



2016 Minerals Yearbook

NICKEL [ADVANCE RELEASE]

NICKEL

By Michele E. McRae

Domestic survey data and tables were prepared by Kristi J. Simmons, statistical assistant.

Reported nickel consumption (primary plus secondary) in the United States in 2016 decreased by 5% to 188,000 metric tons (t) compared with that of 2015 (table 1). U.S. apparent consumption of primary nickel was 104,000 t, or about 5% of the 2.03 million metric tons (Mt) of world consumption reported by the International Nickel Study Group (INSG). Stainless steel production accounted for 44% of U.S. primary consumption in contrast with 66% globally. This was likely a reflection of the large number of specialty metal companies and a readily available supply of stainless steel scrap in the United States (table 4). U.S. industry was estimated to have melted 90,000 t of nickel contained in scrap, a slight decrease from 90,600 t (revised) in 2015 (table 2) (Nickel Institute, 2016, p. 14; International Nickel Study Group, 2017, p. A-1).

World mine production of nickel was 2.04 Mt of contained nickel in 2016, a 6% decrease from that of 2015 (table 10). According to Platts Metals Week, the London Metal Exchange Ltd. (LME) average monthly cash price for nickel metal trended upward during 2016 and averaged \$11,010 per metric ton in December compared with \$8,689 per metric ton in December 2015. However, the LME average annual price was \$9,594 per metric ton in 2016, a 19% decrease compared with the average annual price of \$11,831 per metric ton in 2015 (table 1). The 2016 average price was the lowest average annual cash price since 2002, when the annual average price was \$6,772 per metric ton. Daily stocks of nickel metal held in LME-approved warehouses generally decreased during the year and ended the year at 372,066 t, a 16% decrease compared with stocks at yearend 2015.

Stainless steel accounted for about 66% of global primary nickel (nickel produced from mined material rather than that recovered from recycled scrap) consumption. World production of stainless and heat-resistant steel was 45.8 Mt in 2016, a 10% increase compared with 2015. China was the leading producer of stainless steel, accounting for about 54% of world output, as well as the leading consumer (International Stainless Steel Forum, 2017, p. 5, 8, 13). On a global basis, nonferrous alloys accounted for about 10% of primary nickel use; electroplating and other surface finishing, 9%; alloy steels other than stainless, 8%; batteries, catalysts, and specialty chemicals, 4%; and foundry products, 3% (Nickel Institute, 2016, p. 14).

Legislation and Government Programs

U.S. Coinage.—Dimes, half dollars, nickels, one-dollar coins, and quarters contain nickel in the form of either cupronickel or manganese-brass alloy. Total nickel consumption for coin production was 3,614 t in 2016, a 10% decrease compared with 2015 (U.S. Mint, undated a, b).

Production

The United States had one nickel mine in operation, the underground Eagle Mine in the Upper Peninsula of Michigan, which began operation in 2014. The Eagle Mine produced 24,100 t of nickel in concentrate compared with 27,200 t in 2015 (table 1). Lower production was attributed to lower mill head grades (Lundin Mining Corp., 2017b, p. 2, 18). Limited quantities of byproduct nickel were recovered at some copper and precious metal refineries, particularly the Stillwater Mining Co. (Littleton, CO) base metal refinery in Columbus, MT. Leading processors of recycled nickel included International Metals Reclamation Co. Inc.'s (INMETCO's) [owned by Horsehead Holding Corp. (Pittsburgh, PA)] secondary smelter in Ellwood, PA, that processed nickel-containing scrap and Gulf Chemical & Metallurgical Corp.'s (Freeport, TX) [owned by ERAMET Group (France)] facility in Freeport, TX, that processed spent catalysts from petroleum refineries. The refinery and secondary recovery data from these operations were included with scrap statistics to avoid disclosing company proprietary data (tables 1-5).

No ferronickel was produced from ores in the United States in 2016. Any U.S. ferronickel exports were likely either reexports or material upgraded for special purposes.

Michigan.—Lundin Mining Corp. (Canada) mined the Eagle deposit—a chalcopyrite-pentlandite-rich peridotite intrusion, historically known as the Yellow Dog peridotite, in the Upper Peninsula of Michigan. The ore was processed at the associated Humboldt mill, which produced separate concentrates of copper and nickel sulfides. The two sulfide concentrates were railed on a dedicated spur from Humboldt Township to the Canadian National Railway line, and then to smelters in Canada or to ports for shipment overseas (Lundin Mining Corp., 2017a, p. 22-25). In 2016, trade statistics from the U.S. Census Bureau indicated that 58% of total United States nickel concentrates exports went to China, and 40% went to Canada.

In June, Lundin announced an initial resource estimate and results of a Preliminary Economic Assessment of the Eagle East project, which is located approximately 2 kilometers (km; 1 mile) east and 600 meters below the Eagle deposit and part of the same intrusive complex. The company concluded that Eagle East could potentially be developed using existing infrastructure and mining methods similar to those used at the Eagle Mine, initiated a feasibility study, and began development of an access ramp. If approved, the project was expected to begin contributing mill feed in 2020 and would extend the Eagle Mine life to at least 2023 (Lundin Mining Corp., 2017b, p. 3, 19).

Minnesota.—PolyMet Mining Corp. (Canada) was waiting for approval to begin developing the copper, nickel, and

platinum-group-element (PGE) NorthMet deposit, located 10 km (6 miles) south of the town of Babbitt in St. Louis County. Ore mined from a proposed open pit would be shipped to the reconditioned Erie mill near Hoyt Lakes, MN, for processing by flotation to produce a marketable concentrate. In phase 2 of the project, the concentrate would be processed in a new hydrometallurgical plant at the Erie site (PolyMet Mining Corp., 2016, p. 14–24).

Following review of the NorthMet final environmental impact statement, the Minnesota Department of Natural Resources determined in March that PolyMet had adequately addressed the requirements of the Minnesota Environmental Protection Act. The company later submitted applications for permits necessary to construct and operate the NorthMet project. In January 2017, the U.S. Forest Service issued a final Record of Decision that authorized the company to exchange private lands within the Superior National Forest for Federal lands overlying the NorthMet deposit (PolyMet Mining Corp., 2017, p. 3–4).

Byproduct Smelter and Refinery Production.—In 2016, Stillwater Mining Co. sold 730 t of nickel in crystalline sulfate, an 11% increase from that of 2015. Stillwater mined PGEs from the J-M Reef in Montana’s Beartooth Mountains. Concentrates from the company’s two mills (East Boulder and Nye) were trucked to Stillwater’s smelting and refining complex at Columbus, MT, where a platinum-group-metal filter cake and byproduct crystalline nickel sulfate containing minor amounts of cobalt were produced. In December, Stillwater entered into a merger agreement with Sibanye Gold Ltd. (Stillwater Mining Co., 2017, p. 7–8, 21, 49).

Secondary Production.—INMETCO operated the only secondary smelter in North America dedicated to recovering chromium- and nickel-containing waste and scrap. The smelter at Ellwood City, PA, produced an iron-base remelt alloy that typically averaged 13% chromium and 12% nickel. Stainless-steel producers used the remelt alloy as a substitute for ferrochromium and ferronickel. INMETCO was capable of processing a wide range of nickel-bearing wastes including flue dust, grinding swarf, mill scale, and shot blast generated during the manufacturing of stainless steel. The complex also accepted filter cakes, plating solutions, spent pickle liquor, sludges, and all types of spent nickel-containing batteries (Horsehead Holding Corp., 2015, p. 8–10). In 2016, INMETCO’s parent company, Horsehead Holding Corp., filed for bankruptcy protection. After completing a restructuring, it emerged as Horsehead Holding LLC, a private company (Horsehead Holding LLC, 2016).

Gulf Chemical & Metallurgical Corp. was one of a limited number of companies worldwide that processed spent catalysts from petroleum refineries. The Freeport facility treated nickel-molybdenum and cobalt-molybdenum hydrotreating catalysts that had been contaminated by nickel and vanadium contained in the crude oil. Gulf Chemical first roasted and leached the spent catalysts to recover the molybdenum and vanadium. The nickel-and-alumina residue was then converted to a marketable nickel-cobalt-molybdenum alloy in a direct-current electric arc furnace (Gulf Chemical & Metallurgical Corp., 2013a, b, 2014). In 2016, the company filed for bankruptcy and announced that it would cease operation in April 2017 (Callahan, 2016).

Consumption

Reported primary nickel consumption in the United States was 97,800 t in 2016, an 8% decrease from a revised 106,000 t in 2015 (table 1). The estimated value of reported primary nickel consumption was \$938 million, a 25% decrease from 2015, owing to the decrease in reported consumption and a 19% decrease in the average annual LME cash price. U.S. industry consumed 13,400 t of ferronickel in 2016, of which 99% was used in stainless, heat-resistant, or specialty alloy steels (table 4).

Stainless Steel and Low-Alloy Steels.—In 2016, stainless steel producers accounted for 44% of reported primary nickel consumption, 67% of total nickel consumption, and 92% of nickel-containing scrap consumption in the United States (table 4). Alloy steels—other than stainless steel—accounted for an additional 4% of U.S. primary nickel use. Production of raw stainless steel and heat-resistant steel in the United States increased by 6% to 2.73 Mt. Nickel-bearing grades, which accounted for 72% of total stainless-steel production, increased by 11% to 1.98 Mt (American Iron and Steel Institute, 2016, 2017).

