed April 25, 2013, via <http://www.geus.dk>.)
- Garde, A.A., Pattison, John, Kokfelt, T.F., McDonald, Iain, and Secher, Karsten, 2013, The norite belt in the Mesoproterozoic Maniitsoq structure, southern West Greenland—Conduit-type Ni-Cu mineralization in impact-triggered, mantle-derived intrusions: Geological Survey of Denmark and Greenland Bulletin, no. 28, p. 45–48. (Accessed September 23, 2013, via <http://www.geus.dk/publications/bull>.)
- General Electric Co., 2012, GE expands advanced battery manufacturing start-up, boosts investment to \$170 million; 450 new high-tech jobs in upstate New York: Schenectady, NY, GE Reports, July 10, 3 p. (Accessed March 20, 2013, at <http://www.gereports.com/ge-expands-advanced-battery-manufacturing-start-up/>.)

- General Electric Co., 2013, Durathon battery: Schenectady, NY, General Electric Co.—Ecoimagination, 3 p. (Accessed March 20, 2013, at <http://www.ecoimagination.com/portofolio/durathon-battery>.)
- Glencore International plc, 2013, Annual report—2012: Baar, Switzerland, Glencore International plc, 168 p.
- GlencoreXstrata plc, 2013, Pro forma—2012: Baar, Switzerland, GlencoreXstrata plc, May 3, 30 p.
- Gulf Chemical & Metallurgical Corp., 2011, Gulf Chemical continues to move forward with \$50 million in environmental improvements: Freeport, TX, Gulf Chemical & Metallurgical Corp. press release, April 5. (Accessed March 13, 2013, at http://www.ERAMET-gulf.com/newsPublications_pressReleasesDetail.asp?NewsPublicationsID=16.)
- Gulf Chemical & Metallurgical Corp., 2013, Spent catalyst recycling: Freeport, TX, Gulf Chemical & Metallurgical Corp. (Accessed March 12, 2013, at <http://www.ERAMET-gulf.com/SpentCatalystRecycling.asp>.)
- Gulf Chemical & Metallurgical Corp., 2014, Gulf 360° - Closing the loop: Freeport, TX, Gulf Chemical & Metallurgical Corp. diagram. (Accessed May 10, 2014, at http://www.ERAMET-gulf.com/aboutGulf_360Process.asp.)
- Highlands Pacific Ltd., 2014, Annual report—For the year ended 31 December 2013: Brisbane, Queensland, Australia, Highlands Pacific Ltd., 67 p.
- Horsehead Holding Corp., 2013, Form 10-K for the year ended December 31, 2012: U.S. Securities and Exchange Commission, 62 p. plus 2 appendices.
- Hudbay Minerals Inc., 2012, Annual information form for the year ended December 31, 2011: Toronto, Ontario, Canada, Hudbay Minerals Inc., 40 p. plus 3 schedules.
- Interfax, 2012, Shareholders of Rezhnickel, Ufaleynickel prepared to hand shares to Development Corp.: Yekaterinburg, Russia, Interfax, July 4. (Accessed April 24, 2014, at <http://www.interfax.com/newsinf.asp?id=344633>.)
- International Nickel Study Group, 2013, World nickel statistics—Yearbook: Lisbon, Portugal, International Nickel Study Group Bulletin, v. 22, no. 12, December, 4 sections (A–D).
- International Nickel Study Group, 2014, World nickel statistics—Monthly Bulletin: Lisbon, Portugal, International Nickel Study Group Bulletin, v. 23, no. 2, February, 4 sections (A–D).
- International Stainless Steel Forum, 2014a, Stainless and heat resisting steel—Crude steel production (ingot/slab equivalent), 2001 through 2013 [by region]: Brussels, Belgium, International Stainless Steel Forum. (Accessed June 10, 2014, at http://www.worldstainless.org/crude_steel_production/crude_2001_to_2010.)
- International Stainless Steel Forum, 2014b, Stainless and heat resisting steel—Crude steel production (ingot/slab equivalent), 2012 [by region and quarter]: Brussels, Belgium, International Stainless Steel Forum. (Accessed June 10, 2014, at http://www.worldstainless.org/crude_steel_production/crude_2012.)
- Jensen, Fergus, 2014, Indonesia's small miners feel betrayed by export ban; fear more layoffs, closures: Thomson Reuters, January 12. (Accessed June 20, 2014, at <http://www.reuters.com/article/2014/01/12/indonesia-minerals-miners-idUSL3NOKM01S20140112>.)
- Jensen, Fergus, and Supriatna, Yayat, 2012, Indonesia plans to limit miners' exports at 2009–10 volume: Thomson Reuters, May 11. (Accessed May 14, 2012, at <http://www.reuters.com/article/2012/05/11/indonesia-minerals-idUSL4E8GB81T20120511>.)
- Kennecott Eagle Minerals Co., 2012, Humboldt mill—Profile: Ishpeming, MI, Kennecott Eagle Minerals Co., 1 p. (Accessed March 9, 2012, at http://kennecotteagleminerals.verite.com/library/media/HumboldtMillProfile_Dec2011.pdf.)
- KGHM International Ltd., 2013, Management discussion and analysis for the year and fourth quarter ended December 31, 2012: Vancouver, British Columbia, Canada, KGHM International Ltd., March 28, 26 p. (Accessed June 12, 2014, at http://www.kghminternational.com/files/doc_financials/quarterly_reports/mda/Q4_2013_KGHMI_MDA_Final.pdf.)
- Koniambo Nickel SAS, 2014, About us—Our shareholders: Koniambo Nickel SAS. (Accessed February 14, 2014, at http://www.koniambonickel.nc/index.php?option=com_content&task=view&id=64&Itemid=116&lang=en.)
- Kosich, Dorothy, 2011, Canada's HudBay to sell Guatemala's Fenix nickel project to Russia's Solway: Mineweb.com, August 8. (Accessed August 8, 2011, via <http://www.mineweb.com>.)
- Kral, Steve, 2013, Ontario remains mining hotbed; Favorable legislation and Ring of Fire offer promising future: Mining Engineering, v. 65, no. 2, February, p. 22–28.
- León, Mariela, 2012, Gobierno asume el control de Minera Loma de Níquel [Government takes control of Minera Loma de Nickel]: El Universal [Caracas, Venezuela], November 13, 2 p. (Accessed February 14, 2014, at <http://www.eluniversal.com/economia/121113/gobierno-asume-el-control-de-minera-loma-de-niquel>.)
- Lundin Mining Corp., 2013, Eagle Mine—USA: Toronto, Ontario, Canada, Lundin Mining Corp., December, 7 p. (Accessed May 9, 2014, at <http://www.lundinmining.com/s/EagleMine.asp>.)
- Lundin Mining Corp., 2014, Annual information form for the year ended December 31, 2013: Toronto, Ontario, Canada, Lundin Mining Corp., 57 p.
- Metallurgical Corporation of China, Ltd., 2013, ENFI completes Tagaung Taung nickel mine project in Myanmar: Metallurgical Corporation of China, Ltd., March 13, 1 p. (Accessed February 14, 2014, at <http://www.mcccchina.com/ENGLISH/Print.asp?ArticleID=17128>.)
- Minnesota Minerals Coordinating Committee, 2014, 2013/2014 mineral development and exploration highlights: St. Paul, MN, Minnesota Department of Natural Resources, Division of Lands and Minerals, February. (Accessed August 13, 2014, via <http://mcc.mn.gov> or http://files.dnr.state.mn.us/lands_minerals/mpes_projects/mn_mineralhighlights_0214.pdf.)
- Mirabela Nickel Ltd., 2013, Annual report—31 December 2012: Perth, Western Australia, Australia, Mirabela Nickel Ltd., 109 p.
- Mistry, Mark, 2012, The importance of understanding material flows—The nickel perspective: International Industrial Ecology Conference, Tel Aviv, Israel, October 18, 2012, presentation, 29 p.
- Moverare, Johan, Sato, Atsushi, Hasselqvist, Magnus, Karlsson, Fredrik, and Reed, R.C., 2011, A new single crystal superalloy for power generation applications (abstract): Proceedings of the 8th International Charles Parsons Turbine Conference, Portsmouth, United Kingdom, September 5–8, 2011, p. G2–2.
- Newby, Douglas, 2012, PolyMet Mining—Copper, nickel and precious metals in the U.S.: Hoyt Lakes, MN, PolyMet Mining Corp., presentation to investors, St. Paul, MN, November 14, 23 p. (Accessed March 8, 2013, at http://www.polymetmining.com/wp-content/uploads/2013/02/PLM_Investor_Presentation_color_2012_11_14_St_Paul_Final_1_.pdf.)
- Newby, Douglas, and Knudson, Jenny, 2014, PolyMet Mining—Copper, nickel & precious metals in the U.S.: Hoyt Lakes, MN, PolyMet Mining Corp., presentation to investors, St. Paul, MN, May, 19 p. (Accessed May 7, 2014, at <http://www.polymetmining.com/wp-content/uploads/2013/02/PLM-Investor-Presentation-2014-04-no-video1.pdf>.)
- Nickel Institute, 2015, Nickel in society: Brussels, Belgium, Nickel Institute. (Accessed March 9, 2015, at <http://www.nickelinstitute.org/en/MediaCentre/Publications/NickelInSociety.aspx>.)
- Nickel Monthly, 2012, Fujian Haihe NPI project comes on stream: Beijing Antaike Information Development Co., Ltd., no. 14, June, p. 9–10.
- Nickel Monthly, 2013, China's nickel apparent consumption reaches 219.3 kt during Q3: Beijing Antaike Information Development Co., Ltd., no. 30, October, p. 5–6.
- Noront Resources Ltd., 2012a, Annual report for fiscal year ended April 30, 2012: Toronto, Ontario, Canada, Noront Resources Ltd., 62 p.
- Noront Resources Ltd., 2012b, NI 43–101 Technical report [and] feasibility study [of] McFauld's Lake property [and] Eagle's Nest project, James Bay Lowlands, Ontario, Canada: Toronto, Ontario, Canada, Micron International Ltd., October 19, 210 p.
- North American Nickel Inc., 2012, New discovery of high grade nickel copper cobalt PGM sulphide mineralization at the Maniitsoq project in Greenland: Vancouver, British Columbia, Canada, North American Nickel Inc. press release, December 3, 2012, 5 p. (Accessed April 25, 2013, via <http://www.northamericannickel.com>.)
- OA0 Mechel, 2013, Form 20–F for the fiscal year ended December 31, 2012: U.S. Securities and Exchange Commission, April 16, 326 p. plus appendices.
- OJSC MMC Norilsk Nickel, 2011, Norilsk Nickel is interested in quickest possible development of Voronezh region deposits: Moscow, Russia, OJSC MMC Norilsk Nickel press release, April 21. (Accessed January 11, 2013, at <http://www.nornik.ru/en/press/news/3232/>.)
- OJSC MMC Norilsk Nickel, 2013, Annual report—2012: Moscow, Russia, OJSC MMC Norilsk Nickel, 247 p.
- Ontario Chamber of Commerce, 2014, Beneath the surface—Uncovering the economic potential of Ontario's Ring of Fire: Toronto, Ontario, Canada, Ontario Chamber of Commerce, 35 p. (Accessed August 21, 2014, via <http://www.occ.ca>.)
- Ontario Prospector, The, 2010, The Noront McFaulds Lake project: The Ontario Prospector, v. 14, no. 2, Fall/Winter, p. 22–29.

