



# 2009 Minerals Yearbook

NICKEL

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The global recession of 2007–09 led to a dramatic drop in nickel mine production. World mine production slid from an alltime high of 1.67 million metric tons (Mt) of contained nickel in 2007 to 1.40 Mt in 2009. The London Metal Exchange (LME) cash mean for nickel metal began plummeting in the spring of 2008 as the global recession continued. By December 2008, the monthly cash mean had dropped to \$9,682 per metric ton—a price level not seen since 2003. At the same time, stocks of nickel metal began to build up in LME-sanctioned warehouses and totaled 78,822 metric tons (t) at the beginning of 2009. The buildup of LME stocks continued during the year and reached an alltime high of 158,424 t at yearend 2009. The monthly cash mean slowly recovered in the second half of 2009 as the economy began to regain strength and, despite the record stock buildup, ended 2009 at \$17,061 per metric ton. Increased imports of nickel by Chinese consumers and speculative buying by hedge funds helped support the price recovery.

The recession affected almost every sector of the nickel market owing to the global nature of the economic downturn and financial crisis. Primary nickel use started to recover worldwide as stainless steel production increased during the second half of 2009. Stainless steel continued to account for more than 60% of primary nickel consumption in the world (Nickel Institute, 2011). China was the leading consumer of primary nickel in 2009 and also the leading producer of stainless steel. The European Union (EU) was the second ranked producer of stainless steel. On a global basis, nonferrous alloys accounted for about 12% of primary nickel use, followed by electroplating and other surface finishing, with 11%.

Reported nickel consumption (primary plus secondary) in the United States decreased by 13% compared with that of 2008. Stainless steel comprised only 39% of U.S. primary consumption, a relatively low percentage compared with similar economically developed countries. The low percentage for the United States was a reflection of the large number of specialty metal industries and a readily available supply of stainless steel scrap.

Global nickel consumption increased by an average of 0.7% per year from 2003 to 2009, despite the recession. The gain was largely fueled by strong economic growth in China and increased use of stainless steel in India. The year-on-year growth rate for global stainless steel usage declined by 8.1% (revised) in 2008, and then decreased by an additional 1.6% in 2009 (Vale S.A., 2010b, p. 3–5; International Nickel Study Group, 2011, p. A1–A11).

The global recession dampened acquisitions and mergers of nickel producers in most parts of the world, with some exceptions. In South Africa, Aquarius Platinum Ltd. acquired Ridge Mining plc and subsequently took over management of the Sheba's Ridge project—a nickel and platinum-group

elements (PGE) property on the eastern limb of the Bushveld Complex. In Australia, Universal Resources Ltd. and Vulcan Resources Ltd. merged to form Altona Mining Ltd. In early 2010, Altona took over management of the shuttered Hautalampi nickel-copper-cobalt mine along with the Kuhmo and Kylylahti copper-nickel projects—all in eastern Finland. Chinese companies continued to acquire mining interests throughout the world and signed offtake agreements with the owners of nickel mines in Australia, Burma, Canada, Turkey, and Zambia.

## Legislation and Government Programs

**Government Stimulus Programs.**—In February, Congress passed the American Recovery and Reinvestment Act of 2009 (Public Law 111–5). The Act allocated \$32.7 billion for upgrading the Nation's energy infrastructure and reducing petroleum consumption in the transportation sector. The \$32.7 billion included \$3.4 billion for clean coal technology and related fossil energy programs, \$2.0 billion for advanced battery manufacturing grants, and \$1.64 billion to double the Nation's supply of renewable energy and boost domestic manufacturing of renewable energy generating equipment. The Act approved more than \$467 million to accelerate the development and use of geothermal and solar energy throughout the United States and also provided \$93 million for wind energy projects (U.S. Department of Energy, 2009a, b). The eligibility dates of special tax credits were extended to encourage construction of advanced power stations designed to capture and transform solar, tidal, or wind energy into electricity and (or) thermal energy (U.S. Internal Revenue Service, 2009). These clean energy programs were expected to spur nickel consumption because design engineers commonly specify austenitic stainless steel, duplex stainless steels, or nickel-based superalloys for critical components in many of the energy-capture or electrical-generating subsystems.

At the State level, a variety of supplemental programs were launched to help accelerate the adoption of clean energy technologies while reducing unemployment. Several State governments already had renewable energy programs in place to encourage contractors to build more energy efficient residential and commercial buildings. At least 32 of the 50 States had some form of solar power rebates, incentives, or tax credits (Valenza, Hahn, and Llorens, 2011). Some States, like Michigan, offered sizable tax credits to companies that agreed to build state-of-the-art facilities for manufacturing advanced batteries. Four major battery suppliers decided to participate in the Michigan program and build batteries for motor vehicle propulsion, giving the suppliers a role in the Federal Government's electric vehicle deployment initiative (Dow Chemical Co., The, 2009; Kim, 2009). The four companies were: A123 Systems Inc., Dow Kokam JV, Johnson Controls-Saft Advanced Power Solutions

LLC, and LG Chem Ltd. Several of the newer electric vehicles used proprietary lithium-ion batteries that contained significant amounts of cobalt and nickel.

**Federal Power Generation Programs.**—The Recovery Act also set aside funds for the development of innovative, low-cost technology that would help existing power generating stations comply with increasingly stringent environmental regulations. For more than a decade, the U.S. Department of Energy (DOE) has supported long-term research designed to reduce greenhouse gas emissions from coal-fired powerplants. At least 80 U.S. coal-fired powerplants have reached or are approaching their life expectancy and cannot be economically retrofitted with existing carbon-capture technology. Austenitic stainless steel and nickel-bearing superalloys would be needed to construct replacement powerplants that operate on natural gas, nuclear energy, or renewable energy. Nickel-base superalloys are expected to play an important role in reducing greenhouse gas emissions from the first generation of advanced coal-fired powerplants. The turbines and boilers of an advanced coal-fired plant would have to operate at significantly higher temperatures and pressures than those at conventional powerplants. The alloys used to fabricate the turbines would have to withstand the rigors of ultra-supercritical (USC) steam. Operation of an advanced USC steam plant should raise the efficiency of the coal combustion process to between 45% and 60% at 650 °C to 760 °C, compared with only 37% for the conventional steam plant. The National Energy Technology Laboratory in Albany, OR, has been evaluating a variety of nickel-base alloys suitable for USC steam turbines, including Inconel 617 (55% nickel), Inconel 718 (52.5% nickel), and Nimonic 90 (55.5% nickel) (Holcomb, 2008).

The use of nickel-bearing steels and superalloys in solar applications is discussed in the Consumption section of this review.

**New U.S. Coinage.**—In April, the U.S. Mint suspended production of the Jefferson nickel (25% nickel by weight) and the Roosevelt dime (8.33% nickel) for the remainder of 2009. As the economy slowed, Americans began exchanging accumulated coins for paper currency, causing coin stocks to build up far above normal levels at the Federal Reserve Bank. At the same time, the need for coins at local retail banks declined because of fewer transactions. As a result, circulating coin production decreased dramatically to a 45-year low. The Mint's operations in Denver and Philadelphia produced a total of only 86.64 million Jefferson nickels and 146.0 million Roosevelt dimes in 2009, down from 640.56 million nickels and 1,050.5 million dimes in 2008 (U.S. Mint, undated b).

The highly successful 50 State Quarters™ Program ended in December 2008. Because of the popularity and budgetary benefits of the program, the U.S. Congress approved the Mint's request to extend the program and honor the District of Columbia and five U.S. Territories on the 2009 quarters. Again, minting was limited because of the recession. The U.S. Mint produced only 636.2 million of the commemorative quarters in 2009, down from 2,538.8 million in 2008. Each coin weighed 5.67 grams (g) and contained 8.33% nickel; thus 300 metric tons (t) of nickel was used in the six commemoratives released in 2009 (U.S. Mint, undated a, b).

In 2009, the U.S. Mint produced 71.26 million Native American dollar coins. The dollar coin contained 2.0% nickel and weighed 8.1 g. The Mint also produced 352 million Presidential dollar coins in 2009. The composition and weight of the new coin were identical to those of the Native American coin. The combined production of dollar coins in 2009 required 69 t of nickel (U.S. Mint, undated b, c).

## Production

**Exploration and Development.**—**Alaska.**—Several companies were actively exploring for copper, nickel, and platinum-group elements (PGEs) in southern Alaska. In late 2008, Pacific North West Capital Corp. (PFN) and Stillwater Mining Co. terminated their joint-exploration venture in the Goodnews Bay—Platinum area, 200 kilometers (km) south of Bethel. Since then, PFN has focused part of its exploration efforts on its wholly owned Tonsina property in the Chugach Mountains, northeast of Valdez. At Tonsina, nickel, copper, and PGE sulfide mineralization occurs with chromite in a dunite-rich, serpentinized ultramafic complex (Pacific North West Capital Corp., 2011).

**Michigan.**—In February, Kennecott Eagle Minerals Co. slowed development of its Eagle copper-nickel mine near Big Bay because of declining nickel prices. Kennecott officials, however, continued to work on permitting and litigation issues tied to the project (Pepin, 2009). In early 2010, the Michigan Department of Environmental Quality (MDEQ) formally approved the permits needed to begin construction of the \$300 million underground mine (Michigan Department of Environmental Quality, 2010).

At yearend 2009, Kennecott decided to move ahead with the project. Site preparation work was scheduled to begin in April 2010 (Pepin, 2010). Ore would be trucked from the 49-hectare mine site to a renovated mill at the defunct Humboldt iron ore mine near Champion, where the copper-nickel sulfides would be concentrated. The concentrates would then be railed to Ontario, Canada, for smelting. Kennecott had purchased the Humboldt mill in September 2008 and began cleaning up the site. The mill, idle since the mid-1990s, had fallen into disrepair and would cost about \$80 million to renovate (Kennecott Eagle Minerals Co., 2009).

**Minnesota.**—PolyMet Mining Corp. (Vancouver, British Columbia, Canada) was preparing to mine the NorthMet ore body—a copper-nickel-PGE deposit in the Duluth Complex—pending approval from the State of Minnesota. In November, the Minnesota Department of Natural Resources released the revised draft environmental impact statement (EIS) for public comment 1 year later than originally envisioned. At yearend, the various Federal and State lead agencies were analyzing comments and recommendations from the public so that the environmental review and permitting process could be completed (PolyMet Mining Corp, 2010).

The NorthMet 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 0.08% nickel. Ore from the proposed NorthMet open pit would be shipped to the reconditioned Cliffs Erie mill near Hoyt Lakes, MN, for crushing, grinding, and subsequent flotation. The concentrate

would be processed at the Erie site in a new hydrometallurgical plant to produce copper cathode, nickel-cobalt hydroxide, and a precious-metals precipitate. In November, PolyMet agreed to sell \$25 million worth of common stock to Glencore International AG (Baar, Switzerland). The \$25 million would be used primarily to fund construction of the NorthMet Mine and make modifications to the existing Erie processing facility, which is 10 km away from the mine site (PolyMet Mining Corp., 2009).

Duluth Metals Ltd. (Toronto, Ontario, Canada), Franconia Minerals Corp. (Spokane, WA), and Teck American Inc. (Spokane) continued to actively evaluate other disseminated sulfide deposits in the Duluth Complex (Minnesota Minerals Coordinating Committee, 2011). In October, Duluth Metals released updated resource figures for its Nokomis deposit, northeast of Birch Lake. The new NI 43-101 estimate includes 550 Mt of indicated resources averaging 0.64% copper and 0.20% nickel plus 274 Mt of inferred resources grading 0.63% copper and 0.21% nickel (Duluth Metals Ltd., 2009). At the beginning of 2010, Duluth Metals announced that it had formed a joint venture with Antofagasta Plc (London, United Kingdom) to develop the Nokomis property. Antofagasta, a leading copper producer, would own 40% of the new venture—Twin Metals Minnesota LLC—and would initially provide \$130 million to the project. Duluth Metals would own the remaining 60% (Duluth Metals Ltd., 2010, p. 3).

**Byproduct Production.**—The United States had no active nickel mines in 2009. Except for limited quantities of byproduct nickel that were recovered at some copper and precious metal refineries, imports and recycling met all needs. In 2009, Stillwater Mining Co. (majority owned by OJSC MMC Norilsk Nickel) shipped 388 t of nickel in crystalline sulfate, down from 423 t in 2008. Stillwater mined PGE ore in Montana's Beartooth Mountains. The company's two mills (East Boulder and Nye) together processed 1.07 Mt of ore and subgrade material. Concentrates from the two mills were trucked to the company's smelting and refining complex at Columbus, MT, where a PGE filter cake and byproduct crystalline nickel sulfate containing minor amounts of cobalt were produced. In May, Stillwater completed construction of a second electric smelting furnace at Columbus, which would allow Stillwater to continue processing concentrates during scheduled maintenance shutdowns (Stillwater Mining Co., 2010, p. 6–13, 20–21, 46–47).