Allegheny Technologies Inc. (ATI) (Pittsburgh, PA) announced that it would permanently close its standard stainless melt shop and sheet finishing operations in Midland, PA, which had been idled in 2015. The plant was part of the company’s Flat Rolled Products business segment. The closure was part of the company’s strategy to reduce its production of cold- and hot-rolled stainless-steel sheets, strips, and plates and focus on higher-value alloys and specialty products (Allegheny Technologies Inc., 2017, p. F-5, F-19, F-20).

Superalloys and Related Nickel-Base Alloys.—Of the primary nickel consumed in the United States in 2016, approximately 26% was used to make high-performance superalloys and related nickel-base alloys, primarily for the aerospace, electric power, and petrochemical industries.

ATI expected that increased fuel efficiency requirements in the commercial aerospace sector would result in increased demand for specialty alloys and metal powders that withstand higher temperatures and continued its strategy of increasing the share of business attributed to higher valued products, including specialty alloys and metallic powders. The company’s revenue from its High Performance Materials & Components segment, which included nickel- and cobalt-base superalloys, as well as hafnium, niobium, titanium, and zirconium alloys, increased from 48% of total revenue in 2014 to 62% of revenue in 2016. Sales of four of the company’s nickel-base alloys increased by 55% in 2016 compared with 2015 (Allegheny Technologies Inc., 2017, p. 4, 5, F-5).

Stocks

Global stocks of nickel in LME-approved warehouses decreased to 372,066 t by December 31, 2016, a 16% decrease compared with 441,342 t at yearend 2015. Approximately 40%, or 149,676 t, was stored at Johor, Malaysia, a decrease of 16% compared with stocks at yearend 2015. Stocks in Rotterdam, the Netherlands—the traditional LME storage point for the

European Union and Russia—decreased by 35% to 85,752 t. All stocks in LME-approved warehouses were Class I material (refined products with a nickel content of 99% or greater) (London Metal Exchange Ltd., 2016).

Data collected by the INSG indicated that, in December 2016, world nickel producers held an additional 84,800 t of primary nickel stocks, essentially the same amount as yearend 2015 (International Nickel Study Group, 2017, p. A1). At yearend 2016, U.S. consumer stocks of primary nickel totaled 6,370 t, a 40% decrease from the 10,600 t held at yearend 2015 (tables 1, 5).

Prices

In January 2016, the LME average monthly cash price was \$8,480 per metric ton. Prices increased for most of 2016, ending the year with a December average of \$11,010 per metric ton. The average annual LME price for 2016 decreased to \$9,594 per metric ton (\$4.35 per pound), 19% less than the 2015 average, and was the lowest average annual cash price since 2002, when the annual average price was \$6,772 per metric ton.

World Review

In 2016, global nickel mine production decreased by 6% to 2.04 Mt, and global plant production decreased by 4% to 1.93 Mt (tables 10, 12). According to the INSG, world consumption of primary nickel increased by 8% to 2.03 Mt (International Nickel Study Group, 2017, p. A-1).

Australia.—Australia was the fourth-ranked nickel-producing country or locality in the world in terms of mine output and was one of the few countries (or) localities that mined both sulfide and lateritic ores. Australia ranked fifth in plant output and predominantly produced refined metal. In 2016, Australia's mine production decreased 9%, and plant production decreased 21% (tables 10, 12). The quantity of Australia's nickel sales has trended downwards since 2012, reflecting the downward trend in nickel price [Department of Mines and Petroleum (Western Australia), 2015, p. 29; 2016, p. 35].

In January, the Palmer Nickel and Cobalt Refinery (operated by Queensland Nickel Pty. Ltd.) in Townsville, Queensland, entered voluntary administration. Refinery operations were shut down in late February when the company was unable to obtain lateritic ore or intermediate feed material from suppliers in New Caledonia, Papua New Guinea, and the Philippines. Creditors later voted to liquidate the company (ABC Online Services, 2016; FTI Consulting (Australia) Pty. Ltd., 2016, p. 4, 10, 13).

Citing low nickel prices, Panoramic Resources Ltd. placed its Savannah underground nickel-copper sulfide mine on care-and-maintenance status in late May. However, the company intended to continue exploration to increase identified resources, update a combined feasibility study for Savannah and Savannah North projects, optimize mining and milling rates, and study the possibility of producing alternate products such as separate copper and nickel concentrates or nickel-copper-cobalt matte (Panoramic Resources Ltd., 2016, p. 2, 3).

Independence Group NL completed construction and commenced ore and concentrate production at its Nova project. The project consisted of an underground nickel-copper-cobalt mine and concentrate processing plant capable of producing

26,000 metric tons per year (t/yr) of nickel in concentrate with an initial estimated 10-year mine life. The project was expected to reach full capacity in 2017. The first concentrate was shipped to BHP Billiton's Nickel West Operation in December. Under the terms of two offtake agreements, for the first 3 years of operation, 50% of the concentrate would be sold to BHP Billiton's Nickel West operations, and the remaining 50% would be sold to Glencore plc for shipment overseas (Independence Group NL, 2016; 2017, p. 13–15).

Owing to low nickel prices, Mincor Resources NL placed the Mariners and Miitel Mines on care-and-maintenance status in February. On the basis of an updated feasibility study, the company concluded that the Mariners Mine reserves were depleted, and the mine was allowed to flood. The nickel price needed to resume operations at the Miitel Mine was found to be higher than that needed to develop the company's Durkin North project. To reduce maintenance costs, the company allowed partial flooding of the Miitel Mine but intended to reevaluate the possibility of reopening the mine in 2018 (Mincor Resources NL, 2016, p. 10–14).

Botswana.—In October, BCL Ltd. and Tati Nickel Mining Co. were placed in liquidation, and all assets of the combined operations were put up for sale. Tati Nickel's operations consisted of two copper-nickel sulfide mines—the open pit Phoenix Mine and the underground Selkirk Mine. BCL's operations consisted of three underground copper-nickel sulfide mines and the Selebei-Phikwe smelter with a capacity of 26,000 t/yr of nickel in matte (International Nickel Study Group, 2016, p. B-7, C-3; Dixon-Warren, undated).

Brazil.—In 2016, Brazil's mine production decreased by 14%, and total plant (refined metal and ferronickel) production decreased 10%, owing primarily to the suspension of operations at Votorantim S.A.'s nickel-cobalt laterite mining operation in Niquelandia, Goias State, and refined nickel and cobalt production at Sao Miguel Paulista, Sao Paulo State (Votorantim, S.A., 2017, p. 54). Ferronickel production increased 25%, with production from three facilities, Anglo American plc's Barro Alto and Codemin operations in Goias State, and Vale S.A.'s Onca Puma operation in Para (Anglo American plc, 2015; Vale S.A., 2017, p. 43).

Mirabela Nickel Ltd.'s Santa Rita open pit sulfide mine and concentrator in Bahia State were placed on care-and-maintenance status in April. The company had been under voluntary administration since September 2015, and creditors later voted to place the company in liquidation after receivers and managers were unable to secure a buyer for the company's assets [Mirabela Nickel Ltd. (in liquidation, receivers and managers appointed), 2016].

Canada.—Canada was the third-ranked nickel-producing country or locality in the world in terms of mine output and ranked fourth in plant output. In 2016, mine production was essentially unchanged from that of 2015, and plant production increased by 6% (tables 10, 12). Four Provinces had active nickel mines in 2016—Manitoba, Newfoundland and Labrador, Ontario, and Quebec—with a total mine output of 236,000 t of nickel contained in concentrate (table 10).

Owing to increased capital costs associated with more stringent sulfur dioxide emissions standards, Vale Canada Ltd.

intended to phase out smelting and refining operations at Thompson, Manitoba. The company would continue to produce concentrate from sulfide ores extracted from the Birchtree and Thompson Mines, which would be shipped to Vale's Long Harbour and Sudbury refineries (Vale S.A., 2017, p. 24, 40).

China.—China was the leading producer of primary nickel but ranked seventh in mine production (tables 10, 12). According to INSG data, most of China's mines are sulfide mines, with reserve grades typically averaging less than 1% nickel (International Nickel Study Group, 2016, p. B-14—B-21).

In 2016, China's total production of primary nickel products decreased by 3% compared with that of 2015. Production of nickel pig iron (NPI) and metal decreased by 2% and 9%, respectively, but production of chemicals increased by 50%.

According to INSG data (International Nickel Study Group, 2017, p. A-7, B-8), China was the world's leading consumer of nickel. Consumption increased by 11% and represented 54% of world consumption in 2016. China's imports of unwrought, unalloyed nickel (Harmonized Schedule number 7502.10) increased by 24% in 2016, which followed a 125% increase in 2015. Imports from Russia accounted for 63% of the total.

In the past 3 years, decreasing NPI production within China was likely related to other changes in China's trade and stocks of nickel ore and concentrates and ferronickel. Gross weight imports of ferronickel (which likely included NPI) increased substantially, by 45% (2014), 131% (2015), and 59% (2016). By contrast, gross weight imports of nickel ore and concentrates decreased, by 33% (2014), 26% (2015), and 9% (2016) (International Nickel Study Group, 2017, p. B-7).

Dominican Republic.—Americano Nickel Ltd., a subsidiary of an international investment fund, Global Special Opportunities Ltd., restarted operations at the company's Falcondo Mine and smelter near Bonao, which it acquired from Glencore in late 2015. Operations, which had been idled since 2013, consisted of a laterite mine and ferronickel plant capable of producing 32,000 t/yr of nickel in ferronickel (International Nickel Study Group, 2016, p. B-24, C-29; Williams, 2016).