- Outokumpu Oyj, 2013, Annual report—Our year 2012: Espoo, Finland, Outokumpu Oyj, 32 p.
- Pepin, John, 2011, Blasting begins—Tribal members visit rock: Mining Journal [Marquette, MI], October 1, 2 p. (Accessed April 2, 2012, via <http://www.miningjournal.net>.)
- Pepin, John, 2012, Mill movement—Humboldt facility restoration moves ahead: Mining Journal [Marquette, MI], January 15, 1 p. (Accessed April 2, 2012, via <http://www.miningjournal.net>.)
- PolyMet Mining Corp., 2013, Form 20-F for the fiscal year ended January 31, 2013: U.S. Securities and Exchange Commission, 120 p.
- PolyMet Mining Corp., 2014, Form 20-F for the fiscal year ended January 31, 2014: U.S. Securities and Exchange Commission, 115 p.
- Poseidon Nickel Ltd., 2013a, Annual report for the year ended 30 June 2013: Subiaco, Western Australia, Australia, Poseidon Nickel Ltd., 119 p.
- Poseidon Nickel Ltd., 2013b, The Windarra Nickel project feasibility study overview: Subiaco, Western Australia, Australia, Poseidon Nickel Ltd., September, unpaginated.
- PT Aneka Tambang Tbk., 2013, Annual report for the year 2012—Financial endurance beyond challenges: Jakarta, Indonesia, PT Aneka Tambang (Persero) Tbk., 593 p.
- PT Vale Indonesia Tbk., 2013, Annual report for the year 2012—A strategy for the long term: Jakarta, Indonesia, PT Vale Indonesia Tbk., 310 p.
- Queensland Nickel Group, The, [undated], Queensland Nickel brochure: Yabulu, Queensland, Australia, The Queensland Nickel Group, 35 p. (Accessed May 6, 2013, at <http://www.qni.com.au/about-qn/pages/overview.aspx.html>.)
- Rio Tinto Group, 2012, Annual report—2011: London, United Kingdom and Melbourne, Victoria, Australia, Rio Tinto Group, 220 p.
- Rusmininfo Ltd., 2012, Voronezh deposits [to] be developed on certain conditions: London, United Kingdom, Rusmininfo Ltd., October 2. (Accessed January 11, 2013, at <http://www.metalinfo.ru/ru/news/58863>.)
- Schwant, Robin, Shen, Chen, and Soare, Monica, 2013, New materials enable unprecedented improvement in turbine performance: Advanced Materials & Processes, January, p. 18–22.
- Sherritt International Corp., 2013, Annual report—2012: Toronto, Ontario, Canada, Sherritt International Corp., 147 p.
- Solway Investment Group Ltd., 2014, Fenix nickel project (Guatemala): Solway Investment Group Ltd. (Accessed June 16, 2014, at http://www.solwaygroup.com/itemf_19.htm.)
- Spinetto, J.P., 2012, Vale weighing nickel means iron focus—Corporate Brazil: Rio de Janeiro, Brazil, Bloomberg News, August 10, 4 p. (Accessed March 3, 2013, at <http://www.bloomberg.com/news/2012-08-10/vale-puts-nickel-on-hold-after-prices-drop-corporate-bra.html>.)
- Stillwater Mining Co., 2013, Form 10-K for the fiscal year ended December 31, 2012: U.S. Securities and Exchange Commission, 122 p. plus 1 annex.
- Swanepoel, Esmarie, 2013, Xstrata starts nickel mining in New Caledonia: Creamer Media's Mining Weekly, April 12, 1 p. (Accessed February 14, 2014, at <http://www.miningweekly.com/article/xstrata-starts-nickel-mining-in-new-caledonia-2013-04-12>.)
- ThyssenKrupp Stainless USA, LLC, 2010, Stainless steel production starts at ThyssenKrupp Stainless USA in Alabama: Calvert, AL, ThyssenKrupp Stainless USA, LLC press release, October 7. (Accessed March 15, 2013, at http://www.thyssenkrupp.com/en/presse/art_detail.html&id=TKBase_12863=8503089_1447616971.)
- ThyssenKrupp Stainless USA, LLC, 2011, Further equipment goes into operation at ThyssenKrupp Stainless USA in Alabama—Only manufacturer in NAFTA countries for stainless flat products in widths of 72 inches: Calvert, AL, ThyssenKrupp Stainless USA, LLC press release. (Accessed March 15, 2013, at http://www.thyssenkrupp.com/en/presse/art_detail.html&id=TKBase_1319526582737_1484155577.)
- ThyssenKrupp Steel USA, LLC, [undated], ThyssenKrupp Steel USA—State-of-the-art capabilities and production: Calvert, AL, ThyssenKrupp Steel USA, LLC brochure, 4 p. (Accessed March 15, 2013, at http://www.thyssenkruppsteelsusa.com/press/lib/newsletters/TKS_visitor_brochure.pdf.)
- Tinseth, Randy, 2014, Current market outlook—2014: Chicago, IL, The Boeing Co., presentation, July, 33 p. (Accessed August 21, 2014, at: http://www.boeing.com/assets/pdf/commercial/cmo/pdf/CMO_2014_Presentation.pdf.)
- U.S. Department of Energy, 2013, Energy.gov—Recovery Act recipient data: Washington, DC, U.S. Department of Energy. (Accessed March 8, 2013, via <http://energy.gov/downloads/recovery-act-recipient-data>.)
- U.S. Energy Information Administration, 2014a, Annual energy outlook 2014, with projections to 2040: Washington, DC, U.S. Energy Information Administration, U.S. Department of Energy, DOE/EIA-0383, April, 268 p.
- U.S. Energy Information Administration, 2014b, Table 1.2—Primary energy production by source, in Monthly Energy Review April 2014: Washington, DC, U.S. Energy Information Administration, U.S. Department of Energy, p. 5.
- U.S. Mint, [undated]a, 2011 America the Beautiful quarter production: Washington, DC, U.S. Mint. (Accessed March 8, 2013, at http://www.usmint.gov/about_the_mint/coin_production/index.cfm?action=production_figures&atbYear=2011#starthere.)
- U.S. Mint, [undated]b, Coin production figures: Washington, DC, U.S. Mint. (Accessed March 8, 2013, at http://www.usmint.gov/about_the_mint/?action=coin_production.)
- Vale S.A., 2011, Vale starts nickel production at Onça Puma: Rio de Janeiro, Brazil, Vale S.A. press release, March 11, 1 p. (Accessed May 7, 2012, via <http://hugin.info/144918/R/1496533/432284.pdf>.)
- Vale S.A., 2013, Form 20-F—2012: Rio de Janeiro, Brazil, Vale S.A., 166 p. plus 8 appendices.
- Vandeputte, Kurt, 2012, Key developments in rechargeable battery materials: Brussels, Belgium, Umicore, PowerPoint presentation at Capital Markets Event, Seoul, Republic of Korea, May 24, 40 p.
- Western Areas NL, 2013, Annual report—FY2013: West Perth, Western Australia, Australia, Western Areas NL, 100 p.
- Xstrata Nickel, 2012, Koniambo Nickel completes construction of first production line and readies for first molten metal by year end: Kone, New Caledonia, Xstrata Nickel press release, November 23. (Accessed March 13, 2013, at <http://www.glencore.com/assets/media/doc/news/xstrata/2012/Koniambo-Nickel-completes-construction-of-first-production-line-and-readies-for-first-molten-metal-by-year-end2.pdf>.)
- Xstrata plc, 2013a, Mineral resources & ore reserves as at 31 December 2012: Zug, Switzerland, Xstrata plc, 51 p.
- Xstrata plc, 2013b, Production report for the 12 months ended 31 December 2012: Zug, Switzerland, Xstrata plc news release, February 12, 13 p. (Accessed June 12, 2014, via <http://www.xstrata.com>.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
- Nickel. Ch. in Mineral Commodity Summaries, annual.
- Nickel. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Nickel. International Strategic Minerals Inventory Summary Report, Circular 930–D, 1985.
- Nickel. Mineral Industry Surveys, monthly.
- Nickel (Ni). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.