Freeport-McMoRan Copper & Gold Inc. (New Orleans, LA) has produced byproduct nickel carbonate at its El Paso, TX, copper refinery since 2004 (Freeport-McMoRan Copper & Gold Inc., 2011, p. 26).

No ferronickel was produced in the United States in 2009 from either domestic or imported ores. Almost all U.S. ferronickel exports were either re-exports or material upgraded for specialty purposes. The steel industry accounted for virtually all the ferronickel consumed in 2009, with more than 98% used in stainless and heat-resistant steels.

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

ferronickel. In December, Horsehead Holding Corp. (Pittsburgh, PA) purchased the Ellwood City facility from Vale for \$34 million. One of Horsehead's subsidiaries is a leading recycler of electric arc furnace (EAF) dust, a secondary material captured in the bag house of the Ellwood City furnace (PRNewswire—FirstCall, 2010).

Gulf Chemical and 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 in 2009. The Freeport facility can treat nickel-molybdenum and cobalt-molybdenum hydrotreating catalysts that have been "poisoned" by nickel and vanadium tied up in porphyrins and other organometallic molecules of crude oil. Gulf Chemical first roasts and leaches the catalysts to recover the molybdenum and vanadium. The byproduct nickel-and-alumina residue is then converted to a crude, but marketable nickel-cobalt alloy in a DC EAF (Gulf Chemical and Metallurgical Corp., 2011).

## Consumption

U.S. apparent consumption of primary nickel was 93,200 t, or about 7% of world consumption. U.S. industry reported consumption of an additional 79,800 t of nickel in scrap. On the basis of U.S. reported consumption, the share of primary nickel consumed in the production of stainless and alloy steels was 46%, up from 43% in 2008.

The estimated value of apparent primary nickel consumption in the United States was \$1.37 billion, down from \$2.43 billion in 2008. Apparent primary consumption decreased by 19% from 115,000 t (revised). The sharp decrease in the value of primary consumption resulted from a 31% decrease in the LME cash price, which may have temporarily spurred usage and stocking. Apparent primary consumption plus reported secondary consumption totaled 173,000 t (table 1).

**Stainless Steel and Low-Alloy Steels.**—In 2009, stainless steel producers accounted for 39% of apparent primary nickel consumption in the United States (table 4) and more than 60% of primary consumption in the world. Production of raw stainless steel and heat-resisting steel in the United States totaled 1.62 Mt in 2009, down by 16% from 1.93 Mt in 2008. Nickel-bearing grades accounted for 1.16 Mt, or 71% of total stainless steel production (American Iron and Steel Institute, 2010a, p. 72–73; b).

The meltshop of North American Stainless (NAS) in Ghent, KY, produced 682,000 t of stainless steel slabs—4% less than that of 2008. NAS was able to maintain its leading position in the flat products market in spite of the global economic crisis (Acerinox, S.A., 2010, p. 24–25, 177–179).

ThyssenKrupp Steel USA, LLC and ThyssenKrupp Stainless USA, LLC have been constructing a \$3.7 billion carbon and stainless steel processing facility at Calvert, AL, since late 2007. Total investment was expected to exceed \$5.0 billion by 2011. The 1,400-hectare (3,500-acre) facility would include a hot strip mill for processing 3 Mt/yr of carbon steel slab from Brazil and would be capable of producing 4.1 Mt/yr of carbon steel end products. The facility would also have a stainless steel meltshop capable of producing up to 1 Mt/yr of stainless steel slabs. The stainless slabs would be rolled at the new hot strip

mill. The ThyssenKrupp project managers chose the greenfield site in Mobile County in part because of its proximity to the Port of Mobile and the Gulf of Mexico. The Brazilian slab would be shipped from Sepetiba Bay, Santa Cruz, in the State of Rio de Janeiro, to Mobile and then transported up the Tombigbee River to the company's river terminal. The first units of the steelmaking complex were expected to come onstream in December 2010. The startup of the stainless steel meltshop was scheduled for December 2012. The meltshop would have a 160-t EAF, a 180-t AOD converter, and a 1,900-millimeter (72-inch) continuous caster (ThyssenKrupp AG, 2010a, b).

**Superalloys and Related Nickel-Based Alloys.**—Of the primary nickel consumed in the United States, approximately 14% was used to make high-performance superalloys and related nickel-based alloys for the aerospace, electric power, and petrochemical industries. Flat or declining sales to manufacturers of jet aircraft engines and other sectors of the aerospace industry were offset by a sharp rise in sales to the electrical energy and defense sectors.

Since 2007, U.S. aerospace sales have steadily increased in the military aircraft, space, and missile sectors of the industry. Civil aircraft sales, in contrast, were less robust in terms of constant dollars. In 2007, civil aircraft sales plateaued at \$42.93 billion, then dropped to \$37.95 billion in 2008 but partially recovered to \$39.30 billion in 2009. A number of factors affected civil sales, including the global economy, the price of jet fuel, environmental regulations, and the availability of aircraft financing (Aerospace Industries Association, 2010, p. 1–4, 8; Blakey, 2010). Shipments of U.S. manufactured civil jet transport increased from 375 in 2008 to 502 in 2009. The end of the 2008 work stoppage at The Boeing Co. accounted for a large part of the 34% increase (Boeing Company, The, 2010). On a global basis, Airbus and Boeing, the two leading manufacturers of large jet transport, delivered a total of 979 commercial aircraft in 2009, compared with 858 in 2008.

In September 2009, Allegheny Technologies Inc. (ATI) signed a 10-year sourcing agreement with Rolls-Royce plc. (London, United Kingdom). ATI agreed to supply Rolls-Royce with nickel-base superalloys suitable for commercial jet engine applications. ATI has had a similar long-term sourcing agreement with General Electric Aviation since January 2007 (Allegheny Technologies Inc., 2009; 2011, p. F25). Rolls-Royce manufactures gas turbines that power jet aircraft, ships, and electrical generators. Each engine blade of the gas turbine is a single crystal of nickel alloy that has been structurally grown in a vacuum furnace, using a ceramic cast (Rolls-Royce plc, 2011, p. 10–11).

**Nickel-Based Batteries and Hybrid Electric Vehicles.**—U.S. demand for nickel in rechargeable batteries continued to increase. In 2009, most of the newer hybrid electric vehicles (HEVs) on U.S. highways used nickel-metal hydride (NiMH) batteries to store the energy recovered from the vehicle's regenerative braking circuitry—a system that reduces overall fuel consumption. 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. For example, each of the four models of the Toyota Prius 2010 was equipped with a 1.4-kilowatt-hour (kWh) NiMH battery pack

manufactured by Panasonic Electric Vehicle JV (Voelcker, 2010). Cobasys (Orion, MI) was the principal North American manufacturer supplying NiMH battery systems for HEV applications. Ovonic Battery Company, Inc. (Auburn Hills, MI), the inventor and developer of the NiMH battery, had joint ventures, licensing agreements, or other strategic alliances with at least 39 battery manufacturers worldwide.

The battery market remains highly competitive and a variety of lithium ion (Li-ion) and lithium phosphate batteries have begun making inroads against the standard NiMH design. Toyota has been evaluating a Li-ion battery that has a trimetal electrode composed of cobalt, nickel, and manganese. In December, Toyota began manufacturing 500 Prius plug-in hybrids for a long-term test program. The plug-ins reportedly use a first generation Li-ion battery manufactured by Panasonic (Hybrid & Electric Vehicle Progress, 2011, p. 1–3; Ng, 2009).

**Nickel Use in the Renewable Energy Industry.**—Solar-generated power currently meets less than 1% of U.S. electrical demand but is expected to grow tenfold during the next 10 years (U.S. Energy Information Administration, 2011, table ES1). One type of solar powerplant uses mirrors to concentrate sunlight onto piping filled with molten salt or an equivalent heat transfer fluid. The pipes, tubing, valves, and vessels in the molten salt part of the system are frequently fabricated from S31600 stainless steel to minimize corrosion from the circulating salt (Wong and Coates, 2010).

In 2009, Nevada Solar One, near Boulder City, NV, was the third-ranked concentrating solar powerplant in the world. The 64-MW plant, which uses 18,240 concentrator tubes and covers 160 hectares, has since been overshadowed by larger facilities under construction in California and Spain. In August, eSolar, Inc. commissioned its 5-MW Sierra Sun Tower at Lancaster, CA. The eSolar facility was the only operating solar tower powerplant in the United States. At yearend 2009, Abengoa was planning to build two large solar power stations in the United States—one in Arizona (the 280-MW Solana project) and one in California (the 250-MW Mojave Solar project) (Abengoa Solar, S.A., 2010, p. 13, 22).

Stainless steel is also used to make heat exchangers and hot water tanks for thermo-solar systems. The U.S. Army recently installed a solar-powered, 210-kW (kilowatt) hot water system at its Brooke Medical Center in Fort Sam Houston, TX. The 420-square-meter (m<sup>2</sup>), roof-mounted collector system provides hot water at 104 °C for showers and for heating buildings. PepsiCo uses solar energy to generate both steam and electricity at its Frito-Lay food processing facility in Modesto, CA. A collector system of parabolic troughs produces hot, pressurized water, which is then converted to steam. The steam, in turn, heats the cooking oil used to fry the plant's potato and corn chips (Frito-Lay North America, Inc., 2010; Abengoa Solar, S.A., 2011a, b).

## Stocks

On January 1, 2009, stocks in LME warehouses worldwide totaled 78,822 t. LME stocks had been slowly building up from an alltime (end-of-month) low of 3,366 t in January 2007. The stock buildup temporarily plateaued during the second quarter of 2009 but began increasing again in August, reaching 158,424 t

on December 31. Data collected by the International Nickel Study Group indicated that, at yearend 2009, world nickel producers (excluding those in Austria, China, Macedonia, Serbia, and the Ural region of Russia) had an additional 89,000 t of primary nickel stocks. About 72%, or 64,400 t, of the producer stocks was class I material (refined products with a nickel content of 99% or greater), which included, in order of decreasing quantity, electrolytic cathode, briquets, pellets, powder, and rondelles. The remaining 28% was class II material (products with a nickel content of less than 99%), which included ferronickel, oxide sinter, and East Asian utility nickel. All stocks in LME warehouses were class I (International Nickel Study Group, 2010, p. A1–A2, A7–A8). In comparison, at yearend, U.S. consumer stocks of primary nickel totaled 8,500 t, 7% less than the 9,180 t (revised) in stock at yearend 2008 (tables 1, 5).

## Prices

The January 2009 average cash price for 99.8%-pure metal on the LME was \$11,302 per metric ton (\$5.127 per pound). Nickel prices weakened slightly in the first quarter, bottoming at \$9,693 per ton (\$4.397 per pound) in March, but then slowly began to rise. The average price for June was \$14,956 per ton (\$6.784 per pound). Prices continued to rise during the second half of 2009. The monthly average for December was \$17,061 per ton (\$7.739 per pound), about 1.5 times greater than that of January. The annual average LME price was \$14,649 per ton (\$6.645 per pound)—31% less than the 2008 average (as posted by the LME and published in Platts Metals Week).

## World Review

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

In 2009, world use of primary nickel was reported to be 1.24 Mt, down by 11% from the alltime high of 1.40 Mt in 2006 (International Nickel Study Group, 2010, p. A–5). A few nickel producers continued to operate at full capacity, but others cut back production and slowed development or postponed projects because of the decline in nickel prices. A prolonged labor dispute crippled Vale Inco's mining and smelting operations in eastern Canada. Global demand, in contrast, continued to be buoyed by upward spiraling apparent consumption in China, which had risen to 472,000 t in 2009 from 66,800 t in 2000. The Chinese stainless steel industry continued to expand and used a record high 340,000 t of primary nickel in 2009. The Chinese stainless steel industry overtook that of the EU in 2009 to become the leading consumer of primary nickel. The steel industry of the EU consumed 174,000 t of primary nickel in 2009, while the Japanese steel industry was in third place with 79,900 t (Eramet Group, 2010, p. 32–44).

Production of raw stainless steel (excluding production in China, the Commonwealth of Independent States, and Eastern Europe) had been increasing at a compound annual growth rate of 4.8% since 1950. That rate includes the recession period when production decreased from 20.8 Mt in 2007 to 18.9 Mt in 2008 and then to 16.1 Mt in 2009 (Vale S.A., 2010b, p. 4). According to the International Stainless Steel Forum (2011), stainless steel production for the entire world declined to 24.6 Mt in 2009 (preliminary) from 25.9 Mt in 2008 and 27.8 Mt in 2007.