Finland.—TerraFame Oy (a subsidiary of TerraFame Group Oy, owned by the Government of Finland) continued to ramp up operations at the polymetallic Sotkamo Mine and bioheap-leaching operation to produce nickel-cobalt sulfide and zinc sulfide. Operations had been idled for approximately 2 years before the company restarted operations in 2015 after acquiring the assets of Talvivaara Sotkamo Ltd. following bankruptcy proceedings. TerraFame produced a total of 9,554 t of nickel in 2016; Finland's Ministerial Committee on Economic Policy decided that negotiations to secure private financing for the operation could continue into 2017 and that additional money could be granted to TerraFame Group Oy to finance future operations (TerraFame Oy, 2016, 2017).

France.—Eramet S.A.'s Sandouville refinery in Le Havre received its last shipment of matte from its smelter in New Caledonia in September. Nickel-cobalt matte would instead be sourced from Boliden AB. Because of the differing composition of the new feed material, Sandouville's processes needed to be redesigned. Production of nickel salts and nickel metal from Boliden's matte was expected to begin in mid-2017 (Thomson Reuters, 2016a; Eramet S.A., 2017, p. 22).

Indonesia.—Through 2013, Indonesia was the leading producer of mined nickel when it produced more than 800,000 t (table 10). Production decreased dramatically in 2014 when the Government of Indonesia began to enforce its ban on the export of key unprocessed metalliferous ores. The regulations, originally enacted as Law No. 4 in 2009, effectively halted all sales of Indonesian nickeliferous direct shipping ore to overseas producers of ferronickel and NPI. The intent of the ban was to stimulate development of processing facilities that would produce higher valued products within Indonesia (Lederer, 2016). Although mine production in Indonesia increased by 53% in 2016 compared to 2015, it remained less than one-quarter of the production in 2013 (table 10). Mines that produced feed material for Perusahaan Perseroan (Persero) PT Aneka Tambang Tbk's (Antam's) ferronickel plant (19% to 21% nickel content) and PT Vale Indonesia Tbk's smelter that produced matte were unaffected by the ban.

Since 2014, Indonesia's NPI industry has expanded rapidly, often funded by leading stainless-steel producers in China. Determining the actual number of new smelters was difficult, however, because any given project likely involved multiple companies from Indonesia and China. In one publication, a new project might be attributed to the Chinese company that funded the project, whereas another publication might attribute the same project to an Indonesian company. The nickel content of NPI from new producers also varied significantly. Some of the first facilities that began production used old technology that yielded NPI with low nickel content. For example, PT Indoferro, which began operation in 2012 using a 450-cubic-meter blast furnace and was likely the first NPI producer outside China, produced NPI with a nickel content of 2.25% to 4.05% (PT Indoferro, undated). Numerous projects that were commissioned in 2016 likely produced NPI with nickel content of 10% or more. Many of the newer projects used electric arc or rotary kiln electric arc furnaces, although even projects using blast furnace technology attained NPI with higher nickel content. Larger projects were implemented in phases, with later phases often producing NPI with higher nickel content (International Nickel Study Group, 2017, D-48, D-49).

The Jakarta Post reported that six nickel pig iron smelters with a combined gross weight capacity of 767,000 t/yr were expected to be operating at yearend 2015, with several additional projects expected to begin production in 2016 (Cahyafitri, 2015). Metal Bulletin Daily (2017) estimated that Indonesia's production of NPI (nickel content) more than tripled to 95,900 t in 2016 from 30,600 t in 2015. The International Nickel Study Group (2017, p. D-48—D-52) estimated that the combined capacity of future NPI projects that it classified as "committed" or "likely" totaled 466,400 t (nickel content).

New Caledonia.—New Caledonia ranked fifth in mine production and sixth in plant production. Mine and plant production increased in 2016, by 6% and 24%, respectively. Plant production included ferronickel and nickel oxide sinter, which increased by 20% and 35%, respectively (tables 10, 12). New Caledonia also produced matte and nickel-cobalt hydroxide, which were exported for further processing (table 11). In addition to the continued low nickel price, mine operations in New Caledonia were adversely affected by the lack of demand from Queensland

Nickel's Palmer refinery. In efforts to bolster the domestic nickel industry, the Government of New Caledonia authorized additional ore exports to China (Thomson Reuters, 2016b).

By the end of 2016, Société Le Nickel (SLN) had implemented plans to reduce production costs by 25% compared with 2015. A key component of the plan was to discontinue production of matte, which it had produced since the 1880s, and instead focus on ferronickel production. In August, SLN closed the Bessemer workshop that produced matte for export to Eramet's Sandouville refinery. In efforts to support the nickel industry, France's Prime Minister announced that the Government of New Caledonia would loan the company money and provide funding for a new power plant (Eramet S.A., 2016; 2017, p. 11, 24–25).

Philippines.—The Philippines was the leading producer of mined nickel, accounting for approximately 17% of world production (table 10). Because of a shortage of processing facilities, the country exported most of its production as direct shipping ore. However, two companies operated hydrometallurgical processing plants that produced mixed nickel-cobalt sulfide compounds that were shipped to Japan for refining.

In 2016, Philippines mine production decreased by 26% (table 10), primarily because of the Department of Environment and Natural Resources' implementation of Memorandum Order (DMO) No. 2016–01, which was issued in July (Department of Environment and Natural Resources, 2016). All mines, regardless of operating status, were to be audited to determine the adequacy of each operation's environmental protection measures, and a moratorium was placed on the processing and approval of all proposed mining projects. According to the Mines and Geosciences Bureau (2017), of 28 nickel mines, operations at 7 had been suspended, and an additional 4 had temporarily stopped operating at yearend 2016.

Russia.—Russia ranked second in both nickel mine and plant production. In 2016, Russia was one of the few countries that mined both sulfide and lateritic ores, which totaled 253,000 t of contained nickel, a 9% decrease from 2015. Russia produced refined nickel and chemicals in 2016, which totaled 194,000 t, a 17% decrease compared with 2015. Plant production has decreased 28% since 2012, owing to decreases in refined metal production and the discontinuation of ferronickel production (tables 10, 12).

PJSC MMC Norilsk Nickel, Russia's leading nickel producer, was in the process of restructuring its mining and metal processing operations. As part of that plan, in August Norilsk permanently closed all smelting and refining operations of the Polar Division's Nickel Plant, which had been in operation since 1942. The company completed upgrades to the Nadezhda Metallurgical Plant to enable the plant to process all nickel concentrate from the Polar Division's Norilsk and Talnakh concentrators. Upgrades to the Talnakh concentrator that were intended to increase ore-processing volumes were completed in 2016 and the plant was expected to be fully operational in 2017. All of the company's nickel refining would take place in Harjavalta, Finland, and the Kola Peninsula. Construction of a second nickel electrolytic plant was expected to increase the Kola refinery's capacity to 190,000 t/yr by 2019 from 165,000 t/yr in 2016 (PJSC MMC Norilsk Nickel, 2017, p. 19, 23, 66, 71, 74).

Vietnam.—Asian Mineral Resources Ltd. produced nickel concentrate from massive sulfide veins at the Ban Phuc Nickel

Mine located 160 km west of Hanoi. Citing depletion of reserves and sustained low nickel prices, the company placed the mine and beneficiation plant on care-and-maintenance status in September (Asian Mineral Resources Ltd., 2017, p. 4–5).

Outlook

From 2006 to 2016, global nickel consumption has had a compound annual growth rate of approximately 4% (International Nickel Study Group, 2016, p. A–1). Stainless steel is expected to continue to be the leading end use of primary nickel. World stainless melt shop production (gross weight) has had a long-term compound annual growth rate of about 6%, climbing from 1 Mt in 1950 to 45.8 Mt in 2016. Chromium-nickel grades (300 series) constitute more than 50% of stainless-steel production (International Stainless Steel Forum, 2017, p. 4, 15).

Increased demand for more-fuel-efficient engines is expected to increase demand for nickel in the transportation manufacturing sector. In the aerospace market, the use of nickel alloys allows for more-fuel-efficient jet aircraft engines by reducing weight while allowing for more thrust and higher operating temperatures. In the automotive sector, austenitic stainless steels have been shown to reduce the weight of individual frame components by 20% compared to carbon steels, leading to improved fuel efficiency (Nickel, 2006, p. 13; 2008, p. 6).

The electric power industry is expected to remain an important consumer of austenitic stainless steel and various nickel-base superalloys—both for new construction and renovation. Global demand for electricity continues to increase and is accelerating as the population of the world increases.

The use of nickel in batteries has been estimated at 3% to 4% of total global consumption. Although there is significant opportunity for increased demand for nickel in battery applications, the battery market is highly competitive and evolving rapidly, particularly in vehicle electrification. Increased consumption of nickel in battery applications depends on a variety of factors such as how widely electric vehicles are adopted and which battery technologies are used. Many of the non-plug-in hybrid electric vehicles on U.S. highways use nickel-metal hydride batteries. Nickel has recently begun to be used in lithium-ion cathode materials, primarily as nickel-cobalt-manganese and nickel-cobalt-aluminum. Lithium-ion batteries are primarily used in consumer electronics, but the larger capacities required for vehicle electrification are expected to accelerate demand for nickel in the sector (Roskill Information Services Ltd., 2017).

References Cited

- ABC Online Services, 2016, Clive Palmer's Queensland Nickel creditors vote to liquidate debt-laden company: ABC Online Services, April 22. (Accessed June 12, 2018, at <http://www.abc.net.au/news/2016-04-22/clive-palmer-queensland-nickel-creditors-vote-to-liquidate/7349930>.)
- Allegheny Technologies Inc., 2017, ATI annual report 2016: Pittsburgh, PA, Allegheny Technologies Inc., 103 p. (Accessed June 1, 2018, at <http://ir.atimetals.com/~media/Files/A/ATIMetals-IR/annual-reports/ati2016ar.pdf>.)