Other

- International Nickel Study Group (Lisbon, Portugal).
- Nickel. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
- Nickel Institute (Toronto).
- Roskill Information Services Ltd.

TABLE I
SALIENT NICKEL STATISTICS¹

(Metric tons of contained nickel unless otherwise specified)

	2008	2009	2010	2011	2012
United States:					
Secondary recovery from purchased scrap:					
From ferrous scrap	77,500	72,100	73,300	77,700 ^r	80,400
From nonferrous scrap	9,250	7,730	8,640 ^r	8,940 ^r	9,500
Shipments of purchased scrap ²	161,000	152,000	139,000	130,000 ^r	127,000
Exports:					
Primary	11,600	7,030 ^r	12,600	12,400	9,100
Secondary	94,600	90,000	80,300	64,800	59,800
Imports for consumption:					
Primary	129,000	99,900	129,000	138,000	133,000
Secondary	20,100	17,700	23,800	21,300	22,300
Consumption:					
Reported:					
Primary	103,000 ^r	83,100 ^r	98,700 ^r	107,000 ^r	110,000
Secondary, purchased scrap	86,700	79,800 ^r	81,900 ^r	86,600 ^r	89,900
Total	189,000 ^r	163,000 ^r	181,000 ^r	194,000 ^r	200,000
Apparent, primary	99,800 ^r	92,500 ^r	118,000 ^r	126,000 ^r	126,000
Apparent primary plus reported secondary	186,000 ^r	172,000 ^r	200,000 ^r	213,000 ^r	216,000
Stocks, yearend:					
Producers and traders	5,860	5,490	6,240 ^p	6,650 ^p	5,980 ^p
Consumer, primary	9,480 ^r	9,140 ^r	10,900 ^r	11,700 ^r	10,200
Consumer, secondary	6,320	5,520	6,150	6,640 ^r	6,530
Total	21,700 ^r	20,100 ^r	23,300 ^r	25,000 ^r	22,700
Price, cash, London Metal Exchange:					
Average annual dollars per metric ton	21,104	14,649	21,804	22,890	17,533
Average annual dollars per pound	9.572	6.645	9.890	10.383	7.953
Price, Type 304 stainless steel scrap, gross weight: ³					
Average annual dollars per metric ton	2,361	1,462	2,200	2,276	1,860
Average annual dollars per long ton	2,399	1,486	2,235	2,312	1,890
World, mine production	1,630,000 ^r	1,380,000 ^r	1,650,000 ^r	2,050,000 ^r	2,000,000

^pPreliminary. ^rRevised.

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

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

³Derived 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 and 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 RECOVERY¹

(Metric tons of contained nickel)

	2011	2012
Kind of scrap:		
Aluminum-base ²	1,950	2,110
Copper-base	1,270	1,210
Ferrous-base ³	77,700 ^r	80,400
Nickel-base	5,720 ^r	6,180
Total	86,600^r	89,900
Form of recovery:		
Aluminum-base alloys	1,950	2,110
Copper-base alloys	2,280	1,920
Ferrous alloys	77,800 ^r	80,600
Nickel-base alloys	4,600	5,270
Total	86,600^r	89,900

^rRevised.

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

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

³Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

TABLE 3
REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM¹

(Metric tons of contained nickel)

Form	2011 ^r	2012
Primary:		
Metal	90,500	93,000
Ferronickel	13,900	14,900
Oxide and oxide sinter ²	255	257
Chemicals ³	1,260	511
Other	969	1,230
Total	107,000	110,000
Secondary, scrap ⁴	86,600	89,900
Grand total	194,000	200,000

^rRevised.

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

²Includes chemical-grade oxide.

³Under investigation.

⁴Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4
U.S. CONSUMPTION OF NICKEL, BY USE¹

(Metric tons of contained nickel)

Use	2012							Grand total in 2011 ^r	
	Metal	Ferronickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)		
Consumption reported:									
Cast irons ²	64	--	--	--	3	67	2,060	2,130	67
Chemicals and chemical uses	1,340	--	(3)	326	--	1,670	--	1,670	951
Electric, magnet, expansion alloys	227	W	--	W	--	227	(3)	227	246
Electroplating, sales to platers	6,980	--	--	W	(3)	6,980	--	6,980	6,910
Nickel-copper and copper-nickel alloys	W	--	1	--	W	1	2,250	2,250	2,150
Other nickel and nickel alloys	17,700	81	6	--	46	17,800	W	17,800	19,000
Steel:									
Stainless and heat resisting	32,700	12,500	W	--	85	45,300	76,600	122,000	118,000
Alloys, excludes stainless	2,750	138	--	--	29	2,920	1,960	4,880	6,110
Superalloys	25,400	120	--	1	854	26,400	W	26,400	24,400
Other ⁴	5,800	1,970	250	184	211	8,410	7,050	15,500	15,500
Total	93,000	14,900	257	511	1,230	110,000	89,900	200,000	194,000

^rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

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

²Under investigation.

³Less than ½ unit.

⁴Includes 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 31¹

(Metric tons of contained nickel)

Form	2011 ^r	2012
Primary:		
Metal	8,590	8,980
Ferronickel	1,030	1,010
Oxide and oxide sinter	57	24
Chemicals ²	1,890	93
Other	107	98
Total	11,700	10,200
Secondary, scrap	6,640	6,530
Grand total	18,300	16,700

^rRevised.

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

²Under investigation.

TABLE 6
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS¹

Class	2011		2012	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	914	\$22,400	1,240	\$23,800
Ferronickel	23	630	182	5,190
Powder and flakes	1,500	61,500	1,350	54,600
Metallurgical-grade oxide ²	4,590	31,600	1,700	17,900
Chemicals: ²				
Catalysts	3,560	244,000	3,410	247,000
Salts ³	1,840	30,900	1,230	23,000
Total	12,400	391,000	9,100	372,000
Secondary:²				
Stainless steel scrap	49,200	958,000	46,800	804,000
Waste and scrap	15,600	128,000	13,000	121,000
Total	64,800	1,090,000	59,800	925,000
Grand total	77,200	1,480,000	68,900	1,300,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	253	7,520	326	10,300
Sheets, strip, foil	436	15,200	356	12,400
Tubes and pipes	202	7,240	138	2,360
Total	891	30,000	820	25,100
Alloyed, gross weight:				
Unwrought alloyed ingot	6,480	170,000	5,500	149,000
Bars, rods, profiles, wire	18,600	675,000	21,800	796,000
Sheets, strip, foil	14,300	503,000	10,700	390,000
Tubes and pipes	2,370	120,000	2,310	134,000
Other alloyed articles	3,530	370,000	3,590	366,000
Total	45,300	1,840,000	43,900	1,830,000

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

²The 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.

³Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 7
U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY¹

(Metric tons of contained nickel)²

Country	2012							Total in 2011	Wrought nickel in 2012 ⁴	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide ³	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	--	5	--	(5)	238	1	1	245	1,430	1
Belgium	--	8	--	357	56	190	319	930	798	1
Brazil	92	49	1	--	--	1	148	291	224	7
Canada	36	197	174	1,210	9,670	2,240	744	14,300	14,300	28
China	1	213	--	15	10	7,290	724	8,250	11,400	105
Colombia	65	16	--	--	--	(5)	16	97	95	62
Finland	--	--	--	--	--	450	27	477	3,090	--
France	34	4	(5)	--	1	4	39	82	112	44
Germany	(5)	209	(5)	32	338	166	197	942	2,440	85
Hong Kong	--	17	--	(5)	--	575	(5)	592	18	24
India	--	46	--	4	104	4,330	213	4,700	2,340	51
Italy	--	2	--	--	--	251	28	281	312	15
Japan	--	66	--	8	562	2,610	122	3,370	6,430	12
Korea, Republic of	(5)	58	(5)	--	9	5,660	65	5,790	6,010	54
Mexico	966	80	--	(5)	11	97	304	1,460	883	86
Netherlands	--	2	--	--	376	775	362	1,520	2,860	15
Pakistan	--	1	--	--	23	3,110	--	3,130	851	--
Singapore	13	121	--	7	47	114	83	285	1,590	39
South Africa	--	6	--	5	16	--	54	81	57	(5)
Spain	--	(5)	--	--	--	1,230	6	1,240	723	1
Sweden	--	11	--	--	308	189	--	508	448	3
Taiwan	13	25	6	(5)	22	16,200	158	16,400	15,300	45
Thailand	3	69	(5)	--	--	833	36	941	1,160	(5)
United Kingdom	3	55	--	2	975	61	226	1,320	1,410	38
Other	11	87	--	58	187	583	764	1,690	2,970 [†]	104
Total	1,240	1,350	181	1,700	13,000	46,800	4,640	68,900	77,300	820

¹Revised. -- Zero.

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

²The 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 sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.

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

⁴Excluded from "2012, total."

⁵Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY CLASS¹

Class	2011		2012	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	117,000	\$2,770,000	111,000	\$2,010,000
Ferronickel	11,700	269,000	13,000	228,000
Powder and flakes	6,530	191,000	5,210	131,000
Metallurgical-grade oxide ²	451	7,850	868	18,500
Chemicals:²				
Catalysts	1,770	105,000	1,590	111,000
Salts ³	979	21,400	952	19,100
Total	138,000	3,370,000	133,000	2,520,000
Secondary:²				
Stainless steel scrap	12,700	295,000	11,700	236,000
Waste and scrap	8,600	189,000	10,600	209,000
Total	21,300	484,000	22,300	445,000
Grand total	159,000	3,850,000	155,000	2,960,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	301	11,300	669	16,500
Sheets, strip, foil	422	16,200	600	16,700
Tubes and pipes	104	4,160	174	5,670
Total	827	31,700	1,440	38,800
Alloyed, gross weight:				
Unwrought alloyed ingot	7,780	185,000	12,200	237,000
Bars, rods, profiles, wire	10,300	331,000	11,400	344,000
Sheets, strip, foil	3,890	108,000	3,650	91,200
Tubes and pipes	1,640	89,900	1,590	91,000
Other alloyed articles	2,210	125,000	1,350	143,000
Total	25,800	840,000	30,100	906,000

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

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

³Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY¹

(Metric tons of contained nickel)²

Country	2012							Total in 2011	Wrought nickel in 2012 ⁴	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide ³	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	17,200	543	--	753	149	--	--	18,600	19,600	--
Belgium	--	105	--	25	7	1	136	274	360	--
Brazil	3,450	--	1,330	--	117	3	1	4,900	4,390	352
Canada	50,500	2,960	29	17	2,090	7,540	148	63,300	60,300 ^r	1
Colombia	--	--	4,570	--	1	6	--	4,580	3,010	--
Dominican Republic	23	--	1,890	--	--	17	--	1,930	3,580	--
Finland	9,410	50	--	--	--	--	245	9,700	9,170 ^r	--
France	843	6	766	--	1,210	--	383	3,210	2,420	237
Germany	--	151	--	(5)	543	7	357	1,060	1,120	437
Indonesia	--	--	--	--	16	1	--	17	116	--
Israel	--	12	--	--	167	10	--	189	204	(5)
Italy	--	1	--	--	144	--	--	145	104	15
Japan	455	80	--	36	633	40	199	1,440	1,180	158
Mexico	--	--	--	--	1,090	3,560	23	4,670	5,960	24
Netherlands ⁶	11	(5)	75	--	21	--	419	526	527	2
New Caledonia	--	--	2,950	--	--	--	--	2,950	3,570	--
Norway	11,200	--	52	--	--	--	--	11,200	12,100	--
Russia	16,500	382	1,290	--	32	--	--	18,200	22,500 ^r	--
South Africa	259	280	7	(5)	7	--	--	553	1,050	--
Spain	--	1	--	--	69	--	3	73	50	(5)
Taiwan	--	--	--	--	234	56	11	301	234	(5)
United Kingdom	434	572	--	32	2,670	274	171	4,150	3,380	57
Zimbabwe	412	--	--	--	--	--	--	412	324	--
Other	467	67	1	5	1,450	139	446	2,580	4,110	158
Total	111,000	5,210	13,000	868	10,600	11,700	2,540	155,000	159,000	1,440

^rRevised. -- Zero.

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

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

³Primarily oxide, rondelles, and sinter.

⁴Excluded from "2012, total."

⁵Less than ½ unit.

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

Source: U.S. Census Bureau.

TABLE 10
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY^{1,2}

(Metric tons of contained nickel)

Country and products ³	2008	2009	2010	2011	2012
Albania, laterite ore ^c	4,000 ^r	1,000 ^r	3,000 ^r	5,000 ^r	3,000
Australia, ores and concentrate ⁴	188,000 ^r	165,000	170,000 ^r	212,000 ^r	246,000
Botswana, ore milled	28,940	28,595	23,053 ^r	15,675 ^r	17,948
Brazil, ore	67,116	41,059	108,983	131,673 ^r	139,230
Burma, ore ^c	10	10	-- ^r	800 ^{r,5}	5,000 ⁵
Canada, concentrate	259,651	135,037 ^r	160,063 ^r	219,025 ^r	204,161
China ^c	79,500	84,800	80,000 ^r	90,000 ^{r,5}	93,300 ⁵
Colombia, laterite ore	64,200	72,000 ^r	70,200 ^{r,c}	70,000 ^r	84,000
Cuba:					
Recoverable laterite: ^c					
Limonitic	34,600 ^r	32,100 ^r	32,500 ^r	38,100 ^r	35,700
Serpentinic	35,800 ^r	37,900 ^r	37,200 ^r	34,400 ^r	32,500
Total	70,400 ^r	70,000 ^r	69,700 ^r	72,500 ^r	68,200
Oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor ⁶	-- ^r	-- ^r	-- ^r	-- ^r	--
Dominican Republic, laterite ore	31,300	500 ^r	--	21,693	25,590
Finland, concentrate ⁷	43,343 ^r	10,304 ^r	29,448 ^r	63,209 ^r	46,755
Greece, laterite ore	18,646	10,203	16,345	21,710	22,000
Guatemala, laterite ore	--	--	--	--	3,240 ⁸
Indonesia, laterite ore ⁹	219,300	202,800	235,800	297,000	228,000
Kazakhstan, laterite ore ^c	500	500	500	500	450
Kosovo, laterite ore ¹⁰	8,500 ^r	10,500	9,100 ^r	7,700 ^r	4,400
Macedonia, ferronickel produced ¹¹	15,026	12,000	14,413	17,292	19,427
Madagascar, laterite ore	--	--	2,000 ^r	5,900 ^r	10,000
Morocco, nickel sulfate ^c	507 ^r	733 ^r	317 ^r	217 ^r	225
New Caledonia, ore	102,700 ^r	92,500 ^r	129,800 ^r	130,700 ^r	131,700 ^c
Norway, concentrate	377	369 ^r	351 ^r	339	351
Papua New Guinea, ore	--	--	--	-- ^r	11,700 ¹²
Philippines:					
Ore	71,281 ^r	104,060 ^r	165,180 ^r	296,569 ^r	293,731
Concentrate ¹³	8,019 ^r	14,940 ^r	24,820 ^r	22,794 ^r	23,890
Total	79,300 ^r	119,000 ^r	190,000 ^r	319,363 ^r	317,621
Russia, marketable mine production:					
Laterite ore ¹⁴	47,551 ^r	32,294 ^r	41,179 ^r	41,777 ^r	28,210
Sulfide concentrate ¹⁵	229,765 ^r	229,493 ^r	228,093 ^r	225,616 ^r	217,085
Total	277,316 ^r	261,787 ^r	269,272 ^r	267,393 ^r	245,295
South Africa, concentrate	31,675	34,605	39,960 ^r	43,321 ^r	45,945
Spain, concentrate ¹⁶	8,136	8,035 ^r	6,300 ^r	--	6,300 ^p
Turkey, laterite ore ^c	1,000 ^r	800 ^r	1,400 ^r	3,000 ^r	2,400
Ukraine, laterite ore ^c	8,000 ^r	--	--	--	--
Venezuela, laterite ore	10,900 ^r	10,400 ^r	11,400 ^r	19,500 ^r	6,060
Zambia, concentrate ¹⁷	750 ^r	280 ^c	2,482 ^r	2,724 ^r	--
Zimbabwe, concentrate	6,354	4,858	6,200 ^{r,c}	7,992 ^r	7,899
Grand total	1,630,000 ^r	1,380,000 ^r	1,650,000 ^r	2,050,000 ^r	2,000,000
Of which:					
Concentrate ¹⁸	588,000 ^r	438,000 ^r	498,000 ^r	585,000 ^r	552,000
Ore and ore milled	458,000 ^r	431,000 ^r	597,000 ^r	787,000 ^r	845,000
Laterite ore	484,000 ^r	411,000 ^r	460,000 ^r	566,000 ^r	486,000
Ferronickel produced	15,000	12,000	14,400	17,300	19,400
Nickel sulfate ^c	507 ^r	733 ^r	317 ^r	217 ^r	225
Unspecified and (or) undifferentiated	79,500 ^r	84,800 ^r	80,000 ^r	90,000 ^r	93,300

^cEstimated. ^pPreliminary. ^rRevised. -- Zero.