**Albania.**—Balkan Resources Inc. (Montreal, Quebec, Canada) was managing the Devolli-Kokogllave-Zemblak project near Korca. The 50-50 joint project with European Nickel PLC (London, United Kingdom) was at the prefeasibility stage of development. The joint venture (Devolli Resources, sh.p.k.) planned to develop European Nickel's Devolli deposit and Balkan Resources' Kokogllave and Zemblak deposits as a single mining operation if the project proved economically feasible. The three licensed areas cover a total of 51 square kilometers and contain at least 102 Mt of lateritic ore grading 1.2% nickel. The Devolli deposit has two components—the Kapshtica West area, which contains 13.7 Mt of inferred resources grading 1.21% nickel, and the Verniku area, with 21.9 Mt grading 1.19% nickel (Balkan Resources Inc., 2010; European Nickel PLC, 2010) (table 13).

**Australia.**—Australia was the third ranked nickel-producing country in the world. Seven companies in Western Australia reported producing salable nickel in 2009. One other company, plus two of the seven, trucked sulfide ore to BHP Billiton's concentrator at Kambalda for further processing [Department of Mines and Petroleum (Western Australia), 2010, p. 38–40]. In February, OZ Minerals Ltd. (Melbourne, Victoria) placed its Avebury Mine in Tasmania on care-and-maintenance status because of deteriorating nickel prices. Avebury remained closed for the remainder of 2009.

**Laterite Operations.**—In December 2008, BHP Billiton suspended production at its newly constructed Ravensthorpe mining and processing complex, northwest of Esperance in Western Australia. The \$2.09 billion complex was designed to recover up to 50,000 metric tons per year (t/yr) of contained nickel and 1,400 t/yr of cobalt in the form of a nickel-cobalt hydroxide precipitate. The mixed hydroxide precipitate was initially sent to the company's Yabulu refinery in Queensland for further processing, but the shipments of precipitate were halted because of concerns about profitability. The Yabulu refinery continued to process laterite ores purchased from third party mines in Indonesia, New Caledonia, and the Philippines as its main feedstocks. In July, BHP Billiton sold the Yabulu refinery to an Australian entrepreneur for an undisclosed amount of money (Keenan, 2009). In 2009, the Yabulu refinery produced about 35,000 t of nickel in compacts (a product similar to rondelles) averaging 98.5% nickel or greater (BHP Billiton, 2009, p. 34–36, 53, 108, 113, 165).

In the second half of 2009, First Quantum Minerals Ltd. approached BHP Billiton and offered to buy the Ravensthorpe complex for \$340 million. Engineers for First Quantum thought that the plant was capable of producing between

28,000 and 39,000 t/yr of nickel metal if \$150 million worth of modifications were made to the front end of the complex. BHP Billiton agreed to sell and the transaction was closed in February 2010. Recommissioning was scheduled for late 2011. The three laterite deposits at Ravensthorpe—Halley's, Hale-Bopp, and Shoemaker-Levy—have 235 Mt of combined reserves grading 0.67% nickel (First Quantum Minerals Ltd., 2009; 2010a; b, p. 9–12).

The Murrin Murrin joint venture near Leonora used sulfuric acid to leach nickel and cobalt from lateritic ores in high temperature, high-pressure autoclaves. The laterite mining and processing operation produced 32,977 t of nickel, up by 8% from 30,514 t produced in 2008. Murrin Murrin was jointly owned by Minara Resources Ltd. (60% interest) and Glenmurrin Pty. Ltd. (a subsidiary of Glencore) (40%). Nickel production was higher in 2009 than in 2008, but ore grades were slightly lower. In 2009, Murrin Murrin mined 1.64 Mt (dry) of ore grading 1.29% nickel and 0.104% cobalt. Minara was in the process of installing a sixth reduction autoclave at the Murrin Murrin refinery. A new \$1.7 million autoclave was scheduled to be commissioned in late 2010 (Minara Resources Ltd., 2010, p. 6, 16, 19).

**Sulfide Operations.**—*Tasmania.*—In February, OZ Minerals stopped hauling ore and put its new Avebury Mine near Zeehan on indefinite care-and-maintenance status. In June, China Minmetals Corp. (Beijing, China) acquired the mine and mill when Minmetals bought OZ Minerals for \$1.39 billion. A new Australian company, Minerals and Metals Group Ltd., was created to manage all of the assets of OZ Minerals, including Avebury. The Avebury mill, commissioned in August 2008, was designed to produce about 8,500 t/yr of contained nickel in concentrate (OZ Minerals Ltd., 2008; China Minmetals Corp., 2009).

*Western Australia.*—In 2009, BHP Billiton's Nickel West produced 66,300 t of metal briquettes and powder at Kwinana from concentrates smelted at Kalgoorlie. Kwinana also produced several intermediate products, including cobalt-nickel sulfide, copper sulfide, and ammonium sulfate. Nickel West was the third ranked producer of nickel-in-concentrate in the world.

The Kalgoorlie smelter produced about 28,200 t of nickel in finished matte for export. The matte typically contains 68% nickel. About one-third of the concentrate came from the Mount Keith Mine in the Northern Goldfields region. The remaining two-thirds came from Leinster and third party mines at Kambalda. Nickel West continued to expand its Mount Keith operation and was reevaluating the undeveloped Yakabindie deposit, 25 km south of Mount Keith. About 15% of the nickel ores at Mount Keith contain excessive levels of talc. In September, contractors began constructing a magnesium oxide flotation circuit at Mount Keith designed to separate the talc from the pentlandite concentrate, producing a marketable coproduct (BHP Billiton, 2010, p. 34–36).

In 2009, Norilsk Nickel International produced 1,223 t of nickel in concentrates at its Lake Johnston sulfide flotation plant. The concentrates were produced from ores mined at its nearby Emily Ann and Maggie Hays underground workings or from ores supplied on a toll basis by Western Areas NL. Norilsk Nickel International also operated the Black Swan-Silver

Swan mining complex and the Waterloo underground mine. In late 2008, Norilsk Nickel International had placed its Silver Swan and Waterloo Mines on care-and-maintenance status. In February 2009, Norilsk's Australian subsidiary also placed its Black Swan and Lake Johnson Mines on care-and-maintenance status. All four mines were still closed at the beginning of 2010 (OJSC MMC Norilsk Nickel, 2010, p. 52–55, 62).

Western Areas NL commissioned its high-grade Flying Fox Mine at Forresteria in late 2008 and was constructing a second high-grade mine, Spotted Quoll, in the district. The two mines reportedly have a combined 3.94 Mt of resources grading 5.3% nickel. The Tim King open pit at Spotted Quoll was scheduled to begin production in June 2010. Development of the underground portion of Spotted Quoll was scheduled to begin in March 2011 (Department of Mines and Petroleum [Western Australia], 2010, p. 38; Western Areas NL, 2010, p. 4–16, 19).

In November 2008, production was suspended at more than eight other Western Australian mines because of deteriorating nickel prices. Some of these mines resumed production in fiscal year 2009–10. This second set of active mines included the Carnilya Hill, Mariners, McMahon, Miitel, and Otter Juan Mines (Mincor Resources NL), the Cosmos, Tapinos, and Sinclair Mines (Xstrata Nickel Australasia Pty. Ltd.), the Lanfranchi and Savannah Mines (Panoramic Resources Ltd.), and the Lounge Lizard Mine (Kagara Ltd.) (Department of Mines and Petroleum [Western Australia], 2010, p. 38–40).

**Brazil.**—Three companies mined nickel ore in Brazil in 2009—Anglo American Brasil Ltda., Cia. de Nickel do Brasil, and Grupo Votorantim. Four major mining and (or) metallurgical processing complexes were under construction—the Barro Alto ferronickel smelter and refinery in Goiás State (Anglo American plc), the Niquelandia ferronickel smelter in Goiás State (Votorantim Metais), the Onca Puma mining and ferronickel complex in Pará State (Vale Inco Ltd.), and the Santa Rita Mine in Bahia State (Mirabela Nickel Ltd.).

Votorantim Metais was the leading producer of electrolytic nickel in Latin America and operated a nickel-cobalt refinery in São Miguel Paulista, São Paulo State, capable of producing 23,000 t/yr of electrolytic nickel and 1,420 t/yr of electrolytic cobalt. The São Miguel Paulista refinery used intermediate nickel carbonate from the company's operation in Niquelandia for feed. The electrolytic nickel was 99.9% pure and was registered on the LME. Votorantim's sulfide smelter at Fortaleza de Minas, Minas Gerais State, produced an estimated 9,500 t of nickel in matte in 2009, primarily for export to Finland, up from 8,328 t (revised) in 2008 (Da Silva, 2010). The matte typically assays 50% to 55% nickel, 7% to 12% copper, and 0.14% to 1% cobalt (Votorantim Metais, 2008).

In August, Mirabela Nickel Ltd. (Perth, Australia) began mining at its Santa Rita project near Ipiáu, Bahia. The crushing, grinding, and concentrating complex was commissioned in October. When rampup is completed in 2010, Santa Rita was projected to produce 27,000 t/yr of nickel in sulfide concentrate. Mirabela expected to ship 50% of the concentrate produced at Santa Rita to Norilsk Nickel's Harjavalta smelter in Finland for further processing. The remaining 50% would be trucked 1,350 km to the Fortaleza smelter in Minas Gerais. Santa Rita reportedly had 15 Mt of proven reserves averaging 0.65%

nickel and 106 Mt of probable reserves grading 0.59% nickel (Mirabela Nickel Ltd., 2009, p. 2–8, 12–13).

**Burma.**—China Nonferrous Metal Mining Group (CNMC) was in charge of developing the Tagaung Taung (Dagongshan) laterite mine in Thabeikkyn township, Mandalay Division. CNMC began a feasibility study of the \$800 million project in mid-2004 and was given approval to proceed in 2007 by the National Development & Reform Commission of China. The Government of Myanmar was a partner in the project and has issued the required investment and mining permits. Tagaung Taung is a 12-km by 18-km massif that rises 750 meters (m) above the lower terraces of the Ayeyawaddy River. The massif is composed largely of serpentized harzburgite (orthopyroxene peridotite) and dunite (olivine peridotite). The laterite deposit reportedly has 70 Mt of ore grading 2.0% nickel. Construction of the mining and smelting complex began in December. The mine was scheduled to be commissioned in mid-2011. The adjacent smelter would be capable of producing 22,000 t/yr of nickel in ferronickel averaging 26% nickel. All the ferronickel would be shipped to Chinese stainless steel producers. Power for the smelter would come from the Shweli Hydel project in Nam Khan Township, Northern Shan State (China Business News, 2010; Government of Myanmar, Ministry of Mining, 2011).

**Canada.—Manitoba.**—Vale Inco's operations at Thompson produced 28,800 t of refined nickel in 2009 from ores extracted from the Birchtree and Thompson Mines. The Thompson Mine extracted 1.27 Mt of ore grading 1.98% nickel, while the Birchtree Mine extracted 769,000 t grading 1.48% nickel (Vale S.A., 2010a, p. 32–36).

In February, Crowflight Minerals Inc. shipped the first nickel concentrates from its new Bucko Lake Mine near Wabowden. By June, Bucko Lake was operating at greater than 60% of mill capacity. In November, Crowflight suspended all mining and milling operations for 3 months so that key improvements and upgrades could be made to the operation. The mine produced 627 t of nickel in concentrate in 2009 and resumed milling in March 2010. All of the concentrate was processed at Xstrata's Falconbridge smelting complex in Ontario (Crowflight Minerals Inc., 2010, p. 1–9).

**Newfoundland and Labrador.**—The Ovoid Mine at Vale Inco's Voisey's Bay operation extracted 990,000 t of ore grading 3.20% nickel and 2.57% copper. The mined tonnage yielded 39,700 t of finished nickel, down from a record 77,500 t in 2008 (Vale S.A., 2010a, p. 34–35). A prolonged labor dispute that began in August and continued into 2010 was responsible for the 49% decrease in production of concentrate. Vale Inco shipped the high-grade nickel concentrate produced at Voisey's Bay to Sudbury and Thompson for smelting and downstream processing.

**Ontario.**—Sudbury has been the largest nickel-producing district in Canada since the discovery of the first ore body in 1883. Vale Inco's Ontario Division was the leading nickel producer despite a prolonged strike that began in July. The division produced only 43,600 t of finished nickel in 2009 on an ore-source basis, compared with 85,300 t in 2008 and 70,700 t in 2007. The division had six mines operating in 2009, the largest being the Stobie in terms of gross tonnage, followed by the Coleman. Part of the refined nickel was recovered from

intermediate nickel oxide at the division's Clydach refinery in the United Kingdom (Vale S.A., 2010a, p. 32–36).

Vale Inco continued to develop its new \$450 million Totten Mine despite the ongoing strike. The new mine could be operational by the end of 2011 (Tollinsky, 2009).