- American Iron and Steel Institute, 2016, Quarterly production of stainless and heat resisting raw steel (AIS 104)—Fourth quarter [2015]: Washington, DC, American Iron and Steel Institute, 2 p.
- American Iron and Steel Institute, 2017, Quarterly production of stainless and heat resisting steel (AIS 104)—Fourth quarter [2016]: Washington, DC, American Iron and Steel Institute, 2 p.
- Anglo American plc, 2015, Mine profile—Barro Alto: London, United Kingdom, Anglo American plc, October 6. (Accessed January 19, 2018, at [http://www.angloamerican.com/media/our-stories/mine-profile-barro-alto.](http://www.angloamerican.com/media/our-stories/mine-profile-barro-alto))
- Asian Mineral Resources Ltd., 2017, Management's discussion and analysis—Year ended December 31, 2016: Toronto, Ontario, Canada, Asian Mineral Resources Ltd., 26 p. (Accessed June 29, 2018, at [http://asianmineralres.com/media/21764/amr_mda2016.pdf.](http://asianmineralres.com/media/21764/amr_mda2016.pdf))
- Cahyafitri, Raras, 2015, Two smelters to start operation by year-end: The Jakarta [Indonesia] Post, November 24. (Accessed June 27, 2018, at [http://www.thejakartapost.com/news/2015/11/24/two-smelters-start-operation-year-end.html.](http://www.thejakartapost.com/news/2015/11/24/two-smelters-start-operation-year-end.html))
- Callahan, Erin, 2016, Gulf Chemical to close its doors: Freeport, TX, The Facts, November 14. (Accessed May 31, 2018, at [http://thefacts.com/article_72c72ed5-5d83-5786-91d4-56a2d48475d4.html.](http://thefacts.com/article_72c72ed5-5d83-5786-91d4-56a2d48475d4.html))
- Department of Environment and Natural Resources [Philippines], 2016, Memorandum Order No. 2016-01: Quezon City, Philippines, Department of Environment and Natural Resources, July 8, 2 p. (Accessed June 29, 2018, [http://server2.denr.gov.ph/uploads/rmdd/dmo-2016-01.pdf.](http://server2.denr.gov.ph/uploads/rmdd/dmo-2016-01.pdf))
- Department of Mines and Petroleum (Western Australia), 2015, Western Australian mineral and petroleum statistics digest—2014-15: East Perth, Western Australia, Australia, Department of Mines and Petroleum (Western Australia), 70 p. (Accessed January 18, 2018, at [http://www.dmp.wa.gov.au/Documents/About-Us-Careers/Stats_Digest_2014-15.pdf.](http://www.dmp.wa.gov.au/Documents/About-Us-Careers/Stats_Digest_2014-15.pdf))
- Department of Mines and Petroleum (Western Australia), 2016, Western Australian mineral and petroleum statistics digest—2015-16: East Perth, Western Australia, Australia, Department of Mines and Petroleum (Western Australia), 70 p. (Accessed June 14, 2018, at [http://www.dmp.wa.gov.au/Documents/About-Us-Careers/Stats_Digest_2015-16.pdf.](http://www.dmp.wa.gov.au/Documents/About-Us-Careers/Stats_Digest_2015-16.pdf))
- Dixon-Warren, Nigel, [undated], BCL Ltd. (in liquidation) and Tati Nickel Mining Company (proprietary) Ltd. (in provisional liquidation) (collectively referred to as the BCL Group) proposed disposal of the BCL Group: Gaborone, Botswana, Botswana Chamber of Mines. (Accessed June 19, 2018, at [http://www.bcm.org.bw/proposed-disposal-of-the-bcl-group/.](http://www.bcm.org.bw/proposed-disposal-of-the-bcl-group/))
- Eramet S.A., 2016, SLN focuses on SLN 25 ferronickel production: Paris, France, Eramet S.A., August 16. (Accessed June 29, 2018, at [http://www.eramet.com/en/news/sln-focuses-slnr-25-ferronickel-production.](http://www.eramet.com/en/news/sln-focuses-slnr-25-ferronickel-production))
- Eramet S.A., 2017, Annual report 2016: Paris, France, Eramet S.A., 47 p. (Accessed June 26, 2018, at [http://www.eramet.com/en/system/files/publications/pdf/ra_eramet_2016_uk.pdf.](http://www.eramet.com/en/system/files/publications/pdf/ra_eramet_2016_uk.pdf))
- FTI Consulting (Australia) Pty. Ltd., 2016, Report by administrators—Queensland Nickel Pty Ltd (Administrators Appointed): Brisbane, Queensland, Australia, FTI Consulting (Australia) Pty. Ltd., April 11, 106 p. (Accessed June 12, 2018, at [http://www.parliament.qld.gov.au/Documents/TableOffice/TabledPapers/2016/5516T578.pdf.](http://www.parliament.qld.gov.au/Documents/TableOffice/TabledPapers/2016/5516T578.pdf))
- Gulf Chemical & Metallurgical Corp., 2013a, Refining refiners' spent catalysts: Freeport, TX, Gulf Chemical & Metallurgical Corp. press release, November 14. (Accessed July 10, 2015, at [http://www.ERAMET-gulf.com/newsPublications_pressReleasesDetail.asp?NewsPublicationsID=18.](http://www.ERAMET-gulf.com/newsPublications_pressReleasesDetail.asp?NewsPublicationsID=18))
- Gulf Chemical & Metallurgical Corp., 2013b, Spent catalyst recycling: Freeport, TX, Gulf Chemical & Metallurgical Corp. (Accessed March 12, 2013, at [http://www.ERAMET-gulf.com/SpentCatalystRecycling.asp.](http://www.ERAMET-gulf.com/SpentCatalystRecycling.asp))
- Gulf Chemical & Metallurgical Corp., 2014, Gulf 360^o—Closing the loop: Freeport, TX, Gulf Chemical & Metallurgical Corp. diagram. (Accessed May 10, 2014, at [http://www.ERAMET-gulf.com/about_Gulf_360Process.asp.](http://www.ERAMET-gulf.com/about_Gulf_360Process.asp))
- Horsehead Holding Corp., 2015, Form 10-K—2015: U.S. Securities and Exchange Commission, 76 p. plus exhibits. (Accessed February 15, 2018, at [https://www.sec.gov/Archives/edgar/data/1385544/000119312516725704/d236839d10k.htm#tx236839_11.](https://www.sec.gov/Archives/edgar/data/1385544/000119312516725704/d236839d10k.htm#tx236839_11))
- Horsehead Holding LLC, 2016, Horsehead restructuring complete: Pittsburgh, PA, BusinessWire, September 30. (Accessed May 31, 2018, at [https://www.businesswire.com/news/home/20160930005829/en/Horsehead-Restructuring-Complete.](https://www.businesswire.com/news/home/20160930005829/en/Horsehead-Restructuring-Complete))
- Independence Group NL, 2016, First nickel concentrate shipment from Nova project: South Perth, Western Australia, Australia, Independence Group NL ASX release, December 12. (Accessed May 29, 2018, at [http://www.igo.com.au/irm/PDF/4714_0/FirstConcentrateShipmentfromNova.](http://www.igo.com.au/irm/PDF/4714_0/FirstConcentrateShipmentfromNova))
- Independence Group NL, 2017, December 2016 quarter results presentation: South Perth, Western Australia, Australia, Independence Group NL presentation, January 25, 19 p. (Accessed May 29, 2018, at [http://www.igo.com.au/irm/PDF/5757_0/December2016QuarterPresentation.](http://www.igo.com.au/irm/PDF/5757_0/December2016QuarterPresentation))
- International Nickel Study Group, 2016, World directory of nickel production: Lisbon, Portugal, International Nickel Study Group, 5 sections (A–E).
- International Nickel Study Group, 2017, World nickel statistics—Monthly Bulletin: Lisbon, Portugal, International Nickel Study Group Bulletin, v. 26, no. 5, May, 4 sections (A–D).
- International Stainless Steel Forum, 2017, Stainless steel in figures 2017: Brussels, Belgium, International Stainless Steel Forum, 25 p. (Accessed May 18, 2018, at [http://www.worldstainless.org/Files/issf/non-image-files/PDF/ISSF_Stainless_Steel_in_Figures_2017_English_Public.pdf.](http://www.worldstainless.org/Files/issf/non-image-files/PDF/ISSF_Stainless_Steel_in_Figures_2017_English_Public.pdf))
- Lederer, G.W., 2016, Resource nationalism in Indonesia—Effects of the 2014 mineral export ban: U.S. Geological Survey Fact Sheet 2016-3072, September, 6 p. (Accessed January 24, 2018, at [https://pubs.usgs.gov/fs/2016/3072/fs20163072.pdf.](https://pubs.usgs.gov/fs/2016/3072/fs20163072.pdf))
- London Metal Exchange Ltd., 2016, Nickel stocks: London, United Kingdom, London Metal Exchange Ltd., December 31.
- Lundin Mining Corp., 2017a, Annual information form for the year ended December 31, 2016: Toronto, Ontario, Canada, Lundin Mining Corp., March 24, 72 p. (Accessed May 18, 2018, at [http://www.lundinmining.com/i/pdf/2016-AIF.pdf.](http://www.lundinmining.com/i/pdf/2016-AIF.pdf))
- Lundin Mining Corp., 2017b, Management's discussion and analysis for the year ended December 31, 2016: Toronto, Ontario, Canada, Lundin Mining Corp., February 22, 48 p. (Accessed May 18, 2018, at [http://www.lundinmining.com/i/pdf/2016YE.pdf.](http://www.lundinmining.com/i/pdf/2016YE.pdf))
- Metal Bulletin Daily, 2017, 2016 review—China-backed Indonesian nickel projects step up production to satisfy growing Chinese NPI demand: Metal Bulletin Daily, no. 9490.3, January 4, p. 7.
- Mincor Resources NL, 2016, Annual report 2016: West Perth, Western Australia, Australia, Mincor Resources NL, 92 p. (Accessed June 13, 2018, at [http://www.mincor.com.au/images/mincor---iuchadaize.pdf.](http://www.mincor.com.au/images/mincor---iuchadaize.pdf))
- Mines and Geosciences Bureau [Philippines], 2017, Metals output dips by 8% in 2016: Quezon City, Philippines, Department of Environment and Natural Resources, February 7, 9 p. (Accessed June 29, 2018, at [http://www.mgb.gov.ph/images/2016-Year-End-Review.pdf.](http://www.mgb.gov.ph/images/2016-Year-End-Review.pdf))
- Mirabela Nickel Ltd. (in liquidation, receivers and managers appointed), 2016, Sale process and operational update: Perth, Western Australia, Australia, Mirabela Nickel Ltd. (in liquidation, receivers and managers appointed), June 15. (Accessed June 14, 2018, via [https://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&issuerNo=00025114.](https://www.sedar.com/DisplayCompanyDocuments.do?lang=EN&issuerNo=00025114))
- Nickel, 2006, Farther, faster, and safer—Making air travel cleaner, quieter, and more fuel efficient: Nickel, v. 21, no. 3, May, p. 12–13. (Accessed January 29, 2018, at [https://www.nickelinstitute.org/~media/Files/Magazine/Volume21/Vol21-03May2006.ashx?la=en.](https://www.nickelinstitute.org/~media/Files/Magazine/Volume21/Vol21-03May2006.ashx?la=en))
- Nickel, 2008, Stainless steel car frames—The next generation: Nickel, v. 24, no. 1, December, p. 6–7. (Accessed January 29, 2018, at [https://www.nickelinstitute.org/~media/Files/Magazine/Volume24/Vol24-01Dec2008.ashx#page=6?la=en.](https://www.nickelinstitute.org/~media/Files/Magazine/Volume24/Vol24-01Dec2008.ashx#page=6?la=en))
- Nickel Institute, 2016, The life of Ni: Toronto, Ontario, Canada, Nickel Institute, 18 p. (Accessed May 18, 2018, via [https://www.nickelinstitute.org/en/MediaCentre/Publications/TheLifeofNi.aspx.](https://www.nickelinstitute.org/en/MediaCentre/Publications/TheLifeofNi.aspx))
- Panoramic Resources Ltd., 2016, Quarterly report for the period ending 30 June 2016: Perth, Western Australia, Australia, Panoramic Resources Ltd., July 29, 19 p. (Accessed May 29, 2018, at [http://panoramicresources.com/wp-content/uploads/2016/07/160729-Quarterly-Report-June-2016_FINAL.pdf.](http://panoramicresources.com/wp-content/uploads/2016/07/160729-Quarterly-Report-June-2016_FINAL.pdf))
- PJSC MMC Norilsk Nickel, 2017, Annual report 2016: Moscow, Russia, PJSC MMC Norilsk Nickel, 244 p. (Accessed June 29, 2018, via [https://ar2016.nornik.ru/en/about-report.](https://ar2016.nornik.ru/en/about-report))
- PolyMet Mining Corp., 2016, Form 20-F—2016: U.S. Securities and Exchange Commission, 62 p. plus exhibits. (Accessed January 11, 2018, at [http://polymetmining.com/wp-content/uploads/2013/02/SEDAR-2016-01-31-Annual-Report-on-Form-20F.pdf.](http://polymetmining.com/wp-content/uploads/2013/02/SEDAR-2016-01-31-Annual-Report-on-Form-20F.pdf))