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

²Insofar 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. Includes data available through March 2, 2015.

³North Korea may have an active nickel mine, but information is inadequate to make reliable estimates of output.

⁴Australian Bureau of Agricultural and Resource Economics (ABARE) data for mines in Western Australia and Tasmania.

TABLE 10—Continued
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY^{1,2}

³Burma's new Tagaung Taung Mine is a joint project of the Government of Burma, China's Taiyuan Iron and Steel (Group) Co., Ltd., and the China Nonferrous Metal Mining Group Co., Ltd. (CNMC). The joint venture officially began recovering laterite ore on March 27, 2011.

⁶Included in table 11 (nickel intermediate materials), but revised to zero in this table.

⁷The gross weight of concentrates processed in Finland from domestic ores was, in metric tons, as follows: 2008—43,038 (under investigation); 2009—11,413 (revised); 2010—43,151 (revised); 2011—87,974 (revised); and 2012—99,089.

⁸In 2012, Cunico Resources Group N.V. acquired Guaxilan, S.A. and began mining high-grade saprolitic ores for export to Eastern Europe. Solway Investment Group Ltd. was also active in Guatemala and began upgrading the long-dormant Fenix Mine and ferronickel plant west of El Estor.

⁹Includes a small amount of cobalt that was not recovered separately.

¹⁰On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

¹¹Cunico 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.

¹²At 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.

¹³Nickel content of concentrate produced at Rio Tuba in 2008–12 by Coral Bay Nickel Corp.

¹⁴Nickel content of ore mined in the Ural Mountains region.

¹⁵Nickel content of concentrate produced on the Kola and Taimyr Peninsulas.

¹⁶In 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.

¹⁷Albidon 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 from March to December 2009 until ramp-up problems were resolved and world nickel prices recovered.

¹⁸Includes "Russia, sulfide concentrate."

TABLE 11
NICKEL: WORLD PRODUCTION OF INTERMEDIATE PRODUCTS FOR EXPORT, BY COUNTRY^{1,2,3}

(Metric tons of contained nickel)

Country	2008	2009	2010	2011	2012
Matte:					
Australia ⁴	31,085	27,531 ^r	59,186 ^r	51,081 ^r	66,295
Botswana	28,940	27,905 ^r	25,127 ^r	28,800 ^{r,e}	24,000 ^e
Brazil ⁵	8,328	8,518	14,308	13,703 ^r	14,345 ^p
Canada ⁶	76,908	68,972	70,127	73,724	80,765 ^p
China ⁷	1,530 ^r	--	1	--	--
Finland	--	735	10,381	16,088	12,915
Indonesia ⁸	72,385 ^r	67,329 ^r	75,989 ^r	66,900 ^r	70,717
New Caledonia	13,564	13,902	13,917	13,780	13,417
Philippines	10,562	17,800	20,500	22,794	23,890
Russia ⁹	1,500 ^r	100 ^r	85 ^r	65 ^r	1
Zimbabwe ¹⁰	1,572 ^r	1,608 ^r	3,105 ^r	3,519 ^r	3,787
Total	246,000^r	234,000^r	293,000^r	290,000^{r,e}	310,000^e
Other:					
Cuba: ¹¹					
Sulfide precipitate	32,099 ^r	33,856 ^r	34,197 ^r	34,816 ^r	34,325
Ammoniacal liquor precipitate and unspecified ^c	2,500 ^r	2,400 ^r	2,400 ^r	2,400 ^r	2,300
Total^e	34,600^r	36,300^r	36,600^r	37,200^r	36,600
New Caledonia, nickel hydroxide cake	--	--	222	7,374 ^{r,12}	3,378
Papua New Guinea, mixed hydroxide product	--	--	--	--	5,283
Grand total, other	34,600^r	36,300^r	36,800^r	44,600^r	45,300

^cEstimated. ^pPreliminary. ^rRevised. -- Zero.

¹Includes data available through March 2, 2015. Data represent nickel content of matte and other intermediate materials produced.

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

³Source: International Nickel Study Group (INSG) World Nickel Statistics.

⁴Figures exclude toll-refined material. Total matte production on a contained nickel basis, in metric tons, was as follows: 2008—31,000; 2009—28,000 (revised); 2010—54,000 (revised); 2011—57,000 (revised); and 2012—66,000.

⁵Represents the output of the Fortaleza smelter. All of the Fortaleza matte is shipped to Finland for further processing.

⁶Nickel content of reported exports. Matte from the smelter at Falconbridge typically assays 55% nickel.

⁷China's 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: 2008—114,000; 2009—143,000 (revised); 2010—139,000 (revised); 2011—166,000 (revised); and 2012—170,000.

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

⁹Primarily exports to China. Sources: International Nickel Study Group (INSG); United Nations Statistics Division. The average nickel content of the exported matte is estimated to be 25%.

¹⁰Zimplats material shipped to the Impala Refinery at Springs, South Africa.

¹¹Corrected to remove coproduct cobalt.

¹²Derived from both limonitic laterite and saprolitic laterite ores.

TABLE 12
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT^{1,2}

(Metric tons of contained nickel)

Country and product ³	2008	2009	2010	2011	2012
Australia:					
Metal	89,474 ^r	123,204 ^r	92,200	97,655 ^r	115,796 ^p
Unspecified ⁴	19,441 ^r	8,006 ^r	9,400 ^r	12,558 ^r	12,963 ^p
Total	108,915 ^r	131,210 ^r	101,600 ^r	110,213 ^r	128,759 ^p
Austria, ferronickel and ferronickel molybdenum^c	500 ^r	700	600	700 ^r	800
Brazil:⁵					
Ferronickel	7,136	9,427	8,465	16,750 ^r	31,342 ^p
Metal	18,530	16,598	19,111	20,521 ^r	21,437 ^p
Total	25,666	26,025	27,576	37,271 ^r	52,779 ^p
Burma, ferronickel	--	--	--	--	(6)
Canada, unspecified⁷	167,732	116,909	105,413	142,445	139,800 ^p
China:^{e,8}					
Ferronickel and high-nickel pig iron	70,900	98,000 ^r	158,000 ^r	254,000 ^r	308,000 ^p
Metal	129,000	165,000	159,000	175,000 ^r	229,000
Chemicals and unspecified	8,000 ⁹	8,000	8,500	8,900 ^r	9,000 ^p
Total	207,900 ⁹	271,000 ^r	326,000 ^r	438,000 ^r	546,000
Colombia, ferronickel	41,636	51,802	49,443	37,817	47,408
Cuba, oxide sinter and oxides¹⁰	30,200 ^r	27,900 ^r	27,100 ^r	29,200 ^r	28,700 ^e
Dominican Republic, ferronickel	18,782	--	--	13,498	15,186
Finland:¹¹					
Metal, electrolytic, including cathode and briquettes	42,971 ^r	41,848 ^r	41,317 ^r	43,840 ^r	39,374
Chemicals and unspecified, including powder, salts, solutions, and other	6,904 ^r	4,900 ^r	7,866 ^r	7,275 ^r	6,500
Total	49,875 ^r	46,748 ^r	49,183 ^r	51,115 ^r	45,874
France:					
Metal	11,397 ^r	11,996 ^r	10,799 ^r	11,697 ^r	11,273
Chemicals	1,839 ^r	1,959 ^r	2,080	2,039 ^r	1,927
Total ¹²	13,236 ^r	13,955 ^r	12,879 ^r	13,736 ^r	13,200
Greece, ferronickel	16,650	8,269	13,956 ^r	18,527 ^r	18,632
India:¹³					
Ferronickel ¹⁴	-- ^r	-- ^r	-- ^r	-- ^r	--
Ferronickel magnesium	93	88	96 ^r	107 ^{r, e}	114 ^e
Nickel sulfate ¹⁵	-- ^r	-- ^r	-- ^r	-- ^r	--
Total	93	88	96 ^r	107 ^{r, e}	114 ^e
Indonesia, ferronickel	17,566	12,550	18,688	19,690	18,373
Japan:					
Ferronickel	59,259	54,491	64,350 ^r	62,773 ^r	73,248
Metal	34,861	29,351	40,228	41,290	41,947
Oxide sinter	61,753	58,808	59,011	50,437	52,000 ^e
Chemicals	2,333	1,669	2,497	2,383	2,362
Total	158,206	144,319	166,086 ^r	156,883 ^r	169,557
Korea, Republic of:					
Ferronickel	2,506	21,609	20,965	19,300 ^{r, e}	19,800 ^{p, e}
Metal	(16)	(16)	(16)	(16)	(16)
Total	2,506	21,609	20,965	19,300 ^{r, e}	19,800 ^{p, e}
Kosovo, ferronickel¹⁷	3,655 ^r	10,538 ^r	9,081 ^r	7,728 ^r	4,436
Macedonia, ferronickel	15,026	12,000	14,413	17,292	19,247
Madagascar, metal	--	--	--	--	5,695
Morocco, chemicals, including nickel sulfate	(18) ^r	(18) ^r	(18) ^r	(18) ^r	(18)
New Caledonia:					
Ferronickel	37,467	38,230	39,802	40,015	43,030 ^p
Nickel oxide sinter	--	--	--	--	2,353 ^p
Total	37,467	38,230	39,802	40,015	45,383 ^p
Norway, metal	88,741	88,577	92,185	92,427	91,687