Xstrata, Sudbury's other principal producer, mined 716,000 t of ore with an average grade of 1.31% nickel and 2.08% copper (Xstrata plc, 2010b, p. 7). Xstrata's smelter at Falconbridge produced 65,889 t of nickel in matte, which was shipped to the company's Nikkelverk operations in Norway for refining. Xstrata's new Nickel Rim South Mine, which opened in 2009, offset declining production from the Craig, Fraser, and Thayer-Lindsley operations. Xstrata halted all mining operations at Thayer-Lindsley in January 2009 because the mine was an older, higher cost operation in a depressed nickel market and was approaching the end of its productive life (Xstrata plc, 2008a, b).

In late 2008, FNX Mining Co. Inc. began cutting back nickel mining operations at the Levack Complex on the north rim of the Sudbury Basin. Because of the decline in nickel prices, the company decided that the contact nickel deposits at the Levack Mine could no longer be economically mined. At yearend 2008, FNX suspended nickel ore production at the adjacent McCreedy West Mine. In 2009, FNX focused its efforts on mining copper-precious metal ores from the Rob's deposit at Levack, the 700 and PM deposits at McCreedy West, and the 2000 deposit at the Podolsky Mine. Because of this shift in strategy, FNX's payable nickel production in 2009 was only 1,990 t, compared with 5,940 t in 2008 (FNX Mining Co. Inc., 2010, p. 7–15).

Xstrata mined 209,000 t of ore averaging 1.02% nickel at its Montcalm Mine near Timmins and treated 226,000 t of ore at the company's Kidd mill, where 1,961 t of nickel in concentrate was recovered (Xstrata plc, 2010b, p. 7).

In June 2009, Noront Resources Ltd. (Toronto) discovered additional nickel-copper-PGE mineralization at its Eagle One deposit in the McFaulds Lake District. The district is located in the James Bay Lowlands, in the far northwestern corner of Ontario, where infrastructure is minimal. The original discovery of copper-nickel sulfides at the Eagle One site in August 2007 accelerated an exploration rush north of the Albany River that led to the identification of two massive chromite zones and a variety of nonferrous metal targets in and around a large ultramafic intrusion—the Ring of Fire (53° N latitude, 86° W longitude). At yearend 2009, Eagle One (later renamed Eagle's Nest) had 6.9 Mt of indicated resources averaging 2.04% nickel and 0.95% copper (Noront Resources Ltd., 2010; 2011; Schwartz, 2010).

**Quebec.**—Xstrata's Raglan Mine in northern Quebec produced 29,262 t of nickel in concentrate, which was 13% greater than the 25,873 t recovered in 2008 (Xstrata plc, 2010b, p. 7).

**China.**—According to the China Nonferrous Metals Industry Association, China produced 165,000 t of electrolytic nickel in 2009, up 28% from 129,000 t in 2008. Electrolytic nickel from Jinchuan Non-ferrous Metals Corp. (JNMC) accounted for 131,000 t, or 79% of the national total. JNMC operated the Yongchang mining complex at Jinchang in Gansu Province



(Copper & Nickel Monthly, 2010, p. 22–24). Jilin Jien Nickel Industry Co., Ltd. produced about 8,500 t of nickel in salts, metal, and matte in 2009. Jilin Jien had two operations in Jilin Province plus the Siziwngqi Mine in Inner Mongolia. Xinjiang Xinxin Mining Industry Co., Ltd. and at least four other companies also produced primary nickel in China during 2009.

Chinese consumption of primary forms of nickel continued to escalate and was estimated to have reached 472,000 t in 2009, which was 35% greater than that of 2008 (Eramet Group, 2010, p. 43). The Chinese stainless steel industry accounted for 72% of the country's primary nickel consumption. China was the world's leading stainless-steel-producing country in 2009, with a crude stainless steel output of 9.55 Mt, 35% greater than the 7.09 Mt in 2008. Chinese production of stainless steel resumed its upward growth in 2009 after registering a decline the previous year for the first time in more than a decade. Chinese production of stainless steel has been growing at an average annual rate of 37% since 1999. Four companies—the Baosteel Group, Lianzhong Iron and Steel Co. (LISCO), Taiyuan Iron & Steel (Group) Co., Ltd. (TISCO), and Zhangjiagang Pohang Stainless Steel Co. Ltd. (ZPSS)—accounted for about 60% of the country's stainless steel meltshop production (Vale S.A., 2010b, p. 4, 16).

Since 2001, China had consumed more stainless steel annually than any other country. In 2009, China consumed 8.54 Mt of stainless steel, about 41% of the world total and a tonnage larger than the total consumption of Japan, the United States, and Western Europe combined. Chinese imports of stainless steel had been declining since 2006 but rose slightly in 2009 to 1.29 Mt. Exports slipped to 0.897 Mt in 2008 and declined even further in 2009 to 0.660 Mt (Vale S.A., 2010b, p. 4, 6, 12, 16, A37–A38).

China has a large electroplating industry and a number of rechargeable battery manufacturers that use nickel. China's plating industry accounted for about 13% of the country's primary nickel demand in 2009, while battery manufacturers consumed about 5% (Copper & Nickel Monthly, 2010, p. 9–13, 33–35; Eramet Group, 2010, p. 43).

In 2008, China's stainless steel producers used relatively inexpensive nickeliferous pig iron (NPI), typically grading 4% to 6% nickel, as a substitute for ferronickel and scrap. Most NPI producers halted production in 2009 because of declining demand. The market price for NPI was very close to production costs. A few companies in Jiangsu and Shandong Provinces, however, remained open because of low transport costs and their proximity to key seaports. Three NPI operations in Jiangsu Province reported sales in 2009: Boruite (a 200-t/yr blast furnace operation producing 5% nickel NPI), Huaibei (a 2,160-t/yr EAF operation producing 14.5% nickel NPI), and Jinxiang (a 960-t/yr EAF operation producing 12% nickel NPI) (Copper & Nickel Monthly, 2010, p. 22–24).

**Finland.**—Talvivaara Mining Co. Plc (Espoo) began heap bioleaching on a commercial scale in July 2008. The company produced its first metal sulfide precipitates from the leach solution in October 2008 and delivered its first shipment of mixed nickel-cobalt sulfide to Norilsk Nickel Harjavalta Oy in February 2009 (Talvivaara Mining Co. Plc., 2009, p. 24–27).

**Indonesia.**—PT Aneka Tambang Tbk. (Antam) cut back production of saprolite ore when purchases from NPI producers in China began to decline. The state-owned company mined 5.85 Mt (wet) of various laterite ores, down from the alltime high of 7.11 Mt in 2007. About 83% of the production was direct shipping ore for export—primarily to China, Eastern Europe, and Japan. Antam produced only 12,550 t of nickel in ferronickel, down from 17,566 t in 2008. 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., 2010, p. 54–55, 76–77).

PT Inco mined 3.60 Mt of ore averaging 2.02% nickel from its Pomalaa and Sorowako concessions on Sulawesi. The production figure represents the amount of product delivered to the company's smelter from its adjoining dryer kilns. The smelter produced 68,800 t of nickel in matte for export to Japan, up from 68,300 t in 2008. Vale has a 59% interest in PT Inco (Vale S.A., 2010a, p. 33–35).

**Korea, Republic of.**—In late 2008, Société du Nickel de Nouvelle-Calédonie et Corée (SNNC) commissioned a ferronickel plant at Gwangyang, adjacent to the stainless steel operations of Pohang Iron and Steel Co. Ltd. (POSCO). By October 2009, the plant was operating close to design capacity—30,000 t/yr of nickel in ferronickel shot averaging 17% to 18% nickel. SNNC is a joint venture of Société Minière du Sud Pacifique (SMSP) (51%) and POSCO (49%).

**Madagascar.**—The Ambatovy project passed a number of key milestones in 2009. At yearend, engineering was 98% complete and construction was almost two-thirds complete. The Ambatovy project is built around the Sherritt hydrometallurgical process for recovering nickel and cobalt from lateritic ores. The Ambatovy ore would be piped 220 km from the mining area to the processing plant as a water-based slurry. The ore would be treated with sulfuric acid in autoclaves operating at elevated temperatures and pressures to dissolve the nickel and cobalt. The metal-rich solution is recovered by countercurrent decantation washing and treated to produce a mixed sulfide intermediate. The mixed sulfide intermediate will be dissolved, producing a concentrated solution of nickel and cobalt, which are separated by solvent extraction (Sherritt International Corp., 2010 a, p. 11–16; b, p. 2.)

**New Caledonia.**—Société Le Nickel (a subsidiary of Eramet) produced 38,229 t of nickel in ferronickel at its Doniambo smelter. The smelter also produced 13,902 t of nickel in matte, which was shipped to Eramet's Sandouville refinery in France for conversion into LME-grade metal and chemicals (International Nickel Study Group, 2010).

In 2009, Vale Inco Nouvelle-Calédonie SAS (formerly named Goro Nickel SAS) began conducting performance tests in stages at its new Grand Sud hydrometallurgical plant. Performance testing of the autoclaves was scheduled to begin in February 2010. The \$4.3 billion mining and processing complex was expected to have a production capacity of 60,000 t/yr of nickel in intermediate product (Vale S.A., 2010a, p. 32–34).

SMSP and its joint-venture partner, Xstrata, were developing the saprolitic portion of the Koniambo laterite deposit near Kone in the Northern Province. The metallurgical plant was

being constructed in modules in China, with the first module scheduled to arrive in the summer of 2010. The plant would be capable of producing 60,000 t/yr of nickel in ferronickel (Xstrata plc, 2010a, p. 14, 50, 82).

**Russia.**—About 82% of Norilsk's sales of marketable nickel came from its Russian operations. The other 18% was generated by the company's holdings in Australia, Botswana, Finland, and South Africa. Norilsk's operations on the Kola and Taimyr Peninsulas had a combined output of 232,813 t of nickel metal—about 89% of Russia's primary nickel output for the year. Norilsk's two Arctic subsidiaries exported almost all of their nickel production; only about 10,000 t, or less than 5%, was sold to Russian consumers (OJSC MMC Norilsk Nickel, 2010, p. 52–62).

OAo Mechel (Moscow) owned and operated the Southern Urals ferronickel smelter in Orenburg Oblast and the two laterite mines—Buruktal and Sakahara—that supplied the operation. Mechel produced 15,565 t of nickel in low-iron ferronickel in 2009. The bulk of the production was shipped to the ports of Kaliningrad and St. Petersburg for export to the EU. The remainder was used to make stainless steel at Mechel's stainless steel plant at Chelyabinsk (OAo Mechel, 2010, p. 99–107).

## Outlook

U.S. nickel consumers will probably be dependent on foreign sources of refined metal and ferronickel for at least the next 25 years. The ongoing expansion of nickel laterite mining operations in Brazil, Indonesia, New Caledonia, and other tropical countries will help meet the increasing demand for nickel worldwide. The nickel output from Vale's state-of-the-art leach facility at Goro in New Caledonia is expected to satisfy the near-term rise in global demand projected after 2010. Long-range forecasts of growing usage in Asia have encouraged parastatal companies in China to fund the development of greenfield laterite mines in Burma, Papua New Guinea, and Turkey. European and North American companies were seriously considering funding large-scale laterite projects in Cameroon, Guatemala, and the Philippines. Ongoing political unrest in Côte d'Ivoire, however, discouraged development of the Biankouma and Sipilou deposits.

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

Producers and consumers of nickel are optimistic about the long-term outlook for the metal. Unprecedented urbanization, especially in Brazil, China, India, Russia, and other emerging nations, should help spur nickel consumption, particularly in industries that manufacture chemicals, cutlery, food service equipment, home appliances, and kitchen utensils.

A number of environmental scientists and climatologists have expressed concerns about global warming and associated climate changes. Some researchers have stated that carbon

emissions must be reduced by approximately 80% by the year 2050 to avoid a 2 °C increase in global warming. Many older coal-fired powerplants—worldwide—would have to be retired to accomplish this reduction. Global demand for electricity, however, continues to increase. To meet demand, the power industry will have to build many more generating stations—stations that either operate on renewable energy (geothermal, solar, or wind) or are designed to better utilize uranium or thorium (safer, fourth generation nuclear reactors) (Kirsch, 2009). Development of advanced USC coal-fired plants would also help. All of this construction would require large tonnages of nickel-bearing stainless steel and superalloys (Wong and Coates, 2010).

Consumption of nickel in the transportation sector is expected to increase, but at a slower rate than in the past. European and North American usage of nickel- and cobalt-base superalloys was expected to escalate between 2013 and 2017, largely because of increasing demand for new jet aircraft. The Boeing Co. and Airbus S.A.S. both have a large backlog of jet-aircraft orders (Boeing Co., The, 2010). Some energy analysts have predicted that world crude oil production may peak a decade earlier than predicted—perhaps as soon as 2014 (Nashawi, Malallah, and Al-Bisharah, 2010). Significantly higher gasoline prices could encourage the replacement of conventional automobile steel frames with lighter ones fabricated from stronger stainless steel. The burgeoning development of renewable energy sources was expected to accelerate research on cost-effective, more advanced batteries, especially for automobiles and remote power stations.