- PolyMet Mining Corp., 2017, Annual information form for the fiscal year ended January 31, 2017: Toronto, Ontario, Canada, PolyMet Mining Corp., 36 p. (Accessed May 30, 2018, at <http://polymetmining.com/wp-content/uploads/2013/02/0-2017-AIF-FINAL.pdf>.)
- PT Indoferro, [undated], PT Indoferro—Nickel pig iron plant: Jakarta, Indonesia, PT Indoferro presentation. (Accessed June 27, 2018, via <http://www.indoferro.growthsteelgroup.com/indoferro.php>.)
- Roskill Information Services Ltd., 2017, Nickel market beware—Batteries can no longer be ignored: London, United Kingdom, Roskill Information Services Ltd. press release, April 20. (Accessed January 29, 2018, at <https://roskill.com/news/nickel-market-beware-batteries-can-no-longer-ignored/>.)
- Stillwater Mining Co., 2017, Form 10-K—2016: U.S. Securities and Exchange Commission, 108 p. (Accessed February 6, 2018, at <https://www.sec.gov/Archives/edgar/data/931948/000093194817000012/swc-12312016x10k.htm>.)
- Terrafame Oy, 2016, Terrafame achieved its key targets during the company's first year of operation: Tuhkakyta, Finland, Terrafame Oy, September 1. (Accessed June 27, 2018, at <https://www.terrafame.com/news-from-the-mine/news/2016/09/terrafame-achieved-its-key-targets-during-the-companys-first-year-of-operation.html>.)
- Terrafame Oy, 2017, Terrafame's EBITDA positive in the fourth quarter of 2016—Full-year net sales exceeded EUR 100 million: Tuhkakyta, Finland, Terrafame Oy, January 19. (Accessed June 27, 2018, via <https://www.terrafame.fi/ajankohtaista/uutiset/2017/01/>.)
- Thomson Reuters, 2016a, Eramet sees progress in nickel rescue plan, shares slide: Thomson Reuters, July 28. (Accessed June 26, 2018, at <https://www.reuters.com/article/eramet-nickel/eramet-sees-progress-in-nickel-rescue-plan-shares-slide-idUSL8N1AE3J8>.)
- Thomson Reuters, 2016b, New Caledonia approves extra nickel ore shipments to China: Thomson Reuters, December 30. (Accessed June 29, 2018, at <https://www.reuters.com/article/newcaledonia-nickel-china/new-caledonia-approves-extra-nickel-ore-exports-to-china-idUSL5N1EP11D>.)
- U.S. Mint, [undated]a, Circulating coin production figures: Washington, DC, U.S. Mint. (Accessed May 18, 2018, via <https://competition.usmint.gov/circulating-coins-production-figures/>.)
- U.S. Mint, [undated]b, Coin specifications: Washington, DC, U.S. Mint. (Accessed May 18, 2018, at https://www.usmint.gov/about_the_mint/index583f.html?action=coin_specifications.)
- Vale S.A., 2017, Form 20-F—2016: U.S. Securities and Exchange Commission, 173 p. plus financial statements. (Accessed June 14, 2018, via <http://www.vale.com/EN/investors/information-market/annual-reports/20f/Pages/default.aspx>.)
- Votorantim S.A., 2017, Report 2016: Sao Paulo, Brazil, Votorantim S.A., 114 p. (Accessed June 14, 2018, via http://votorantim.mzweb.com.br/votorantim/web/conteudo_en.asp?idioma=1&conta=44&tipo=38219&id=0&submenu=0&img=0&ano=2015.)
- Williams, Sam, 2016, In brief—Americano restarts Falcondo operations: Santiago, Chile, Business News Americas, September 14. (Accessed June 26, 2018, at <http://www.bnamericas.com/en/news/mining/in-brief-americano-restarts-falcondo-operations>.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

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

Other

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

TABLE 1
SALIENT NICKEL STATISTICS¹

(Metric tons of contained nickel unless otherwise specified)

	2012	2013	2014	2015	2016
United States:					
Production, concentrate	--	--	4,300	27,200	24,100
Secondary recovery from purchased scrap:					
From ferrous scrap	82,300	81,100	82,500	85,000	84,200
From nonferrous scrap	7,960 ^r	8,070 ^r	9,010 ^r	5,600 ^r	5,790
Shipments of purchased scrap ²	128,000 ^r	124,000 ^r	109,000 ^r	116,000 ^r	121,000
Exports:					
Ores and concentrates ³	760	1,010	3,320	25,400	22,400
Primary	9,130	10,600	10,400	9,600 ^r	10,300
Secondary	59,600	61,100	56,300	51,900	63,700
Imports for consumption:					
Ores and concentrates ³	(4)	3	92	24	(4)
Primary	133,000	126,000	156,000	130,000	111,000
Secondary	22,300	26,300	39,000	27,100	32,300
Consumption:					
Reported:					
Primary	106,000 ^r	107,000 ^r	113,000 ^r	106,000 ^r	97,800
Secondary, purchased scrap	90,300 ^r	89,100 ^r	91,500 ^r	90,600 ^r	90,000
Total	197,000 ^r	196,000 ^r	204,000 ^r	197,000 ^r	188,000
Apparent, primary ⁵	124,000 ^r	111,000	149,000 ^r	118,000 ^r	104,000
Apparent, primary ⁵ plus reported secondary	215,000	200,000 ^r	240,000 ^r	209,000 ^r	194,000
Stocks, yearend:					
London Metal Exchange, U.S. warehouses	402	3,950	1,560	4,210	5,230
Consumer, primary	10,200	11,800	11,100 ^r	10,600	6,370
Consumer, secondary	6,570	6,670 ^r	12,100	8,570 ^r	8,800
Total	17,200 ^r	22,400 ^r	24,800 ^r	23,400 ^r	20,400
Price, cash, London Metal Exchange:					
Average annual dollars per metric ton	17,533	15,018	16,865	11,831	9,594
Average annual dollars per pound	7.953	6.812	7.650	5.367	4.352
Price, Type 304 stainless steel scrap, gross weight: ⁶					
Average annual dollars per metric ton	1,859	1,574	1,714	1,240	1,075
Average annual dollars per long ton	1,889	1,599	1,742	1,260	1,092
World, mine production	2,420,000 ^r	2,660,000 ^r	2,170,000 ^r	2,180,000 ^r	2,040,000

^rRevised. -- Zero.