See footnotes at end of table.

TABLE 12—Continued
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT^{1,2}

(Metric tons of contained nickel)

Country and product ³	2008	2009	2010	2011	2012
Russia:					
Ferronickel					
High-nickel	16,158	15,565	16,799	16,899	9,782
Other ^{e, 19}	4,910	5,130	5,140 ^r	5,090 ^r	2,940
Total, ferronickel	21,068	20,695	21,939 ^r	21,989 ^r	12,722
Metal	242,209	239,269	245,543	242,228 ^r	239,632 ^p
Chemicals	2,900	2,700	2,700	2,700	2,600
Total, Russia	266,177	262,664	270,182 ^r	266,917 ^r	254,954
South Africa:					
Ferronickel, high-nickel	4,300	630 ^r	614 ^r	575 ^r	658
Metal	29,400 ^r	34,200 ^r	34,700 ^r	35,900 ^r	30,100 ^p
Chemicals ²⁰	4,450	4,850	1,345 ^r	1,930 ^r	1,515
Total	38,150 ^r	39,680 ^r	36,659 ^r	38,405 ^r	32,273
Taiwan, metal	(16)	(16)	(16)	(16)	(16)
Ukraine, ferronickel ²¹	16,224	12,392	15,467 ^r	13,655 ^r	20,782
United Kingdom, metal ²²	40,800	17,800	31,650	37,400	34,300 ^p
Venezuela, ferronickel ^e	10,900	10,400	11,700	13,400	8,100
Zimbabwe, metal: ^e					
Refined from domestic nickel ore	3,400	--	--	--	--
Toll refined from imported nickel feed ²³	10,300	5,000 ^r	4,039 ^{r,9}	3,715 ^{r,9}	2,400
Total	13,700	5,000 ^r	4,039 ^{r,9}	3,715 ^{r,9}	2,400
Grand total	1,390,000 ^r	1,370,000 ^r	1,440,000	1,620,000 ^r	1,760,000
Of which:					
Ferronickel, including ferronickel magnesium, ferronickel molybdenum, and high-nickel pig iron	344,000 ^r	362,000 ^r	448,000 ^r	558,000 ^r	642,000
Metal	741,000 ^r	773,000 ^r	771,000 ^r	802,000 ^r	863,000
Oxide sinter	92,000 ^r	86,700 ^r	86,100 ^r	79,600 ^r	83,100
Chemicals, including nickel sulfate	11,500 ^r	11,200 ^r	8,620 ^r	9,050 ^r	8,404
Unspecified	202,000	138,000	131,000 ^r	171,000 ^r	168,000

^eEstimated. ^pPreliminary. ^rRevised. -- Zero.

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

²Includes data available through March 3, 2015.

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

⁴Class 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.

⁵Source: DNPM/DIPLAM-RAL, MDIC/SECEX (DNPM Sumário Mineral 2009—2013). Production year 2009 is under investigation. Brazil produced nickel carbonate (an intermediate product for metal production), in metric tons: 2008—18,580; 2009—16,766; 2010—30,161 (revised preliminary number); (revised preliminary number); 2011—19,381 (revised); and 2012—19,400 (estimated). Companhia Brasileira de Metalurgia e Mineração (CBMM) produced nickel niobium for sale to the superalloys industry.

⁶The Tagaung Taung nickel mine concentrating and smelting ferronickel complex is funded by China Nonferrous Metal Mining Company Group Co., Ltd. (CNMC). China ENFI Engineering Corp. (ENFI) designed the complex for an annual output of 25,000 metric tons of nickelferrite and nickel metal. The nickelferrite pelletization system was started on March 5, 2013, and proved to be stable and successfully put into operation.

⁷Nickel 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 16.

⁸Preliminary 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 nickelferrous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

⁹Reported figure.

¹⁰Cuba 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.

¹¹Most of the production is extracted from imported raw materials.

¹²Reported by ERAMET for Sandouville. Excludes secondary production from spent rechargeable batteries.

¹³India's fiscal year ending March 31 of that year stated.

TABLE 12—Continued
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT^{1,2}

¹⁴Vidarbha 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.

¹⁵In 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.

¹⁶Nickel 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: 2008—27,266 (revised); 2009—16,404 (revised); 2010—12,200 (revised); 2011—11,706 (revised); and 2012—11,000 (estimated). Taiwan: 2008—15,162 (revised); 2009—11,148 (revised); 2010—12,200 (revised); 2011—11,706 (revised); and 2012—11,700 (estimated).

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

¹⁸Nickel content of nickel sulfate is listed in table 10. 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.

¹⁹Includes ferronickel chromium and Ni-resist cast iron.

²⁰Includes nickel sulfate plus exported metal in concentrate.

²¹May include nickel in remelt alloys derived from scrap.

²²Tonnages include nickel contents of chemicals.

²³Data 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 2017

Projected year of first production	Country (state/province)	Project and company ¹	Resource grade (% nickel)	Estimated resources (thousand metric tons) ²	Annual production capacity (metric tons of contained nickel)	Nickel product
2012	Burma (Thabeikkyin, Mandalay)	Tagaung Taung ³ China Nonferrous Metal 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	Indonesia (Port of Ciwandan, Cilegon city, Banten province, Java island)	Cilegon nickel pig iron complex Nickel ore sintering plant Single blast furnace with a nickel pig iron casting capacity of 250,000 metric tons/year PT Indoferro (subsidiary of Growth Steel Group)	XX	XX	8,000	Nickel pig iron briquettes (2.25%–4.05% nickel).
2012	Madagascar (Moramanga)	Ambatovy (Ambatovy and Analamay deposits) Sherritt International Corp. (40%), Korea Resources Corp. (27.5%), Sumitomo Corp. (27.5%), and SNC-Lavalin Inc. (5%)	1.04 0.87 0.85 1.01	78,000 ⁴ 91,000 19,000 42,000	60,000	Nickel metal powder and briquettes.
2012	Papua New Guinea (Madang)	Ramu Metallurgical Corporation of China, Ltd. consortium (85%), ⁵ Highlands Pacific Ltd. (8.56%), and Mineral Resources Development Co. (6.44%)	0.93 1.07 1.04	42,000 30,000 71,000	31,000	Nickel-cobalt hydroxide.
2012	Philippines (Surigao del Norte and Surigao del Sur)	Adlay-Cagdiano-Tandawa (mine expansion) Surigao Integrated Resources Corp. (assignment from CTP Construction and Mining Corp.) and Shenzhou Mining Group Corp.	1.61 1.58	5,800 13,000	20,000	Direct shipping ore.
2012	Philippines (Zambales)	Acoje and Zambales—Stage 1 David M. Consunji, Inc. (DMCI) Holdings, Inc., ENK PLC (formerly European Nickel PLC), ⁷ and Montemina Resource Corp. (MRC) ⁹	0.93 0.96 1.08 1.18 1.22	22,000 ⁶ 16,000 ⁶ 4,800 ⁸ 24,000 ⁸ 18,000 ¹⁰	24,000	Do.
2013	New Caledonia (Northern)	Koniambo (sapolite ores)/ North Plant Société Minière du Sud Pacifique S.A. (51%) and Xstrata Nickel (49%)	2.54 2.45 2.50	21,000 54,000 83,000	60,000	Ferronickel.
2013	Philippines (Surigao del Norte and Surigao del Sur)	Taganito mine and hydrometallurgical processing plant 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%)	1.06 0.68	100,000 ¹¹ 102 ¹¹	30,000	Nickel-cobalt sulfide.
2015	Cuba (Holguin)	Las Camariocas-Yamaguey Quality Cuba S.A. (Ferroniquel S.A. and the Government of Venezuela)	1.32	110,000	21,000	Ferronickel.
2015	Indonesia (Tanjung Buli, East Halmahera, North Maluku)	East Halmahera (PT Feni Haltim) PT Antam (Persero) Tbk	2.17 2.21	9,100 ¹² 550 ¹²	27,000	Do.
2016	Philippines (Agusan del Norte)	Agata (includes Bolobolo-Karihatag and Agata South) Mindoro Resources Ltd.	0.80 0.95 1.00 1.11 1.16 1.18	680 ⁶ 13,000 ⁶ 250 ⁶ 1,700 ⁸ 540 ⁸ 29,000 ⁸	7,500 14,000	Phase I, direct shipping ore. Phase 2, nickel-cobalt hydroxide.
2016	Australia (Western Australia)	NiWest (Eucalytus, Hepi, Mt. Kilkenny, and Wanbanna) Heap leaching and solvent extraction plant GME Resources Ltd.	1.04 0.99 0.96	34,000 22,000 19,000	25,000	Metal.