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

(Metric tons of contained nickel unless otherwise specified)

	2005	2006	2007	2008	2009
United States:					
Secondary recovery from purchased scrap:					
From ferrous scrap	89,700	94,000	89,700	76,100	72,000
From nonferrous scrap	8,820	9,360 <sup>r</sup>	9,220 <sup>r</sup>	9,140 <sup>r</sup>	7,720
Shipments of purchased scrap <sup>2</sup>	139,000	142,000	186,000	160,000	152,000
Exports:					
Primary	7,630	8,050	13,100	11,600	7,030
Secondary	55,600 <sup>r</sup>	59,300	103,000	94,600	90,000
Imports for consumption:					
Primary	143,000	153,000	125,000	129,000	99,900
Secondary	15,500	20,300	16,200	20,100 <sup>r</sup>	17,700
Consumption:					
Reported:					
Primary	100,000	101,000 <sup>r</sup>	101,000	102,000	83,600
Secondary, purchased scrap <sup>3</sup>	98,500	103,000	98,900	85,200	79,800
Total	199,000	205,000 <sup>r</sup>	200,000	187,000 <sup>r</sup>	163,000
Apparent:					
Primary	135,000	144,000 <sup>r</sup>	112,000	115,000	93,200
Secondary	57,800	64,300	6,950 <sup>r,4</sup>	12,400 <sup>r</sup>	8,260
Total	193,000	208,000	119,000	128,000	101,000
Apparent primary plus reported secondary	233,000 <sup>r</sup>	247,000	211,000	200,000	173,000
Stocks, yearend:					
Producers and traders	5,940	6,450	5,690	5,860	6,150
Consumer, primary	6,970	7,670 <sup>r</sup>	7,450 <sup>r</sup>	9,180 <sup>r</sup>	8,500
Consumer, secondary	6,210 <sup>r</sup>	6,420 <sup>r</sup>	11,700	9,990 <sup>r</sup>	9,260
Total	19,100 <sup>r</sup>	20,500	24,800	25,000	23,900
Price, cash, London Metal Exchange:					
Average annual           dollars per metric ton	14,738	24,244	37,216	21,104	14,649
Average annual           dollars per pound	6.685	10.997	16.881	9.572	6.645
Price, 18/8 stainless steel scrap, 304, gross weight: <sup>5</sup>					
Average annual           dollars per metric ton	1,445	2,057	2,952	2,361	1,462
Average annual           dollars per long ton	1,468	2,090	2,999	2,399	1,486
World, mine production	1,460,000 <sup>r</sup>	1,570,000	1,670,000 <sup>r</sup>	1,560,000 <sup>r</sup>	1,400,000

<sup>r</sup>Revised.

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

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

<sup>3</sup>More clearly delineates the amount consumed than does apparent consumption.

<sup>4</sup>The significant decrease in secondary apparent consumption reflects increased exports of scrap to China and Taiwan.

<sup>5</sup>Derived from the average of the Friday consumer buying price range for 18% chromium, 8% nickel scrap in bundles, solids, and clips, Pittsburgh, PA, in American Metal Market (AMM). On November 1, 2006, AMM began reporting prices for Type 316 solids & clips and has changed its listing for 18/8 bundles, solids & clips to Type 304 solids & clips.

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

(Metric tons of contained nickel)

	2008	2009
Kind of scrap:		
Aluminum-base <sup>2</sup>	2,080 <sup>r</sup>	1,580
Copper-base	1,610	1,160
Ferrous-base <sup>3</sup>	76,100	72,000
Nickel-base	5,460 <sup>r</sup>	4,990
Total	85,200	79,800
Form of recovery:		
Aluminum-base alloys	2,080 <sup>r</sup>	1,580
Copper-base alloys	2,560 <sup>r</sup>	1,780
Ferrous alloys	76,100	72,100
Nickel-base alloys	4,470	4,280
Total	85,200	79,800

<sup>r</sup>Revised.

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

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

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

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

(Metric tons of contained nickel)

Form	2008	2009
Primary:		
Metal	88,600	72,500
Ferronickel	11,200 <sup>r</sup>	9,130
Oxide and oxide sinter <sup>2</sup>	216 <sup>r</sup>	148
Chemicals	783 <sup>r</sup>	864
Other	1,360	935
Total	102,000	83,600
Secondary, scrap <sup>3</sup>	85,200	79,800
Grand total	187,000 <sup>r</sup>	163,000

<sup>r</sup>Revised.

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

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

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

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

(Metric tons of contained nickel)

Use	2009							Grand total	Grand total in 2008
	Metal	Ferronickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)		
Consumption reported:									
Cast irons <sup>2</sup>	56	--	--	--	W	56	149	205	232 <sup>r</sup>
Chemicals and chemical uses	1,090	--	--	653	--	1,740	--	1,740	844
Electric, magnet, expansion alloys	140	--	--	--	--	140	1	141	189 <sup>r</sup>
Electroplating, sales to platers	11,500	--	--	44	W	11,500	--	11,500	9,560 <sup>r</sup>
Nickel-copper and copper-nickel alloys	689	--	W	--	14	703	1,890	2,600	4,930 <sup>r</sup>
Other nickel and nickel alloys	16,000	W	W	--	52	16,100	3,810	19,900	22,200 <sup>r</sup>
Steel:									
Stainless and heat resistant	24,200	8,470	W	--	306	32,900	70,800	104,000	110,400 <sup>r</sup>
Alloys, excludes stainless	5,280	400	W	--	W	5,680	619	6,300	8,680 <sup>r</sup>
Superalloys	11,500	W	--	W	311	11,800	236	12,000	22,900 <sup>r</sup>
Other <sup>3</sup>	2,060	260	148	167	252	2,890	2,290	5,180	7,400 <sup>r</sup>
Total	72,500	9,130	148	864	935	83,600	79,800	163,000	187,000 <sup>r</sup>
Consumption, apparent	XX	XX	XX	XX	XX	93,200	8,260	101,000	128,000 <sup>r</sup>

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable. -- Zero.

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

<sup>2</sup>Under investigation.

<sup>3</sup>Includes batteries, catalysts, ceramics, coinage, other alloys containing nickel, and data indicated by symbol W.

TABLE 5  
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES, BY FORM, DECEMBER 31<sup>1</sup>

(Metric tons of contained nickel)

Form	2008 <sup>r</sup>	2009
Primary:		
Metal	6,850	6,240
Ferronickel	839	733
Oxide and oxide sinter	48	77
Chemicals	1,360	1,350
Other	89	97
Total	9,180	8,500
Secondary, scrap	9,990	9,260
Grand total	19,200	17,800

<sup>r</sup>Revised.

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

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

Class	2008		2009	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
<b>Primary:</b>				
<b>Unwrought:</b>				
Cathodes, pellets, briquets, shot	1,380	\$32,500	1,100	\$16,800
Ferronickel	1	113	32	1,050
Powder and flakes	1,190	55,200	1,110	46,700
Metallurgical-grade oxide <sup>2</sup>	4,140	14,900	627	4,850
<b>Chemicals:<sup>2</sup></b>				
Catalysts	2,650	205,000	2,870	221,000
Salts <sup>3</sup>	2,260	37,800	1,280	22,500
Total	11,600	345,000	7,020	313,000
<b>Secondary:<sup>2</sup></b>				
Stainless steel scrap	75,100	1,190,000	84,800	777,000
Waste and scrap	19,500	150,000	5,170	36,200
Total	94,600	1,340,000	90,000	814,000
Grand total	106,000	1,680,000	97,000	1,130,000
<b>Wrought, not alloyed:</b>				
Bars, rods, profiles, wire	360	11,900	233	6,510
Sheets, strip, foil	799	27,300	546	13,100
Tubes and pipes	544	6,320	197	4,630
Total	1,700	45,500	975	24,200
<b>Alloyed, gross weight:</b>				
Unwrought alloyed ingot	7,520	213,000	5,740	128,000
Bars, rods, profiles, wire	20,000	762,000	12,700	414,000
Sheets, strip, foil	7,670	310,000	6,240	197,000
Tubes and pipes	2,770	151,000	1,920	106,000
Other alloyed articles	4,120	295,000	4,110	277,000
Total	42,100	1,730,000	30,700	1,120,000

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

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

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

Source: U.S. Census Bureau.



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

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

Country	2009							Total in 2008	Wrought nickel in 2009 <sup>4</sup>	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide <sup>3</sup>	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	--	4	--	--	355	14	53	426	475	4
Belgium	34	3	--	6	2	202	184	431	752	7
Brazil	128	34	--	--	--	5	242	409	576	1
Canada	13	105	--	561	2,720	1,470	839	5,700	17,400	229
China	46	95	28	2	48	18,100	351	18,700	7,560	59
Colombia	41	24	--	--	--	2	7	74	60	23
Finland	--	--	--	--	--	2,260	--	2,260	4,210	2
France	(s)	7	--	--	4	53	13	77	250	12
Germany	18	298	(s)	2	233	10	96	657	1,170	49
India	--	12	--	--	92	8,970	386	9,460	6,180	9
Italy	--	3	--	--	--	10	39	52	300	24
Japan	1	79	--	5	617	2,900	80	3,690	13,600	5
Korea, Republic of	17	52	--	--	--	11,400	386	11,800	9,630	139
Mexico	661	33	--	13	343	13	114	1,180	1,280	99
Netherlands	--	(s)	--	--	103	205	85	393	1,820	4
South Africa	--	1	--	--	--	--	11	12	69	2
Spain	--	(s)	--	--	--	741	73	814	996	2
Sweden	--	3	--	--	249	127	1	380	422	1
Taiwan	23	20	--	--	11	29,600	174	29,800	24,300	13
Thailand	--	43	--	2	--	2,160	48	2,260	2,380	4
United Kingdom	1	97	--	--	355	119	136	708	943	40
Other	114	195	4	35	34	6,430	839	7,650	11,900	243
Total	1,100	1,110	32	626	5,170	84,800	4,160	97,000	106,000	971

-- Zero.

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

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

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

<sup>4</sup>Excluded from "2009, total."

<sup>5</sup>Less than ½ unit.

Source: U.S. Census Bureau.

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

Class	2008		2009	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
<b>Primary:</b>				
Unwrought:				
Cathodes, pellets, briquets, shot	107,000	\$2,550,000	85,500	\$1,210,000
Ferronickel	11,000	272,000	6,200	84,900
Powder and flakes	6,040	184,000	4,450	83,700
Metallurgical-grade oxide <sup>2</sup>	1,340	32,000	799	10,800
Chemicals: <sup>2</sup>				
Catalysts	1,800	115,000	1,900	78,200
Salts <sup>3</sup>	1,960	45,100	1,010	17,400
Total	129,000	3,200,000	99,900	1,480,000
<b>Secondary:<sup>2</sup></b>				
Stainless steel scrap	10,500	217,000	9,310	138,000
Waste and scrap	9,590	210,000	8,430	112,000
Total	20,100	427,000	17,700	249,000
Grand total	149,000	3,630,000	118,000	1,730,000
<b>Wrought, not alloyed:</b>				
Bars, rods, profiles, wire	250	10,500	131	4,260
Sheets, strip, foil	476 <sup>r</sup>	15,900 <sup>r</sup>	195	5,180
Tubes and pipes	221	7,360	83	4,590
Total	947 <sup>r</sup>	33,800 <sup>r</sup>	409	14,000
<b>Alloyed, gross weight:</b>				
Unwrought alloyed ingot	4,440	117,000	4,590	63,600
Bars, rods, profiles, wire	10,600	328,000	6,450	151,000
Sheets, strip, foil	3,380 <sup>r</sup>	126,000 <sup>r</sup>	1,790	41,900
Tubes and pipes	2,460	77,300	1,670	95,500
Other alloyed articles	2,810	99,200	2,820	87,700
Total	23,700 <sup>r</sup>	748,000 <sup>r</sup>	17,300	439,000

<sup>r</sup>Revised.

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

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

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

Source: U.S. Census Bureau.