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits except prices; may not add to totals shown.

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

³Nickel ores and concentrates (Harmonized Tariff Schedule of the United States code 2604.00.0040). Source: U.S. Census Bureau.

⁴Less than ½ unit.

⁵Defined as primary imports minus primary exports plus adjustments for industry stock changes, including London Metal Exchange and primary consumer stocks.

⁶Derived from the monthly averages of the consumer buying price in Pittsburgh, PA, as published in American Metal Market. The price represents Type 304 solids and clips containing 18% to 20% chromium and 8% to 12% nickel.

TABLE 2
NICKEL RECOVERED FROM PURCHASED SCRAP
IN THE UNITED STATES,
BY KIND OF SCRAP AND FORM OF RECOVERY¹

(Metric tons of contained nickel)

	2015	2016
Kind of scrap:		
Aluminum-base	1,720 ^r	1,780
Copper-base	1,320	1,270
Ferrous-base ²	85,000	84,200
Nickel-base	2,560 ^r	2,750
Total	<u>90,600 ^r</u>	<u>90,000</u>
Form of recovery:		
Aluminum-base alloys	1,720 ^r	1,780
Copper-base alloys	2,350	2,090
Ferrous alloys	85,600 ^r	84,700
Nickel-base alloys	936 ^r	1,380
Total	<u>90,600 ^r</u>	<u>90,000</u>

^rRevised.

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

²Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

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

(Metric tons of contained nickel)

Form	2015	2016
Primary:		
Metal	89,400 ^r	81,300
Ferronickel	13,800 ^r	13,400
Oxide and oxide sinter ²	308	192
Chemicals	W	W
Other	2,910 ^r	2,930
Total	<u>106,000 ^r</u>	<u>97,800</u>
Secondary, scrap ³	<u>90,600 ^r</u>	<u>90,000</u>
Grand total	<u>197,000 ^r</u>	<u>188,000</u>

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

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes chemical-grade oxide.

³Based on gross weight of purchased scrap consumed and estimated average nickel content.

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

(Metric tons of contained nickel)

Use	2016							Grand total in 2015	
	Primary					Secondary (scrap) ³	Grand total		
	Metal	Ferronickel	Oxide and oxide sinter ²	Chemicals	Other forms				Total
Cast irons	39	--	--	--	3	42	117	160	205
Chemicals and chemical uses	W	--	--	W	W	1,750	--	1,750	W
Electric, magnet, expansion alloys	161	--	--	--	--	161	(4)	161	192
Electroplating, sales to platers	7,370	--	--	W	(4)	7,370	--	7,370	7,490
Nickel-copper and copper-nickel alloys	W	--	--	--	41	41	2,740	2,780	2,240
Other nickel and nickel alloys	11,500	W	(4)	--	47	11,600	W	11,600	W
Steel:									
Stainless and heat resistant	29,500	13,200	W	--	116	42,700	83,100	126,000	127,000 ^r
Alloys, excludes stainless	3,500	28	--	--	W	3,530	W	3,530	3,330 ^r
Superalloys	23,300	(4)	--	--	1,970	25,200	W	25,200	26,900 ^r
Other ⁵	2,080	(6)	(6)	(6)	757	5,350	4,030	9,380	29,000 ^r
Total	81,300	13,400	192	(6)	2,930	97,800	90,000	188,000	197,000 ^r

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

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes chemical-grade oxide.

³Based on gross weight of purchased scrap consumed and estimated average nickel content.

⁴Less than ½ unit.

⁵Includes batteries, catalysts, ceramics, coinage, other alloys containing nickel.

⁶Withheld to avoid disclosing company proprietary data.

TABLE 5
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES,
BY FORM, DECEMBER 31¹

(Metric tons of contained nickel)

Form	2015	2016
Primary:		
Metal	9,870 ^r	5,720
Ferronickel	W	W
Oxide and oxide sinter	76	73
Chemicals	W	W
Other	663 ^r	580
Total	10,600	6,370
Secondary, scrap	8,570 ^r	8,800
Grand total	19,200	15,200

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

¹Table includes data available through March 18, 2019. 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 CLASS¹

(Metric tons of contained nickel and thousand dollars unless otherwise specified)

Class	2015		2016	
	Quantity	Value	Quantity	Value
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	2,440	\$34,900	2,680	\$26,800
Ferronickel	118	3,270	123	3,400
Powder and flakes	1,500 ^r	55,600 ^r	1,650	53,100
Metallurgical-grade oxide ²	1,620	22,400	2,010	27,000
Chemicals:				
Catalysts ³	2,990	285,000	2,830	212,000
Salts ⁴	948	14,200	992	11,400
Total	9,600 ^r	416,000 ^r	10,300	334,000
Secondary:⁵				
Stainless steel scrap	38,600 ^r	639,000 ^r	49,000	442,000
Waste and scrap	13,400	107,000	14,600	99,300
Total	51,900	746,000 ^r	63,700	541,000
Grand total	61,500	1,160,000	73,900	875,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	213	9,760	424	11,500
Sheets, strip, foil	255	10,000	255	8,200
Tubes and pipes	58	1,620	67	3,350
Total	526	21,400	746	23,100
Alloyed:⁶				
Unwrought alloyed ingot	6,050	116,000	5,550	104,000
Bars, rods, profiles, wire	19,600 ^r	663,000	21,000	657,000
Sheets, strip, foil	15,200	472,000 ^r	10,500	301,000
Tubes and pipes	2,310	149,000	1,830	117,000
Other alloyed articles	3,330	409,000	2,450	343,000
Total	46,500	1,810,000	41,300	1,520,000

^rRevised.

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

²Nickel content is assumed to be 77%.

³Nickel content is assumed to be 22% for typical catalysts.

⁴Nickel contents are as follows: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, assumed to be 22%.

⁵Nickel contents are assumed to be 50% for waste and scrap and 7.5% for stainless steel scrap.

⁶Quantity reported in gross weight.

Source: U.S. Census Bureau.

TABLE 7
U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY OR LOCALITY¹

(Metric tons of contained nickel)²

Country or locality ³	2016							Total in 2015	Wrought nickel in 2016 ⁴	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide	Waste and scrap	Stainless steel scrap	Chemicals			Total
Australia	--	6	--	(5)	359	4	6	375	541	(5)
Bangladesh	--	--	--	--	34	104	--	138	--	--
Belgium	2	9	--	56	19	153	48	286	549	4
Brazil	222	51	(5)	--	--	2	26	301	260	3
Canada	12	153	2	1,170	9,950	13,800	1,180	26,300	13,000	42
China	513	172	30	4	103	10,000	840	11,700	12,500 ^r	53
Denmark	--	7	--	--	--	--	117	124	155	6
Finland	--	1	--	--	105	5	11	121	620	3
France	--	5	--	5	9	3	98	120	38	20
Germany	--	249	--	14	62	58	58	441	482	83
Hong Kong	40	8	--	--	--	1,060	(5)	1,110	1,200	6
India	18	53	38	2	399	5,090	480	6,080	5,270 ^r	22
Italy	--	4	--	--	--	106	10	120	79	3
Japan	(5)	80	52	--	817	1,250	59	2,260	2,290	11
Korea, Republic of	935	76	--	2	32	1,120	48	2,210	2,410	26
Malaysia	--	--	--	(5)	--	155	41	196	229	4
Mexico	736	399	--	(5)	19	832	67	2,050	2,040	319
Netherlands	--	(5)	--	(5)	411	398	150	960	543	9
Pakistan	--	1	--	--	42	4,770	4	4,820	4,090	--
Saudi Arabia	--	4	--	--	--	2	98	103	39	--
Singapore	2	162	1	2	3	32	70	273	259	6
Spain	40	--	--	--	23	50	5	117	1,350	--
Sweden	--	(5)	--	--	1,460	129	7	1,590	1,470	(5)
Taiwan	110	21	--	1	34	9,400	64	9,630	8,790 ^r	3
Thailand	--	42	(5)	(5)	--	85	36	163	313	2
United Kingdom	--	43	--	692	727	41	41	1,550	1,600	43
Vietnam	(5)	3	--	--	--	109	4	116	80	8
Other ⁶	50	100	(5)	59	22	223	255	709	1,380 ^r	68
Total	2,680	1,650	123	2,010	14,600	49,000	3,820	73,900	61,500	746

^rRevised. -- Zero.

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

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

³Countries and (or) localities listed were the leading export recipients in terms of quantity (contained weight).

⁴Not included in "2016, Total."

⁵Less than ½ unit.

⁶Includes 79 countries and (or) localities, each with less than 100 metric tons total in 2016.

Source: U.S. Census Bureau.