See footnotes at end of table.

TABLE 13—Continued
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2017

Projected year of first production	Country (state/province)	Project and company ¹	Resource grade (% nickel)	Estimated resources (thousand metric tons) ²	Annual production capacity (metric tons of contained nickel)	Nickel product
2016	Indonesia (Southeast Sulawesi, North Konawe regency)	Mandiodo	2.12	3,200 ¹³	20,000	Ferronickel.
		PT Antam (Persero) Tbk	2.09	1,800 ¹³		
			1.49	18,300 ¹⁴		
			1.46	12,800 ¹⁴		
2016	Do.	North Konawe Jilin Horoc NonFerrous Metal Group Co., Ltd. PT Billy Indonesia, and Government of Southeast Sulawesi	1.50	100,000	20,000	Do.
2016	Do.	North Konawe nickel pig iron complex Ibris Nickel Pte. Ltd. of Singapore and Yong-Xing Alloy Material Technology Taizhou Co. Ltd. (Zhaoyang Industrial Park, Jiangsu, China) Rotary kiln electric furnace smelter with a production capacity of 600,000 metric tons/year	XX	XX	48,000	Nickel pig iron briquettes (~8.0% nickel).
2016	Philippines (Mindoro Oriental)	Mindoro I/Sabluyan (Buraboy, Kisluyan, and Shabo areas)	0.85	17,000	53,000	Metal.
		Aglubang Mining Corp. (local partner) and Intex Resources ASA	0.86	210,000		
			0.87	120,000		
2016	Philippines (Zambales)	Acoje and Zambales—Stage 2	0.98	7,100 ¹⁵	24,000	Nickel-cobalt hydroxide.
		David M. Consunji, Inc. (DMCI) Holdings, Inc., ENK PLC (formerly European Nickel PLC), ⁷ and Montemina Resource Corp. (MRC) ⁹	0.98	2,600 ¹⁵		
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	Do.
2017	Australia (Queensland)	Lucky Break (Circular Laterite and Dingo Dam)	0.82	590,000	730	Nickel carbonate. Cathode, later.
		Metallica Minerals Ltd. (50%) and Metals Finance Ltd. (50%)	0.82	48,000		
			0.75	490,000		
2017	Do.	Marlborough (Coorumburra, Slopeaway, and Whereat) ¹⁶ —Stage 1	0.99	12,000	63,000	Metal.
		Gladstone Pacific Nickel Ltd.	0.91	43,000		
			0.70	70,000		
2017	Do.	SCONI (formerly NORNICCO-Greenvale) [Bell Creek, Greenvale, Kokomo, Lucknow, and Minnamoolka deposits]	0.80	17,000	10,000	Do.
			0.58	48,000		
			0.41	24,000		
2017	Australia (Tasmania)	Barnes Hill, Mount Vulcan, and Scott's Hill	1.01	2,500	4,800	Cathode.
		Proto Resources & Investments Ltd. ¹⁷ and Metals Finance Ltd.	0.93	300		
2017	Australia (Western Australia)	Mt. Thirsty (north-northwest of Norseman)	0.60	17,000	9,000	Nickel-cobalt hydroxide intermediate.
		Barra Resources Ltd. (50%) and Conico Ltd. (formerly Fission Energy Ltd.) [50%]	0.51	15,000		
2017	Australia (junction of the Western Australian, South Australian, and Northern Territory borders)	Wingellina (high pressure acid leach project)	1.00	69,000	40,000	Nickel-cobalt hydroxide.
		Metals X Ltd. and Samsung C&T Corp.	0.97	99,000		
			0.97	16,000		
2017	Cameroon (East Province)	Mada and Nkamouna	0.68	60,000 ¹⁸	3,200	Cobalt-nickel sulfide.
		Geovic Cameroon PLC. (60%) and National Investment Corp. (40%)	0.67	21,000 ¹⁸		
			0.19	20,000 ¹⁸		
			0.59	40,000 ¹⁹		
			0.58	180,000 ¹⁹		
2017	Indonesia (Southeast Sulawesi, North Konawe regency)	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.

See footnotes at end of table.

TABLE 13—Continued
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2017

Projected year of first production	Country (state/province)	Project and company ¹	Resource grade (% nickel)	Estimated resources (thousand metric tons) ²	Annual production capacity (metric tons of contained nickel)	Nickel product
2017	New Caledonia (Nakety-Bogota)	Nakety-Bogota ²⁰	1.47	88,000 ²¹	52,000	Ore.
		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)	1.50	140,000 ²²		
2017	Philippines (Romblon)	Romblon (Sibuyan Island—Bato, Binaya-an, and Taclobo) Pelican Resources Ltd.	1.56	7,300	9,000	Direct shipping ore.
2019	Indonesia (Sulawesi)	Central Saluwesi (La Sampala) Rio Tinto Group	1.62	160,000	46,000	Nickel-cobalt hydroxide.
2019	Tanzania (Northern/Lake Victoria)	Dutwa (Ngasamo Hill and Wamangola)	0.92	110,000 ²³	9,000	Nickel-cobalt hydroxide or sulfide.
		African Eagle Resources plc	0.93	100,000 ²⁴		
			0.81	5,400 ²⁵		

Do. Ditto. XX Not applicable.

¹Company names reflect organizational structure as of March 3, 2015.

²Gross weight, dry. Rounded to no more than two significant digits and represent measured, indicated, and (or) inferred resources depending on the depending on the project. When two or more datasets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

³The new Tagaung Taung Mine is a joint project of the China Nonferrous Metal Mining (Group) Co., Ltd. (CNMC), Taiyuan Iron and Steel, and the Government of Burma. The joint venture began recovering laterite ore on March 27, 2011.

⁴Represent mineral resources of only the Ambatovy deposits. Significant additional resources are associated with the Analamay deposits, northeast of the Ambatovy mine area.

⁵Metallurgical Group Corp. of China Ltd. 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%).

⁶Limonite.

⁷In June 2010, European Nickel PLC and Rusina Mining NL merged to form ENK PLC.

⁸Saprolite.

⁹Montemina Resource Corp. (MRC) has a 60% interest in the Zambales (laterite) part of the project.

¹⁰Zambales—laterite.

¹¹Dry metric tons of limonite. Exclude saprolite resources.

¹²Proved and probable resources of nickel in saprolite, dry weight basis.

¹³Measured and indicated resources of nickel in saprolite, dry tonnage.

¹⁴Measured and indicated resources of nickel in limonite, dry tonnage.

¹⁵Acoje saprolitic rock only.

¹⁶The 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.

¹⁷Proto Resources & Investments Ltd. was also evaluating the Waite Kauri North laterite deposit near Leonora in Western Australia.

¹⁸Nkamouna deposit.

¹⁹Mada deposit—first datum is indicated resources; and second is inferred resources.

²⁰Ore would be shipped to Queensland for blending with ores from the Marlborough project and subsequent processing.

²¹Nakety only.

²²Bogota only.

²³Dutwa (Ngasamo Hill and Wamangola)—combined indicated and inferred resources.

²⁴Dutwa (Ngasamo Hill and Wamangola)—total indicated resources.