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

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

Country	2009							Total in 2008	Wrought nickel in 2009 <sup>4</sup>	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide <sup>3</sup>	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	9,450	299	--	787	69	--	1	10,600	16,600	1
Belgium	--	90	--	--	186	--	150	426	427 <sup>r</sup>	--
Brazil	1,650	--	--	--	73	44	--	1,770	203 <sup>r</sup>	--
Canada	35,500	2,280	72	--	1,950	6,840	119	46,700	70,200	1
Colombia	--	--	3,750	--	8	42	--	3,800	2,870	--
Dominican Republic	--	--	230	--	--	8	--	238	5,640	--
Finland	5,550	(5)	--	--	7	--	231	5,780	3,280 <sup>r</sup>	--
France	816	2	--	--	1,150	9	450	2,420	2,080	109
Germany	97	78	--	--	702	27	329	1,230	1,400	180
Indonesia	--	--	149	--	--	--	--	149	50	--
Israel	--	1	--	--	92	1	(5)	94	307	--
Italy	--	--	--	--	21	5	9	35	146	31
Japan	426	50	52	--	273	10	224	1,040	1,370	3
Mexico	--	--	--	--	666	2,030	19	2,710	3,270	(5)
Netherlands <sup>6</sup>	6	10	--	--	72	--	254	342	372	8
New Caledonia	--	--	1,800	--	--	--	--	1,800	2,050	--
Norway	11,200	--	--	--	31	--	--	11,300	10,000	(5)
Russia	19,800	862	--	--	57	--	(5)	20,700	21,200	2
South Africa	83	370	132	--	--	--	--	585	497 <sup>r</sup>	--
Spain	--	--	--	--	56	7	3	66	104	(5)
Taiwan	--	--	--	--	48	98	--	146	71	--
United Kingdom	342	393	13	12	1,660	48	107	2,580	3,570	17
Zimbabwe	514	--	--	--	--	--	--	514	667	--
Other	20	17	--	1	1,310	147	1,020	2,510	2,460 <sup>r</sup>	57
Total	85,500	4,450	6,200	799	8,430	9,310	2,910	118,000	149,000	409

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

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

<sup>2</sup>The nickel contents are assumed to be as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The chemicals category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; 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.

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

<sup>4</sup>Excluded from "2009, total."

<sup>5</sup>Less than ½ unit.

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

Source: U.S. Census Bureau.

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

(Metric tons of contained nickel)

Country and products <sup>2</sup>	2005	2006	2007	2008	2009
Albania, laterite ore <sup>c</sup>	10 <sup>r</sup>	790 <sup>r</sup>	3,700 <sup>r</sup>	3,500 <sup>r</sup>	3,500
Australia, ores and concentrate <sup>3</sup>	188,900	185,000	184,900	199,200	165,000
Botswana, ore milled	39,305	38,000 <sup>e</sup>	27,600 <sup>r,e</sup>	28,940 <sup>r</sup>	28,595
Brazil, ore	74,198	82,492	58,317	67,116 <sup>r</sup>	67,000 <sup>p</sup>
Burma, ore <sup>e</sup>	10	10	10	10	10
Canada, concentrate	199,932	232,948	254,915	259,651 <sup>r</sup>	136,594
China <sup>e</sup>	72,700	82,100	67,000	72,000	79,355 <sup>4</sup>
Colombia, laterite ore	89,031	94,105	100,539 <sup>r</sup>	77,000 <sup>r</sup>	72,000
Cuba, oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor <sup>5</sup>	73,753	73,371	73,934	67,265	65,000 <sup>e</sup>
Dominican Republic, laterite ore	53,124	47,516	47,125	31,300	--
Finland, concentrate <sup>6</sup>	3,386	2,985	3,635	4,303 <sup>r</sup>	4,400 <sup>e</sup>
Greece, laterite ore	23,210	21,670	21,190	18,646 <sup>r</sup>	10,203
Indonesia, laterite ore	135,000	157,000	229,000	192,600	202,800
Kazakhstan, laterite ore <sup>e</sup>	193 <sup>4</sup>	200	200	500	500
Kosovo, laterite ore <sup>7,8</sup>	--	--	1,820 <sup>r</sup>	3,660 <sup>r</sup>	3,960
Macedonia, ferronickel produced <sup>8</sup>	8,141	10,942	15,321	15,026	11,990 <sup>p</sup>
Morocco, nickel sulfate	199 <sup>e</sup>	80	100	100 <sup>e</sup>	100 <sup>e</sup>
New Caledonia, ore	111,939	102,986	125,364	102,583 <sup>r</sup>	92,846
Norway, concentrate	342	320	240	377 <sup>r</sup>	369
Philippines:					
Ore	22,555 <sup>r</sup>	56,463 <sup>r</sup>	81,288	70,082 <sup>r</sup>	120,316
Concentrate <sup>9</sup>	4,081	8,242	10,079	10,562	17,035
Total	26,636 <sup>r</sup>	64,705 <sup>r</sup>	91,367	80,644 <sup>r</sup>	137,351
Russia, marketable mine production:					
Laterite ore <sup>10</sup>	34,419	37,754	45,690	36,807	32,359
Sulfide concentrate <sup>11</sup>	242,758	239,231	234,083	230,000	229,493
Total	277,177	276,985	279,773	266,807	261,852
South Africa, concentrate	42,392	41,599	37,917	31,675	34,606
Spain, concentrate	5,386 <sup>r</sup>	6,398 <sup>r</sup>	6,772 <sup>r</sup>	8,136 <sup>r</sup>	8,029
Turkey, laterite ore <sup>e</sup>	1,000	1,500	--	--	--
Ukraine, laterite ore <sup>e</sup>	6,000	12,000	12,000	8,000	--
Venezuela, laterite ore	21,100 <sup>r</sup>	21,200 <sup>r</sup>	18,900 <sup>r</sup>	13,000 <sup>r</sup>	13,200
Zambia, concentrate <sup>12</sup>	--	--	--	751	300
Zimbabwe, concentrate	9,220 <sup>r</sup>	8,825	8,582 <sup>r</sup>	6,354	5,000 <sup>e</sup>
Grand total	1,460,000 <sup>r</sup>	1,570,000	1,670,000 <sup>r</sup>	1,560,000 <sup>r</sup>	1,400,000
Of which:					
Concentrate <sup>13</sup>	507,000	541,000 <sup>r</sup>	556,000 <sup>r</sup>	552,000 <sup>r</sup>	436,000
Ore and ore milled	248,000 <sup>r</sup>	280,000 <sup>r</sup>	293,000 <sup>r</sup>	269,000 <sup>r</sup>	309,000
Laterite ore	363,000	394,000 <sup>r</sup>	480,000 <sup>r</sup>	385,000 <sup>r</sup>	339,000
Ferronickel produced	8,140	10,900	15,300	15,000	12,000 <sup>p</sup>
Nickel sulfate	199 <sup>e</sup>	80	100	100 <sup>e</sup>	100 <sup>e</sup>
Unspecified and (or) undifferentiated	335,000	340,000	326,000	338,000	309,000

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

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

<sup>2</sup>Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output and this is noted. North Korea may have an active nickel mine, but information is inadequate to make reliable estimates of output. Table includes data available through August 13, 2010.

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

<sup>4</sup>Reported figure.

<sup>5</sup>The Government of Cuba reports plant production on a contained nickel plus cobalt basis. The tonnages shown in this table for Cuba have been adjusted downward to correct for the cobalt. The cobalt content was determined to be 1.16% for granular and powdered oxide, 1.21% for oxide sinter, 7.56% for sulfide precipitate, and 33% for leach ammoniacal precipitate.

<sup>6</sup>The gross weight of concentrates processed in Finland from domestic ores was, in metric tons, as follows: 2005—39,854; 2006—40,474 (revised); 2007—44,824 (revised); 2008—43,038 (revised); and 2009—43,000 (estimated).

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

- <sup>7</sup>On February 17, 2008, the Kosovo Assembly declared independence from Serbia.  
<sup>8</sup>Cunico Resources N.V. (Amsterdam, Netherlands) shipped lateritic ore from Albania to the company's smelter at Kavadarci in Macedonia. The ore came from the Bitinçka and Treni Mines in the Devolli region close to the Greek border. The Kavadarci smelter and Cunico's sister smelter at Gillogovac, Kosovo, also received Albanian ore from a third party.  
<sup>9</sup>Nickel content of concentrate produced at Rio Tuba by Coral Bay Nickel Corp.  
<sup>10</sup>Nickel content of ore mined in the Ural Mountains region.  
<sup>11</sup>Nickel content of concentrate produced on the Kola and Taimyr Peninsulas.  
<sup>12</sup>Albidon Limited concentrates were shipped to Jinchuan Ltd. in China. First production was in June 2008. Anticipated specifications for concentrates are 13% nickel and 0.7% cobalt. Concentrate production comes from company quarterly reports.  
<sup>13</sup>Includes "Russia, sulfide concentrate."

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

(Metric tons of contained nickel)

Country	2005	2006	2007	2008	2009
<b>Matte:</b>					
Australia <sup>3</sup>	44,536	39,561	41,612	31,085	35,441
Botswana	28,212	26,762	22,844	28,940 <sup>r</sup>	29,616
Brazil <sup>4</sup>	6,005	5,416	3,401	3,153 <sup>r</sup>	3,200 <sup>p</sup>
Canada <sup>5</sup>	59,722	56,628	73,922	76,908 <sup>r</sup>	68,972 <sup>p</sup>
China <sup>6</sup>	26	758	1,980	3,240	--
Indonesia <sup>7</sup>	77,471	72,782	77,928	73,356 <sup>r</sup>	68,300 <sup>p</sup>
New Caledonia	12,838	13,655	14,842 <sup>r</sup>	13,564 <sup>r</sup>	13,902
Russia <sup>8</sup>	700	1,300	670 <sup>e</sup>	600 <sup>e</sup>	240 <sup>e</sup>
Zimbabwe <sup>e,9</sup>	1,400	1,600	1,400	2,000	2,500
<b>Total</b>	<b>231,000</b>	<b>218,000</b>	<b>239,000<sup>r</sup></b>	<b>233,000<sup>r</sup></b>	<b>222,000</b>
<b>Other, Cuba:<sup>10</sup></b>					
Sulfide precipitate	32,354	30,967	31,116	32,465	32,500 <sup>e</sup>
Ammoniacal liquor precipitate	2,278	3,283	2,907	322	300 <sup>e</sup>
<b>Total</b>	<b>34,632</b>	<b>34,250</b>	<b>34,023</b>	<b>32,787</b>	<b>32,800<sup>e</sup></b>

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

<sup>1</sup>Table includes data available through August 13, 2010. Data represent nickel content of matte and other intermediate materials produced.

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

<sup>3</sup>Figures exclude toll-refined material.

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

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

<sup>6</sup>Chinese exports were estimated to have a nickel content of 63%. Total matte production on a contained nickel basis, in metric tons, was estimated as follows: 2005—83,500; 2006—99,800; 2007—105,000; 2008—110,000; and 2009—120,000.

<sup>7</sup>Represents the nickel output of the Soroako smelter. The Soroako matte is shipped to Japan for further processing and contains on average 78% nickel.

<sup>8</sup>Primarily exports to China. Sources: International Nickel Study Group; United Nations Statistics Division.

<sup>9</sup>Zimbabwe Platinum Mines Limited (Zimplats) of Delta Gold Limited (Delta) material shipped to the Impala Refining Services PGM Refinery of Impala Platinum Holdings Limited (Implats) at Springs, South Africa.

<sup>10</sup>Corrected to remove coproduct cobalt.