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

(Metric tons of contained nickel and thousand dollars unless otherwise specified)

Class	2015		2016	
	Quantity	Value	Quantity	Value
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	109,000	\$1,410,000	95,100	\$940,000
Ferronickel	11,100	139,000	8,090	102,000
Powder and flakes	5,230	98,500	4,720	76,900
Metallurgical-grade oxide ²	895	18,500	407	8,170
Chemicals:				
Catalysts ³	2,740	89,700	1,500	88,300
Salts ⁴	949	16,900	1,330	17,200
Total	130,000	1,770,000	111,000	1,230,000
Secondary:⁵				
Stainless steel scrap	14,400	165,000	19,700	182,000
Waste and scrap	12,700	173,000	12,600	143,000
Total	27,100	337,000	32,300	325,000
Grand total	157,000	2,110,000	143,000	1,560,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	260	7,060	300	10,000
Sheets, strip, foil	427	10,300	430	8,940
Tubes and pipes	103	2,430	44	901
Total	790	19,800	774	19,900
Alloyed:⁶				
Unwrought alloyed ingot	10,600	173,000	8,110	115,000
Bars, rods, profiles, wire	13,200	317,000	10,400	210,000
Sheets, strip, foil	3,700	84,100	3,540	70,500
Tubes and pipes	1,820	106,000	1,330	85,300
Other alloyed articles	2,950	207,000	3,410	237,000
Total	32,200	887,000	26,700	718,000

¹Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

²Nickel content from Australia, 90%; elsewhere, 77%.

³Nickel content is assumed to be 22% for typical catalysts.

⁴Nickel contents are as follows: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, assumed to be 22%. Excludes nickel carbonate.

⁵Nickel contents are assumed to be 50% for waste and scrap and 7.5% for stainless steel scrap.

⁶Quantity reported in gross weight.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY OR LOCALITY¹

(Metric tons of contained nickel)²

Country or locality ³	2016							Total in 2015	Wrought nickel in 2016 ⁵	
	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide ⁴	Waste and scrap	Stainless steel scrap	Chemicals			
Australia	2,020	450	--	253	137	--	--	2,860	11,900	--
Belgium	--	55	--	--	7	1	234	297	331	--
Brazil	2,150	--	3,200	--	117	31	(6)	5,500	9,980	--
Canada	51,700	3,190	--	--	3,050	12,000	54	70,000	63,100	31
China	211	120	--	146	883	10	17	1,390	1,140	17
Colombia	--	--	1,670	--	--	9	--	1,680	2,550	--
Dominican Republic	--	--	150	--	--	4	--	155	3	--
Finland	8,190	14	--	--	--	--	206	8,410	9,730	--
France	19	7	--	--	794	(6)	402	1,220	1,640	64
Germany	--	32	--	--	1,220	2	392	1,650	1,230	381
Guatemala	--	--	219	--	--	2	--	222	1,290	--
India	--	11	--	--	12	34	260	316	379	62
Italy	--	36	--	--	122	13	8	180	151	1
Japan	3,530	53	--	--	715	38	368	4,710	4,630	60
Korea, Republic of	--	(6)	--	--	272	(6)	249	521	278	--
Madagascar	2,920	--	--	--	--	--	--	2,920	7,250	--
Mexico	--	2	--	--	1,290	7,410	1	8,700	7,980	--
Netherlands	1,100	--	--	--	40	--	267	1,410	313	15
New Caledonia	--	--	2,850	--	--	--	--	2,850	3,020	--
Norway	11,900	--	--	--	--	(6)	--	11,900	13,100	--
Philippines	--	--	--	--	--	--	145	145	77	--
Russia	9,420	58	--	--	153	--	(6)	9,630	8,840	4
Singapore	--	--	--	--	220	(6)	--	220	174	(6)
South Africa	1,860	280	--	--	--	--	3	2,150	1,250	--
Switzerland	--	(6)	--	--	149	4	--	153	102	29
Taiwan	--	--	--	--	166	4	23	193	238	(6)
Turkey	--	--	--	--	266	--	--	266	282	--
United Kingdom	48	402	6	8	2,670	2	71	3,210	3,470	31
Other ⁷	--	13	--	--	308	109	127	558	2,500 ^r	77
Total	95,100	4,720	8,090	407	12,600	19,700	2,830	143,000	157,000	774

¹Revised. -- Zero.

²Table includes data available through March 18, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

³The nickel contents are assumed to be as follows: metallurgical-grade oxide from Australia, 90%; and from elsewhere, 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%; sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.

⁴Countries and (or) localities listed were the leading exporters in the United States in 2016 in terms of quantity (contained weight).

⁵Primarily oxide, rondelles, and sinter.

⁶Not included in "2016, Total."

⁷Less than ½ unit.

⁸Includes 45 countries and (or) localities, each with less than 100 metric tons total in 2016.

Source: U.S. Census Bureau.

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

(Metric tons of contained nickel)

Country or locality ³	2012	2013	2014	2015	2016
Albania, laterite ore ^c	1,000	2,100	4,900	6,500 ^r	3,960
Australia, undifferentiated or other	282,067 ^r	290,986 ^r	266,181 ^r	225,227 ^r	204,356
Botswana, sulfide ore, content of matte produced	17,942 ^r	22,848	14,958	16,789	16,878
Brazil, undifferentiated or other, ore	109,000 ^r	108,000 ^r	102,000 ^r	89,302 ^r	77,000 ^e
Burma, laterite ore	5,000 ^e	6,100 ^r	21,000	26,400	22,800
Canada, sulfide ore, concentrate	211,701	227,743	228,867	234,519 ^r	235,707
China, undifferentiated or other	93,300 ^r	93,200 ^r	101,100 ^r	101,400 ^r	98,000 ^e
Colombia, laterite ore: ⁴					
Mined	77,900 ^r	74,400 ^r	NA	NA	NA
Dry	NA	NA	47,400 ^r	43,900 ^r	41,600
Cuba, laterite ore	68,007 ^r	55,620 ^r	51,587 ^r	56,400	51,600
Dominican Republic, laterite ore	25,590	15,825	--	4,000 ^r	19,900
Finland, undifferentiated or other	19,590	19,440	18,730	9,383 ^r	20,654
Greece, laterite ore	21,980	19,100	21,405	19,610	19,431
Guatemala, laterite ore	2,400	10,200 ^{r,e}	46,800	56,400 ^r	45,900
Indonesia, laterite ore	648,400	834,200	177,100	129,600 ^r	198,900
Kazakhstan, laterite ore	450 ^e	--	--	--	--
Kosovo, laterite ore	4,436	7,606	6,724	7,418	4,300
Macedonia, laterite ore	1,680	-- ^r	-- ^r	--	--
Madagascar, laterite ore, nickel-cobalt sulfide ^c	8,300	29,000 ^r	43,000 ^r	55,000 ^r	49,000
Morocco, undifferentiated or other	288	160 ^r	-- ^r	-- ^r	--
New Caledonia, laterite ore	131,693	164,406	175,174 ^r	193,199 ^r	204,207
Norway, undifferentiated or other	352 ^r	335 ^r	400 ^r	285 ^r	220
Papua New Guinea, laterite ore, nickel-cobalt hydroxide ⁵	5,283	11,369	20,987	25,582	22,269
Philippines, laterite ore	322,424 ^r	315,633 ^r	443,909 ^r	470,042 ^r	347,423
Russia:					
Laterite ore	26,620	10,400 ^{r,e}	11,200 ^e	7,400 ^r	7,000 ^e
Sulfide ore, concentrate	270,030	270,700	271,950	269,310	245,520
South Africa, sulfide ore, concentrate	45,945	51,208	54,956	56,689	48,994
Spain, sulfide ore, concentrate	2,398	7,574	8,631	7,213	--
Turkey, laterite ore	4,400 ^r	1,200	3,223 ^r	9,600	10,200
United States, sulfide ore, concentrate	--	--	4,300	27,200	24,100
Venezuela, laterite ore ^c	8,100	--	5,000 ^r	4,800 ^r	--
Vietnam, sulfide ore, concentrate	--	1,166	6,854	8,607	4,272
Zimbabwe, sulfide ore, concentrate	7,899	12,962	16,633	16,109 ^r	17,743
Total	2,420,000 ^r	2,660,000 ^r	2,170,000 ^r	2,180,000 ^r	2,040,000
Of which: ⁶					
Laterite ore	1,360,000 ^r	1,560,000 ^r	1,080,000 ^r	1,120,000 ^r	1,050,000
Sulfide ore	556,000	594,000	607,000	636,000 ^r	593,000
Undifferentiated or other	505,000 ^r	512,000 ^r	488,000 ^r	426,000 ^r	400,000

^cEstimated. ^rRevised. NA Not available. -- Zero.

¹Table includes data available through March 1, 2018. All data was reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output, and this was noted.

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

⁴Prior to 2014, mine production was as reported by the International Study Group. From 2014 onward, mine production data were estimated using data from South 32 Company.

⁵Often called mixed hydroxide product or MHP by industry.

⁶An effort has been made to characterize each country's or locality's mine production by ore type (laterite, sulfide, and undifferentiated or other), but the data may include a small amount of production from other ore types.