²⁵Dutwa (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 2017

Projected year of first production	Country (state/province)	Project and company ¹	Resource grade (% nickel)	Estimated resources (thousand metric tons) ²	Annual production capacity (metric tons of contained nickel)	Nickel product
2012	Canada (Quebec)	Raglan-Kikialik Xstrata Nickel (GlencoreXstrata since May 2013)	3.10	1,800	24,000	Concentrate.
2012	Finland (Lappi)	Kevitsa First Quantum Minerals Ltd.	0.29	89,000	11,000	Do.
			0.32	150,000		
			0.29	35,000		
2012	Finland (Pohiois)	Outokumpu Copper (Kylälahti mine and Luikonlahti mill) Altona Mining Ltd. ³	0.20	1,400	450	Cobalt-nickel concentrate.
			0.20	5,400		
			0.25	900		
2013	Canada (Quebec)	Nunavik (South Raglan) [Allammaq, Expo, Ivakkak, Mequillon, Mesamax, Puimajuq and TK deposits] Canadian Royalties Ltd. (controlled by Jilin Jien Nickel Industry Co., Ltd.) ⁴	0.93	560	6,800	Concentrate.
			0.93	21,000		
			0.73	5,200		
2013	China (Xinjiang Autonomous region/ East Tianshan)	Tula'ergen (Qincheng Township) Xinjiang Hami Hexin Mining Ltd.	1.10	100,000	3,000	Do.
2013	Vietnam (Son La)	Ban Phuc Asian Mineral Resources Ltd. and Son La Mechanical Engineering JSC	2.78 ⁵	730	6,600	Do.
			2.60 ⁵	960		
			1.94 ⁵	170		
			1.05 ⁶	200		
			1.23 ⁶	700		
			1.14 ⁶	400		
2014	Canada (Ontario)	Fraser Morgan Xstrata Nickel (GlencoreXstrata since May 2013)	1.94	4,400	6,000	Ore.
			1.81	2,400		
			1.70	1,800		
2014	Do.	Totten (plus new Clarabelle mill addition) Vale Canada	1.33	8,400	8,200	Concentrate.
2014	China (Gansu)	Heishan Jinchuan Group Co., Ltd.	0.60	23,000	5,000	Do.
2014	United States (Michigan)	Eagle Sold by Rio Tinto Group to Lundin Mining Corp. in July 2013	4.80	1,500	17,000	Do.
			3.10	3,300		
			1.00	49		
2015	Australia (Western Australia)	Cosmic Boy and Diggers ⁷ Western Areas Ltd.	1.46 ⁸	2,100	7,000	Do.
			2.40 ⁹	380		
			1.00 ¹⁰	10,000		
2015	Do.	Mt. Windarra and Cerberus Poseidon Nickel Ltd.	1.24	910	7,000	Do.
			1.72	3,000		
			1.51 ¹¹	4,600		
2015	Canada (Ontario)	Onaping Depth Xstrata Nickel (GlencoreXstrata since May 2013)	2.67	15,000	10,000	Do.
			3.60	1,200		
2015	Canada (Quebec)	Raglan-Qakimajurg Xstrata Nickel (GlencoreXstrata since May 2013)	4.52	2,500	11,000	Do.
2015	United States (Minnesota)	NorthMet PolyMet Mining Corp. and Glencore International AG	0.08	213,000	7,100	Concentrate, initially.
			0.07	590,000		Byproduct nickel-cobalt hydroxide, later.
			0.07	260,000		
2016	Canada (Manitoba)	Minago Victory Nickel Inc.	0.56	11,000	11,000	Concentrate.
			0.51	43,000		
			0.53	15,000		
2016	Canada (Ontario)	Eagle's Nest-McFaulds Lake Noront Resources Ltd. and Baosteel Resources International Co., Ltd.	2.08	5,400	15,000	Do.
			1.50	5,600		
			1.10	9,000		
			0.31	1,600 ¹²		

See footnotes at end of table.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2017

Projected year of first production	Country (state/province)	Project and company ¹	Resource grade (% nickel)	Estimated resources (thousand metric tons) ²	Annual production capacity (metric tons of contained nickel)	Nickel product
2016	Canada (Quebec)	Dumont	0.29	360,000	49,000	Ferronickel.
		Royal Nickel Corp.	0.26	1,300,000		
			0.26	510,000		
2016	Russia (Amur)	Kun-Manie (Ikensoe, Maly Krumkon, and Vodorazdelny)	0.61	3,700	16,000	Concentrate.
		Amur Minerals Corp.	0.48	48,000		
			0.54	17,000		
2017	Australia (Western Australia)	New Morning/Daybreak	3.70 ⁵	320	3,000	Ore.
		Western Areas NL	3.50 ⁵	93		
			0.90 ⁶	1,100		
			0.90 ⁶	660		
2017	Do.	Radio Hill (conventional heap leaching)	0.61	2,000	7,400	Nickel-copper concentrate.
		Fox Resources Ltd.	0.42	2,000		
2017	Botswana (Selebi-Phikwe region)	Dikoloti The Japan Oil, Gas and Metals National Corp. (81%) and Discovery Metals Ltd. (19%)	0.70	4,100	2,000	Nickel-cobalt sulfide.
2017	Canada (British Columbia)	Turnagain	0.22	230,000	24,000	Concentrate.
		Hard Creek Nickel Corp.	0.21	640,000		
			0.20	980,000		
2017	Canada (Manitoba)	Makwa (formerly Maskwa)	0.61	7,200	3,600	Do.
		Mustang Minerals Corp. ¹³	0.27	700		
2017	Canada (Ontario)	Hart	1.40	1,500	9,000	Do.
		Liberty Mines Inc. [Jilin Jien Nickel Industry Co., Ltd. (60%)]	1.27	320		
2017	Do.	Kenbridge (open pit)	0.43	3,300	3,900	Do.
		Canadian Arrow Mines Ltd.	0.38	1,100		
2017	Canada (Sudbury)	Copper Cliff Mine (merger and expansion) (formerly Copper Cliff Deep project) Vale Canada	1.15	130,000	NA	Ore.
2017	Canada (Yukon Territory)	Wellgreen Wellgreen Platinum Ltd. (formerly Prophecy Platinum Corp.)	0.31	450,000	14,000	Concentrate.
2017	Finland (Oulu)	Kuhmo (Arola, Hietaharju, Peura-aho, Sika-aho, and Vaara) Altona Mining Ltd. ³ and Polar Mining Oy	0.55 ¹⁴	6,000	3,000	Do.
2017	Russia (Kola Peninsula)	Vuruchuaivench (10 kilometers southwest of Monchegorsk) MMC Norilsk Nickel-Kola MMC	0.23	17,500	NA	Metal.
2017	Russia (Taimyr Peninsula)	Maslovsky (Butter) Russian Platinum Co. (in late 2012 and 2013 ownership of the deposit was contested by MMC Norilsk Nickel-Polar Division)	0.33	728,000	18,000	Concentrate.
2017	Tanzania (Kagera region)	Kabanga	2.49	14,000	40,000	Concentrate.
		Barrick Gold Corp. (50%) and Xstrata Nickel (50%)	2.72	23,000		
			2.24	19,000		
2017	Tanzania (Lindi and Mtwara regions)	Nachingwea Regional Exploration Project, including Ntaka Hill Nickel Sulphide Project	0.58	20,000 ¹⁵	25,000	Do.
		IMX Resources Ltd. and MMG Exploation Holdings Ltd. ¹⁶	0.66	36,000		
2017	United States (Minnesota)	Nokomis/Maturi Extension	0.20 ¹⁷	550,000	19,000	Byproduct nickel-cobalt sulfide or hydroxide.
		Birch Lake, Maturi, Spruce Road	0.21 ¹⁷	270,000		
		Twin Metals Minnesota LLC ¹⁸ [Duluth Metals Ltd. (60%) and Antofagasta PLC (40%)]	0.17 ¹⁹	180,000		
			0.16 ¹⁹	40,000		
			0.25 ²⁰	120,000		
		0.21 ²¹	120,000			

See footnotes at end of table.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2017

Do. Ditto. NA Not available.

¹Company names reflect organizational structure as of March 25, 2015. 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.

²Gross weight, dry. Rounded to no more than two significant digits and represent measured, indicated, and (or) inferred resources depending on the project. When two or more datasets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

³Altona Mining Ltd. was created when Universal Resources Ltd. merged with Vulcan Resources Ltd. in February 2010.

⁴On 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.

⁵Massive sulfides.

⁶Disseminated sulfides.

⁷Includes Diggers Rocks, Diggers South, Purple Haze, and Seagull resources.

⁸Diggers areas—probable ore reserves.

⁹Cosmic Boy area—indicated resources.

¹⁰Diggers areas—indicated resources.

¹¹Cerberus deposit.

¹²Inferred resources of East zone.

¹³Mustang Minerals Corp. was also evaluating the potential of resources at the nearby Mayville property.

¹⁴Kuhmo project area—total indicated and inferred resources.

¹⁵Measured and indicated resources.

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

¹⁷Nokomis deposit—indicated and inferred resources.

¹⁸In March 2011, Twin Metals Minnesota LLC (TMM) acquired Franconia Minerals Corp., doubling the project's mineral and land assets.

¹⁹Birch Lake deposit—indicated and inferred resources.

²⁰Maturi deposit resource.

²¹Spruce Road open pit resource.

Sources: Australian Mines Atlas 2011; Canadian Minerals Yearbook 2012; company annual reports, presentations, and press releases; CRU International, Ltd., and the International Nickel Study Group.