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

(Metric tons of contained nickel)

Country and product <sup>3</sup>	2005	2006	2007	2008	2009
<b>Australia:</b>					
Metal	112,600	105,100	100,300	89,500	123,200
Unspecified <sup>4</sup>	9,700	11,400	14,200 <sup>r</sup>	19,400 <sup>r</sup>	8,000
Total	122,300	116,500	114,500 <sup>r</sup>	108,900 <sup>r</sup>	131,200
<b>Austria, ferronickel and ferronickel molybdenum<sup>5</sup></b>	1,000	900	900	500 <sup>r</sup>	700
<b>Brazil:<sup>5</sup></b>					
Ferronickel	9,596	9,814	9,918	10,244 <sup>r</sup>	9,453 <sup>p</sup>
Metal	20,714	21,339	21,635	18,530 <sup>r</sup>	20,056 <sup>p</sup>
Total	30,310	31,153	31,553	28,774 <sup>r</sup>	29,509 <sup>p</sup>
<b>Canada, unspecified<sup>6</sup></b>	139,683	146,899	153,647	167,732	116,909
<b>China:<sup>7</sup></b>					
Ferronickel and high nickel pig iron	2,900	31,000	84,500	70,900	100,000
Metal	95,100	102,000	116,000	129,000	165,000
Chemicals and unspecified <sup>c</sup>	5,000	5,000	6,000 <sup>s</sup>	8,000 <sup>s</sup>	8,000
Total	103,000	138,000	206,500	207,900	273,000
<b>Colombia, ferronickel</b>	52,749	51,137	49,314 <sup>r</sup>	41,636	51,802
<b>Cuba, oxide sinter and oxides<sup>9</sup></b>	39,121	39,121	39,911	34,478	34,500 <sup>c</sup>
<b>Dominican Republic, ferronickel</b>	28,668	29,675 <sup>r</sup>	29,128 <sup>r</sup>	18,742 <sup>r</sup>	--
<b>Finland:<sup>10</sup></b>					
Metal	34,709	42,299	49,700	42,971 <sup>r</sup>	41,848
Chemicals and unspecified	4,450	5,170	5,200	8,142 <sup>r</sup>	5,000 <sup>c</sup>
Total	39,159	47,469	54,900	51,113 <sup>r</sup>	46,848
<b>France:</b>					
Metal	10,500	11,400	11,200	11,500	11,900
Chemicals <sup>c</sup>	2,000	2,000	2,000	2,000	2,000
Total <sup>11</sup>	12,500	13,400	13,200	13,500	13,900
<b>Greece, ferronickel</b>	19,235	17,740	18,670	16,640 <sup>r</sup>	8,269
<b>India:<sup>12</sup></b>					
Ferronickel	--	(13)	(13)	(13)	(13)
Ferronickel magnesium	--	41	52	93	88
Nickel sulfate	--	(14)	(14)	(14)	(14)
Total	--	41	52	93	88
<b>Indonesia, ferronickel</b>	7,338	14,474	18,532 <sup>r</sup>	17,566 <sup>r</sup>	12,550
<b>Japan:</b>					
Ferronickel	76,390	66,668	68,346	59,259 <sup>r</sup>	58,936
Metal	29,399	29,254	30,402	34,861 <sup>r</sup>	30,200
Oxide sinter	56,700	53,877	60,151	54,900 <sup>r,c</sup>	57,190
Chemicals	2,208	2,531	2,270	2,333 <sup>r</sup>	1,671
Total	164,697	152,330	161,169	151,353 <sup>r</sup>	147,997
<b>Korea, Republic of:</b>					
Ferronickel	--	--	--	2,506	21,609 <sup>p</sup>
Metal	(15)	(15)	(15)	(15)	(15)
Total	(15)	(15)	(15)	2,506	21,609 <sup>p</sup>
<b>Kosovo, ferronickel<sup>c,16</sup></b>	--	--	800	7,100	4,700
<b>Macedonia, ferronickel</b>	8,141	10,942	15,321	15,026	11,990 <sup>p</sup>
<b>Morocco, chemicals<sup>c</sup></b>	130	125	125	125	125
<b>New Caledonia, ferronickel</b>	46,738	48,723	44,954	37,467	38,230
<b>Norway, metal</b>	84,886	81,974	87,590	88,741	88,577
<b>Poland, chemicals<sup>17</sup></b>	453	465	475 <sup>c</sup>	475 <sup>c</sup>	475 <sup>c</sup>
<b>Russia:</b>					
Ferronickel					
High-nickel	12,600	14,436	17,111	16,158	15,565
Other <sup>c,18</sup>	4,290 <sup>r</sup>	4,490 <sup>r</sup>	4,690 <sup>r</sup>	4,905 <sup>r</sup>	5,125
Metal	249,479	255,045	248,363	242,409	237,270

See footnotes at end of table.

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

(Metric tons of contained nickel)

Country and product <sup>3</sup>	2005	2006	2007	2008	2009
<b>Russia—Continued:</b>					
Oxide sinter	4,075	2,713	235	--	--
Chemicals <sup>c</sup>	3,200	3,500	3,100	2,900	2,700
Total	273,644 <sup>r</sup>	280,184 <sup>r</sup>	273,499 <sup>r</sup>	266,372 <sup>r</sup>	260,660
<b>South Africa:</b>					
Ferronickel, high-nickel	90	100	5,000	4,300	800
Metal	42,400	41,800	34,400	30,200 <sup>r</sup>	34,000 <sup>e</sup>
Chemicals <sup>e, 19</sup>	7,400	7,600	6,800	6,800	6,800
Total	49,890 <sup>r</sup>	49,500 <sup>r</sup>	46,200 <sup>r</sup>	41,300 <sup>r</sup>	41,600 <sup>e</sup>
Taiwan, metal	(15)	(15)	(15)	(15)	(15)
Ukraine, ferronickel <sup>20</sup>	14,211 <sup>r</sup>	15,223 <sup>r</sup>	12,074 <sup>r</sup>	16,224 <sup>r</sup>	12,392
United Kingdom, metal <sup>21</sup>	37,127	36,770	34,064	41,000 <sup>r</sup>	17,800 <sup>p</sup>
Venezuela, ferronickel	16,900	16,600	15,700 <sup>r</sup>	10,900 <sup>r</sup>	10,400
<b>Zimbabwe, metal:<sup>c</sup></b>					
Refined from domestic nickel ore	7,500	5,510 <sup>8</sup>	4,500	3,400	--
Toll refined from imported nickel feed <sup>22</sup>	5,700	9,000	9,500	10,300	5,000
Total	13,200	14,510 <sup>8</sup>	14,000	13,700	5,000
<b>Grand total</b>	<b>1,310,000<sup>r</sup></b>	<b>1,350,000</b>	<b>1,440,000<sup>r</sup></b>	<b>1,400,000<sup>r</sup></b>	<b>1,380,000</b>
<b>Of which:</b>					
Ferronickel, including ferronickel magnesium	301,000 <sup>r</sup>	332,000 <sup>r</sup>	395,000 <sup>r</sup>	350,000 <sup>r</sup>	363,000
Metal	730,000	741,000	748,000	742,000 <sup>r</sup>	775,000
Oxide sinter	99,900	95,700	100,000	89,400 <sup>r</sup>	91,700
Chemicals, including nickel sulfate	15,400	16,200	14,800	14,600	13,800
Unspecified	159,000 <sup>r</sup>	168,000 <sup>r</sup>	179,000 <sup>r</sup>	203,000 <sup>r</sup>	138,000

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

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

<sup>2</sup>Table includes data available through August 13, 2010.

<sup>3</sup>In addition to the countries listed, North Korea is thought to have produced metallic nickel and (or) ferronickel, but information is inadequate to make reliable estimates of output levels. Several countries produce nickel-containing matte, but output of nickel in such materials has been excluded from this table to avoid double counting. Countries producing matte for export are listed in table 11.

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

<sup>5</sup>Brazil produced nickel carbonate (an intermediate product for metal production), in metric tons: 2005—21,116; 2006—21,630; 2007—20,796; and 2008–09—20,800 (estimated).

<sup>6</sup>Nickel contained in products of smelters and refineries in forms that are ready for use by consumers. Figures include the nickel content of nickel oxide sinter exported to the Republic of Korea and Taiwan. More information can be found in footnote 15.

<sup>7</sup>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 2006–09, China also produced nickeliferous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

<sup>8</sup>Reported figure.

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

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

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

<sup>12</sup>Fiscal year ending March 31 of that stated.

<sup>13</sup>Vidarbha Nickel Pvt. Ltd. of Nagpur, Maharashtra State, has produced ferronickel from spent nickel catalysts, but no production data were available.

<sup>14</sup>Nickel sulfate was produced in the past as a byproduct at the Ghatsila copper smelter in Jharkhand State. The facility is capable of producing 390 tons (gross weight) per year of nickel sulfate, but no production data were available.

<sup>15</sup>Nickel metal production for the Republic of Korea and Taiwan are not included because the production is derived wholly from imported metallurgical-grade oxides and to include them would result in double counting. Metal production figures are as follows, in metric tons: Republic of Korea: 2005—26,300 (estimated); 2006—28,085; 2007—28,675; 2008—28,653; and 2009—28,000 (estimated). Taiwan: 2005–09—11,000 (estimated).

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

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

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<sup>17</sup>Nickel content of nickel sulfate. Most of the nickel sulfate was a byproduct of the concentrating, smelting, and refining of domestically mined copper ores. Some production, however, may have been derived from imported nickeliferous raw materials that were blended with the domestic copper concentrates.

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

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

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

<sup>21</sup>Includes nickel contents of chemicals.

<sup>22</sup>Data represent production from matte imported from Botswana and nickel sulfate imported from South Africa.



TABLE 13  
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2010	Brazil (Para)	Onca-Puma	1.72	110,000	58,000	Ferronickel.
		Mineração Onça Puma Vale Inco Ltd.	0.75	314,000		
2010	New Caledonia (Southern)	Vale Nouvelle-Calédonie <sup>3</sup>	1.34	96,000	60,000	Nickel oxide.
		Vale Inco Nouvelle-Calédonie S.A.S. <sup>4</sup>	2.01	24,000		
		Vale Inco Ltd., Société de Participation Minière du Sud Calédonien S.A.S., and Sumitomo consortium	1.70	83,000		
2011	Australia (Queensland)	Lucky Break (Circular Laterite and Dingo Dam)	0.82	590,000	730	Nickel carbonate.
		Metallica Minerals Ltd. and Metals Finance Corp.	0.82	48,000		
			0.75	490,000		
2011	Brazil (Goias)	Barro Alto	1.30	3,500	36,000	Ferronickel.
		Anglo American plc	1.27	16,600		
			1.45	61,000		
2011	Madagascar	Ambatovy (Ambatovy and Analamay deposits)	1.12	44,000	60,000	Nickel metal powder and briquettes.
		Sherritt International Corp., Sumitomo Corp., South Korean consortium, and SNC-Lavalin Group Inc.	0.99	81,000		
2011	Papua New Guinea (Madang)	Ramu	0.91	76,000	33,000	Nickel-cobalt hydroxide.
		China Metallurgical Group Corp. consortium, Highlands Pacific Ltd., and Mineral Resources Development Co.	1.01	67,000		
2012	Burma (Thabeikkyin, Mandalay)	Tagaung Taung	2.02	40,000	22,000	Ferronickel.
		China Nonferrous Metals Mining Group Co., Ltd. and Government of Burma				
2012	Indonesia (Sulawesi)	Morowali	1.50	500,000	7,500	Direct shipping ore.
		PT Sinosteel Indonesia Mining				
2012	Philippines (Surigao del Norte and Surigao del Sur)	Adlay-Cagdianao-Tandawa	1.61	5,800	5,000	Do.
		CTP Construction and Mining Corp.	1.58	13,000		
2013	Australia (Western Australia)	Yerilla (Aubils, Boyce Creek, and Jump-up Dam)	1.01	22,000	5,000	Iron-nickel-cobalt alloy.
		Heron Resources Ltd. and Ningbo Shanshan Co. Ltd.	0.77	110,000		
2013	New Caledonia (Northern)	Koniambo (saprolite ores)	2.54	21,000	60,000	Ferronickel.
		Xstrata Nickel and Soc. Minière du Sud Pacifique S.A.	2.45	54,000		
			2.50	83,000		
2013	Philippines (Surigao del Norte)	Agata	1.00	1,400	7,500	Ore initially.
		Mindoro Resources Ltd.	1.16 <sup>5</sup>	640		
			0.98	8,400		
			1.18 <sup>5</sup>	17,000		
			1.06	3,800		
2014	Australia (Queensland)	Marlborough (Coorumburra, Slopeaway, and Whereat) <sup>6</sup>	0.99	12,000	63,000	Metal.
		Gladstone Pacific Nickel Ltd.	0.91	43,000		
			0.88	16,000		
2014	Do.	Nornico-Greenvale (Bell Creek, Greenvale, Kokomo, and Minnamoolka deposits) Metallica Minerals Ltd.	0.81	46,000	10,000	Do.
2014	Australia (Western Australia)	NiWest (Eucalyptus, Hepi, and Mt. Kilkenny)	1.18	19,000	30,000	Nickel-cobalt sulfide.
		GME Resources Ltd.	1.14	8,500		
			1.13	3,700		
2014	Do.	Kalgoorlie (Goongarrie and Siberia)	0.74	320,000	36,000	Nickel-cobalt hydroxide.
		Heron Resources Ltd. <sup>7</sup>	0.69	270,000		

See footnotes at end of table.