TABLE 11
NICKEL: WORLD PRODUCTION OF INTERMEDIATE PRODUCTS FOR EXPORT, BY COUNTRY OR LOCALITY¹

(Metric tons of contained nickel)

Country or locality	2012	2013	2014	2015	2016
Matte:					
Australia ²	66,294	70,111 ^r	61,541 ^r	44,268 ^r	38,247
Botswana, milled	17,948	22,848	14,958	16,789	14,273
Brazil ³	14,345	11,641	--	--	--
Canada ⁴	69,600 ^r	70,700 ^r	71,100 ^r	78,800 ^r	80,000
Finland	12,915	8,662	8,363	17,000	25,000
Indonesia ⁵	70,717 ^r	75,802 ^r	78,726 ^r	81,177 ^r	77,581
New Caledonia	13,419 ^r	13,279	8,240 ^r	6,762 ^r	4,287
Russia ⁶	1 ^e	--	--	--	--
South Africa	--	5,800	7,700	400	--
Zimbabwe ⁷	3,787	3,909	4,830	3,887	5,434
Total	269,000 ^r	283,000 ^r	255,000	249,000 ^r	245,000
Other:					
Brazil, carbonate	19,611	19,958	18,800	19,600	18,500
Cuba: ^{e, 8}					
Ammoniacal liquor precipitate and unspecified	3,400 ^r	2,470 ^r	2,750 ^r	2,140 ^r	1,760
Nickel cobalt sulfide	33,900 ^r	32,500 ^r	31,900 ^r	32,700 ^r	30,300
New Caledonia, nickel-cobalt hydroxide ⁹	3,378	7,557	12,464	9,685	4,287
Papua New Guinea, nickel-cobalt hydroxide ⁹	5,283	11,369	20,987	25,582	22,269
Philippines, nickel-cobalt sulfide	23,890	26,021	50,647	51,749 ^r	45,613
Total	89,500 ^r	99,900 ^r	138,000 ^r	141,000 ^r	123,000
Grand total	358,000 ^r	383,000 ^r	393,000 ^r	391,000 ^r	368,000

^eEstimated. ^rRevised. -- Zero.

¹Table includes data available through November 23, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Figures exclude toll-refined material.

³Represents the output of the Fortaleza smelter. All of the Fortaleza matte is shipped to Finland for further processing.

⁴Nickel content of matte and other intermediate products as reported by the Global Trade Atlas using Harmonized Tariff System number 7501, with an estimated 55% nickel content.

⁵Represents the nickel output of the Soroako smelter. The Soroako matte was shipped to Japan for further processing and contains on average 78% nickel.

⁶Primarily exports to China. Sources: International Nickel Study Group and United Nations Statistics Division. The average nickel content of the exported matte is estimated to be 25%.

⁷Zimplats matte shipped to the Impala Refinery at Springs, South Africa.

⁸Corrected to remove byproduct cobalt.

⁹Often called mixed hydroxide product or MHP by industry.

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

(Metric tons of contained nickel)

Country or locality	2012	2013	2014	2015	2016
Australia:					
Metal	112,674 ^r	132,753 ^r	129,862 ^r	132,074 ^r	117,920
Unspecified	12,962 ^r	8,499 ^r	7,901	20,904 ^r	2,600
Total	125,636 ^r	141,252 ^r	137,763 ^r	152,978 ^r	120,520
Austria, ferronickel, including ferronickel molybdenum	1,000 ^r	1,000 ^r	1,000	1,000 ^r	1,000
Brazil:					
Ferronickel	31,342	34,501	37,237	54,700 ^{r,e}	68,600
Metal	21,437	19,823	21,000	21,900 ^{r,e}	--
Total	52,779	54,324	58,237	76,600 ^r	68,600
Burma, ferronickel^{e,3}	--	1,300 ^r	16,000 ^r	16,000 ^r	8,800
Canada, unspecified	146,850	152,728	149,486	149,717 ^r	158,381
China:⁴					
Chemicals, including unspecified	9,000	9,000	20,000 ^r	18,891 ^r	28,400
Ferronickel, high-nickel pig iron	353,200	480,000	471,500 ^r	385,035 ^r	375,645
Metal	197,000	227,000	247,000	236,700 ^r	216,200
Total	559,200 ^r	716,000	738,500 ^r	640,626 ^r	620,245
Colombia, ferronickel	51,595	49,320	41,221	36,671	37,091
Cuba, oxide sinter, including oxides⁵	25,702	16,616 ^r	13,251 ^r	13,300 ^{r,e}	13,300 ^e
Dominican Republic, ferronickel	15,186	9,400	--	--	9,913
Finland:^e					
Chemicals, including powder, salts, solutions, and other	6,140 ^r	4,400 ^r	5,960 ^r	7,130 ^r	8,050
Metal, electrolytic, including cathode and briquettes	40,100 ^r	39,900 ^r	36,600 ^r	36,400 ^r	45,600
Total	46,300 ^r	44,300 ^r	42,600	43,500 ^r	53,700
France:^e					
Chemicals	1,930 ^r	1,820 ^r	1,260 ^r	980 ^r	696
Metal	11,300 ^r	10,300	7,140 ^r	5,550 ^r	3,940
Total	13,200 ^r	12,100	8,400 ^r	6,530 ^r	4,640
Greece, ferronickel	18,632	16,826 ^r	18,481	17,114	17,070
Guatemala, ferronickel	--	--	5,040 ^r	10,826	8,688
Indonesia, ferronickel	18,372 ^r	18,249	16,851	17,211	20,293
Japan:					
Chemicals	2,362	2,190 ^{r,e}	5,673	10,045 ^r	11,152
Ferronickel ^e	73,200 ^r	80,600 ^r	70,100 ^r	71,200 ^r	70,300
Metal	41,944	46,405	56,129	64,068 ^r	63,442
Oxide sinter ^e	52,000 ^r	48,900 ^r	45,900 ^r	47,500 ^r	46,900
Total ^e	170,000 ^r	178,000 ^r	178,000 ^r	193,000 ^r	192,000
Korea, Republic of:					
Ferronickel	20,858	25,376	22,799	39,005 ^r	45,600
Metal	(6)	(6)	(6)	(6)	(6)
Total	20,858	25,376	22,799	39,005 ^r	45,600
Kosovo, ferronickel	4,436	7,000 ^r	7,700 ^r	11,300 ^r	1,200
Macedonia, ferronickel	19,247	20,001	18,054	17,699	10,603
Madagascar, metal	5,695	25,148	37,053	47,271	42,105
Morocco, chemicals, nickel hydroxide⁷	288 ^r	160 ^r	-- ^r	-- ^r	--
New Caledonia:					
Ferronickel	43,030	40,459	54,863	56,486	67,518
Oxide sinter	2,353	7,911	7,366	21,044	28,465
Total	45,383	48,370	62,229	77,530	95,983
Norway, metal	91,687	91,017	90,500	91,220 ^r	92,700
Russia:					
Chemicals ^e	2,700	2,700	2,700	2,900	2,400
Ferronickel, high nickel	9,782	--	--	--	--
Ferronickel, other	3,110	--	--	--	--
Metal	254,100 ^r	241,800	234,700 ^r	231,200 ^r	192,000
Total ^e	270,000 ^r	245,000	237,000 ^r	234,000 ^r	194,000
South Africa:					
Chemicals ^{e,8}	5,090 ^r	5,100	3,500	5,200 ^r	4,800
Metal	32,900	33,200	34,100	41,910 ^r	42,100
Total ^e	38,000 ^r	38,300 ^r	37,600	47,100 ^r	46,900

See footnotes at end of table.

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

(Metric tons of contained nickel)

Country or locality	2012	2013	2014	2015	2016
Taiwan, metal	(6)	(6)	(6)	(6)	(6)
Ukraine, ferronickel ⁹	20,628	21,184	18,615	17,952 ^r	18,100
United Kingdom, metal ¹⁰	39,400 ^r	42,400	39,100	38,804 ^r	45,194
Venezuela, ferronickel	8,100	--	5,000 ^r	4,000	--
Zimbabwe, metal, toll refined from imported nickel feed ¹¹	1,754	2,845	2,915	617	--
Grand total	1,810,000	1,980,000	2,000,000	2,000,000 ^r	1,930,000
Of which:					
Chemicals	27,500 ^r	25,400 ^r	39,100 ^r	45,100 ^r	55,500
Ferronickel	692,000	805,000 ^r	804,000 ^r	756,000 ^r	760,000
Metal	850,000 ^r	913,000 ^r	936,000 ^r	948,000 ^r	861,000
Oxide sinter	80,100	73,400 ^r	66,500 ^r	81,800 ^r	88,700
Unspecified	160,000 ^r	161,000 ^r	157,000 ^r	171,000 ^r	161,000

⁶Estimated. ^rRevised. -- Zero.

¹Table includes data available through November 23, 2017. All data is reported unless otherwise noted. Grand totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²North Korea was thought to have produced metallic nickel and (or) ferronickel, but information was inadequate to make reliable estimates of output levels. Several countries and (or) localities produced nickel-containing matte and other intermediate nickel products, but output of nickel in such materials has been excluded from this table to avoid double counting. Countries and (or) localities that produced matte for export are listed in table 11.

³Imports to other countries and (or) localities of ferronickel from Burma, assumed 26% nickel content.

⁴Preliminary figures for ferronickel and chemicals were derived from data published by Beijing Antaike Information Development Co. Ltd. Figures for electrolytic and other class I nickel are based on data provided by the China Nonferrous Metals Industry Association and the International Nickel Study Group. China also produced nickeliferous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

⁵An estimated 1% of reported production is unrecovered cobalt. Cuba also produces nickel sulfide and ammoniacal liquor precipitate, but because they are used as feed material elsewhere, they are not included in this table to avoid double counting.

⁶Utility[®] Nickel production figures for the Republic of Korea and Taiwan were not included because the production was derived wholly from imported metallurgical-grade oxides and to include them would result in double counting.

⁷Most of the nickel hydroxide 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.

⁸Primarily in the form of crystalline nickel sulfate. Estimates include nickel sulfate plus exported metal in concentrate.

⁹May include nickel in remelt alloys derived from scrap.

¹⁰Includes nickel content of chemicals.

¹¹Data represent production from matte imported from Botswana and nickel sulfate imported from South Africa.