TABLE 13—Continued  
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production	Country (state/province)	Project and company <sup>1</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>2</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Cameroon (East Province)	Nkamouna and Mada Geovic Cameroon PLC.	0.68	60,000	3,200	Cobalt-nickel sulfide.
			0.62	61,000		
			0.58	183,000		
2014	Kazakhstan (Kostanai Oblast)	Shevchenko OAO Mechel	0.85	21,000	15,700	Ferronickel or nickel-cobalt hydroxide.
			0.77	83,000		
			0.84	32,000		
2014	Philippines (Mindoro Oriental)	Mindoro/Sabluyan (Buraboy, and Kisluyan, Shabo areas) Aglubang Mining Corp., local partner of and Intex Resources ASA	0.83	220,000	60,000	Nickel-cobalt sulfide intermediate, initially.
			0.77	88,000		
2014	Philippines (Surigao del Norte and Surigao del Sur)	Taganito Sumitomo Metal Mining Co. Ltd. and Nickel Asia Corp.	(8)	(8)	30,000	Nickel-cobalt sulfide intermediate.
2014	Philippines (Zambales)	Acoje and Zambales DMCI Holdings, Inc., Rusina Mining NL, and European Nickel PLC	1.09	34,000	24,500	Nickel-cobalt hydroxide.
			1.01	16,000		
			1.18	24,000		
2014	Turkey (Manisa)	Caldag European Nickel PLC and Jiangxi Rare Earth and Rare Metals Tungsten Group Co., Ltd.	1.13	33,000	21,000	Do.
2015	Albania	Devolli and Kokogllave Balkan Resources Inc. and European Nickel PLC	1.19	22,000	15,000	Do.
			1.21	14,000		
			1.20	30,000		
2015	Brazil (Para)	Araguaia (Pau Preto, Serra do Tapa, and Vale dos Sonhos) Xstrata Nickel	1.44	16,000	36,000	Ferronickel.
			1.31	89,000		
			1.30	18,000		
2015	Do.	Jacaré Anglo American plc	1.19	99,000	34,000	Do.
			1.16	81,000		
			1.54 <sup>5</sup>	25,000		
			1.36 <sup>5</sup>	85,000		
2015	Do.	Vermelho Vale Inco Ltd.	1.25	124,000	46,000	Metal or oxide.
			0.80	148,000		
2015	China (Yunnan)	Yuanjiang Yuanjiang Nickel Co., Ltd., subsidiary of Sino-Platinum Metals Corp., Ltd.	0.91	430,000	5,000	Nickel-cobalt intermediate.
2015	Cuba (Holguin)	Las Camariocas Government of Cuba, Ferroniquel S.A., and others	1.32	110,000	22,500	Ferronickel.
2015	Guatemala (Izabal)	Fenix saprolite (pyrometallurgical process) Cia. Guatemalteca de Niquel S.A., subsidiary of Hudbay Minerals Inc. <sup>9</sup>	2.09 <sup>5</sup>	7,700	22,700	Do.
			1.87 <sup>5</sup>	28,000		
			1.80 <sup>5</sup>	9,700		
2015	Indonesia (Halmahera Island)	Weda Bay (Boki, Mokot, Pintu, and Santa Monica deposits) PT Weda Bay Nickel (Eramet Group and Mitsubishi Corp.) and PT Aneka Tambang	1.45	154,000	60,000	NA. <sup>10</sup>
			1.53	123,000		
2015	Indonesia (Sulawesi)	Sorowako and Bahodopi mines PT International Nickel Indonesia TBK	1.87 <sup>5</sup>	48,000	22,000	Ore for blending and subsequent conversion to matte.
2015	Philippines (Davao Oriental)	Pujada—Mati Hallmark Mining Corp. and Austral-Asia Link Mining Corp. <sup>11</sup>	1.30	200,000	50,000	Nickel-cobalt intermediate.

Do. Ditto. NA Not available.

<sup>1</sup>Company names reflect organizational structure as of December 31, 2009. BHP Billiton Group is a dual listed company comprising BHP Billiton Ltd. and BHP Billiton Plc. Vale Inco Ltd. is a wholly owned subsidiary of Companhia Vale do Rio Doce.

TABLE 13—Continued  
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

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

<sup>3</sup>On December 19, 2008, the name of the project—Goro—was changed to Vale Inco Nouvelle-Calédonie.

<sup>4</sup>Vale Inco Nouvelle-Calédonie was renamed Vale Nouvelle-Calédonie in May 2010.

<sup>5</sup>Saprolite.

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

<sup>7</sup>Vale Inco Ltd. withdrew from the Kalgoorlie Nickel Project in July 2009 after spending \$34 million on feasibility studies.

<sup>8</sup>Nickel Asia Corp. could provide ore from several mine sites on Mindanao Island.

<sup>9</sup>HudBay Minerals Inc. acquired Skye Resources Inc. in August 2008.

<sup>10</sup>Proprietary process currently under development by Centre de Recherche de Trappes (France).

<sup>11</sup>In December 2009, BHP Billiton Group withdrew from the Pujada project and sold its 40% interest to its local partner, Asiaticus Management Corp. (AMCOR).

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

TABLE 14  
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production <sup>1</sup>	Country (state/province)	Project and company <sup>2</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>3</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2009/2011	Canada (Ontario)	Nickel Rim South	1.65	2,800	18,000	Ore.
		Xstrata Nickel	1.48	2,500		
			1.40	13,000		
2010	Australia (Western Australia)	Lounge Lizard <sup>4</sup>	4.83	630	2,300	Do.
		Kagara Ltd. and Western Areas NL	4.37	520		
2010	Do.	Spotted Quoll	5.90 <sup>5</sup>	1,700	10,000	Concentrate.
		Western Areas NL	6.40 <sup>5</sup>	230		
			4.10 <sup>6</sup>	1,700		
2010/2012	Canada (Ontario)	Fraser Morgan	1.94	4,400	6,000	Ore.
		Xstrata Nickel	1.81	2,400		
			1.70	1,800		
2010	Do.	McWatters Liberty Mines Inc. <sup>7</sup>	0.70	870	2,600	Do.
2010 <sup>8</sup>	Do.	Shakespeare	0.33 <sup>5</sup>	12,000	4,100	Ore initially. Concentrate.
		Ursa Major Minerals Inc.	0.37	1,800		
			0.37	700		
2011	Australia (Western Australia)	Sinclair (underground)	(9)	(9)	5,500	Concentrate.
		Xstrata Nickel Australasia <sup>10</sup>				
2011	Canada (Ontario)	Totten (plus new Clarabelle mill addition)	0.74	6,000	8,200	Do.
		Vale Inco Ltd.	0.75	550		
2012	Australia (Western Australia)	Cosmic Boy and Diggers <sup>11</sup>	1.46 <sup>12</sup>	2,100	7,000	Do.
		Western Areas NL	2.40 <sup>13</sup>	380		
			1.00 <sup>14</sup>	10,000		
2012	Finland (Lappi)	Kevitsa	0.31	110,000	10,000	Do.
		First Quantum Minerals Ltd.	0.30	55,000		
			0.29	290,000		
2012	Finland (Pohiois)	Outokumpu Copper (formerly Kylylahti copper-cobalt)	0.17	620	1,400	Zinc-cobalt-copper-nickel concentrate.
		Altona Mining Ltd. <sup>15</sup>	0.20	7,500		
			0.18	310		
2012	Vietnam (Son La)	Ban Phuc	2.68 <sup>16</sup>	1,700	6,400	Concentrate.
		Asian Mineral Resources Ltd. and Son La	1.94 <sup>16</sup>	170		
		Mechanical Engineering JSC	0.59 <sup>17</sup>	13,000		
			0.56 <sup>17</sup>	7,400		
2013	United States (Michigan)	Eagle	3.47	3,600	17,300	Do.
		Kennecott Minerals Co.	3.16	500		
2013	United States (Minnesota)	NorthMet	0.08	580,000	7,100	Concentrate initially. Byproduct nickel-cobalt hydroxide.
		PolyMet Mining Corp.	0.08	230,000		
2014	Australia (Western Australia)	Prospero	6.39	420	10,000	Concentrate.
		Xstrata Nickel Australasia <sup>10</sup>	6.42	470		
			5.03	450		
2014	Canada (Manitoba)	Makwa (formerly Maskwa)	0.55	10,000 <sup>18</sup>	4,200	Do.
		Mustang Minerals Corp.	0.25	1,700		
2014	Do.	Minago	0.59	10,000	11,000	Do.
		Victory Nickel Inc.	0.50	39,000		
			0.53	13,000		
2014	Canada (Quebec)	Nunavik/South Raglan (Allammaq, Mesamax, Mequillon, Expo, Ivakkak, and TK deposits)	0.93	560	6,800	Do.
		Jilin Jien Nickel Industry Co., Ltd. and Goldbrook Ventures Inc. <sup>19</sup>	0.93	21,000		
			0.73	5,200		
2014	China (Gansu)	Heishan Jinchuan Group Ltd.	0.50	30,000	5,000	Do.

See footnotes at end of table.

TABLE 14—Continued  
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production <sup>1</sup>	Country (state/province)	Project and company <sup>2</sup>	Resource grade (% nickel)	Estimated resources (thousand metric tons) <sup>3</sup>	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Tanzania (Kagera region)	Kabanga	2.48	14,000	10,000	Concentrate.
		Barrick Gold Corp. and Xstrata Nickel	2.65	24,000		
			2.90	16,000		
2014	United States (Minnesota)	Birch Lake, Maturi, Spruce Road	0.18 <sup>20</sup>	130,000	8,600	Byproduct nickel-cobalt hydroxide.
		Franconia Minerals Corp.	0.17 <sup>21</sup>	40,000		
			0.25 <sup>22</sup>	120,000		
			0.14 <sup>23</sup>	380,000		
2015	Australia (Western Australia)	New Morning/Daybreak	3.70 <sup>16</sup>	320	3,000	Ore.
		Western Areas NL	3.50 <sup>16</sup>	93		
			0.90 <sup>17</sup>	1,100		
			0.90 <sup>17</sup>	660		
2015	Do.	Sherlock Bay Australasian Resources Ltd.	0.40	25,000	8,500	Bioleachate precipitate.
2015	Canada (Ontario)	Onaping Depth	2.67	15,000	10,000	Ore.
		Xstrata Nickel	3.60	1,200		
2015	Finland (Oulu)	Kuhmo (Arola, Peura-aho, Hietaharju, Sika-aho, and Vaara) Altona Mining Ltd. <sup>15</sup> and Polar Mining Oy	0.55	6,000	3,000	Concentrate.
2015	Russia (Amur)	Kun-Manie (Vodorazdelny, Ikensoe, Maly Krumkon, and Falcon)	0.61	3,700	16,000	Do.
		Amur Minerals Corp.	0.48	48,000		
			0.54	17,000		
2015	South Africa (Mpumalanga)	Sheba's Ridge	0.18	409,000	24,000	Matte.
		Anglo Platinum Ltd., Aquarius Platinum Ltd., and Industrial Development Corp. of South Africa <sup>24</sup>	0.18	313,000		
			0.17	53,000		
2015	United States (Minnesota)	Nokomis/Maturi Extension	0.20	550,000	10,800	Byproduct nickel-cobalt sulfide or hydroxide.
		Twin Metals Minnesota LLC (Duluth Metals Ltd. and Antofagasta PLC)	0.21	270,000		
2015	Zimbabwe	Hunters Road Bindura Nickel Corp.	0.54	45,000	2,000	Concentrate.

Do. Ditto.

<sup>1</sup>Two years are shown for selected newly commissioned projects where the company is ramping up production.

<sup>2</sup>Company names reflect organizational structure as of December 31, 2009. BHP Billiton Group is a dual listed company comprising BHP Billiton Limited and BHP Billiton Plc. Vale Inco Ltd. is a wholly owned subsidiary of Companhia Vale do Rio Doce.

<sup>3</sup>Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

<sup>4</sup>The Lounge Lizard deposit was to be developed as part of Western Areas NL's Flying Fox underground operation.

<sup>5</sup>Open pit.

<sup>6</sup>Underground.

<sup>7</sup>Jilin Jien Nickel Industry Co., Ltd. (China) acquired 51% of Liberty Mines in April 2009.

<sup>8</sup>Test shipments of ore were made in 2008.

<sup>9</sup>The Sinclair deposit remains open at depth.

<sup>10</sup>The Sinclair mining complex was acquired by Xstrata Nickel from Jubilee Mines NL in February 2008. Work was suspended temporarily in April 2009 in response to weak nickel prices.

<sup>11</sup>Includes Diggers Rocks, Diggers South, Purple Haze, and Seagull resources.

<sup>12</sup>Diggers areas, probable ore reserves.

<sup>13</sup>Cosmic Boy area indicated resources.

<sup>14</sup>Diggers areas indicated resources.

<sup>15</sup>Altona Mining Ltd. was created when Universal Resources Ltd. merged with Vulcan Resources Ltd. in February 2010.

<sup>16</sup>Massive sulfides.

<sup>17</sup>Disseminated sulfides.

<sup>18</sup>Mustang Minerals Corp. was also evaluating the potential of resources at the nearby Mayville property.

<sup>19</sup>Jilin Jien Nickel Industry Co., Ltd. and Goldbrook Ventures Inc. completed their acquisition of Canadian Royalties Inc. on January 12, 2010.

<sup>20</sup>Birch Lake deposit indicated resource.

TABLE 14—Continued  
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

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<sup>21</sup>Birch Lake deposit inferred resource.

<sup>22</sup>Maturi deposit resource.

<sup>23</sup>Spruce Road open pit resource.

<sup>24</sup>Aquarius Platinum Ltd. acquired Ridge Mining plc in July 2009 and took over management of Sheba's Ridge in August.

Sources: Canadian Minerals Yearbook 2008, 2009; company annual reports, presentations, and press releases; and CRU International, Ltd.