



2021 Minerals Yearbook

NICKEL [ADVANCE RELEASE]

U.S. Geological Survey, Reston, Virginia: 2025

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NICKEL

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In 2021, domestic production of nickel in concentrate was 18,400 metric tons (t). The concentrate was exported to smelters in Canada and other countries. Shipments of purchased scrap, containing 99,300 t of nickel, decreased slightly from 101,000 t in 2020 (tables 1, 2).

Reported nickel consumption (primary plus secondary) in the United States in 2021 decreased by 5% to 177,000 t from 187,000 t (revised) in 2020 (table 1). U.S. apparent consumption of primary nickel was 96,900 t, or about 3% of the 2.78 million metric tons (Mt) of world consumption reported by the International Nickel Study Group (INSG) (International Nickel Study Group, 2023, p. A–1). Nickel-alloy and stainless-steel production accounted for 41% and 45%, respectively, of U.S. reported primary nickel consumption (table 4) in contrast with 6% and 70%, respectively, of global primary nickel consumption (Project Blue Group Ltd., 2024). This difference 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.

In this chapter, primary nickel refers to a nickel product produced from the beneficiation and processing of mined ore that is ready for use in a downstream consuming industry. However, some smelters and refineries add nickel-containing scrap to mined feed materials. The form and composition of the primary products are typically a function of the mineralogy of the ore deposit and types of processing used. Unwrought nickel metal in all forms [for example, briquette, cathode (electrolytic), flake, pellet, powder, rondelles, and so forth] discussed in this chapter has a purity of more than 99% and generally conforms to the INSG's definition of Class I nickel. Iron- and nickel-containing products, such as ferronickel, nickel pig iron (NPI), and nickel oxide sinter, have a purity less than 99% and generally conform to the INSG's definition of Class II nickel (International Nickel Study Group, 2023, p. iii). Specifications for nickel traded on the London Metal Exchange Ltd. (LME) require a purity of 99.8% by ASTM International standards (London Metal Exchange Ltd., undated). Nickel chemicals and salts also are often produced at nickel refineries but are differentiated from production of metal whenever feasible.

Government Actions and Legislation

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 3,535 t in 2021, a 9% decrease from 3,867 t in 2020 (U.S. Mint, undated a, b).

In 2021, the U.S. Geological Survey (USGS) released an updated draft list of critical minerals that included nickel, among others. Critical minerals are considered high-risk commodities owing to concentrated global production, U.S. reliance on foreign supplies, and their significant cost effects on key but

low-profit U.S. manufacturing industries (Nassar and Fortier, 2021, p. 1, 16).

Production

The United States had one active nickel mine, the underground Eagle Mine, in the Upper Peninsula of Michigan, which began operation in 2014. In 2021, Lundin Mining Corp. (Toronto, Ontario, Canada) produced 18,400 t of nickel in concentrate, compared with 16,700 t in 2020, an increase of 10%. Ore from the Eagle Mine was processed at the nearby Humboldt mill, which produced separate concentrates of copper and nickel sulfide minerals. The two concentrates were transported by rail to smelters in North America or to ports for overseas shipment (Lundin Mining Corp., 2022, p. 3; undated).

Limited quantities of byproduct nickel were recovered at Sibanye Stillwater Ltd.'s (Roodepoort, South Africa) base-metal refinery in Columbus, MT. Leading processors of recycled nickel included AMG Vanadium LLC (Cambridge, OH) [a subsidiary of AMG Critical Materials N.V. (Amsterdam, Netherlands)], International Metals Reclamation Co. Inc. (INMETCO) [owned by American Zinc Recycling LLC (Monaca, PA)], and Gladieux Metals Recycling, LLC (Freeport, TX). 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 2021. Any U.S. ferronickel exports were likely either reexports or material upgraded for special purposes.

Minnesota.—PolyMet Mining Corp. (St. Paul, MN) continued to advance its copper, nickel, and platinum-group-metal (PGM) NorthMet project. The project was located 10 kilometers (km) 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 to be built at the Erie site. In 2018, PolyMet had received all final State permits from the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency. In 2019, the company received the final Record of Decision from the U.S. Forest Service and the Section 404 Wetlands Permit from the U.S. Army Corps of Engineers, which then gave approval to begin construction of the mine. Two permits were subsequently challenged in court, which were unresolved at yearend 2021 (PolyMet Mining Corp., 2022, p. 5–6, 8, 24).

In 2021, Talon Metals Corp. (Toronto, Ontario, Canada) continued development of the Tamarack nickel project. In February, the company announced the results of an updated preliminary economic assessment (PEA). Under the PEA, the company considered three product scenarios: the production of

concentrate to be refined into nickel powder, nickel sulfate for the electric vehicle market, or nickel concentrate to be sold to smelters. The updated indicated resource estimate was 75,000 t of recoverable nickel, and the inferred resources were estimated to be 79,500 t of recoverable nickel (Talon Metals Corp., 2021).

Missouri.—Missouri Cobalt, LLC (St. Louis, MO) continued to progress a new hydrometallurgical facility for the production of battery-grade nickel and cobalt. In 2021, the company announced that the new facility was in the final stages of construction. The company also produced a cobalt-nickel-copper concentrate at its facility in Fredericktown, MO, which had begun production in 2019 (Missouri Cobalt, LLC, 2021).

Byproduct Smelter and Refinery Production.—Sibanye Stillwater mined PGMs at the East Boulder and Stillwater Mines in Montana's Beartooth Mountains. Both mines produced from the J-M Reef zone and operated underground. Concentrates were transported by truck to the smelting and refining complex in Columbus, MT, where a PGM filter cake and byproduct copper, cobalt, and nickel were produced (Sibanye Stillwater Ltd., undated a, b).

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. Stainless-steel producers used the remelt alloy as a substitute for ferrochromium and ferronickel. In 2021, Befesa S.A. (Luxembourg, Luxembourg) acquired American Zinc Recycling, the owner of INMETCO (Horsehead Holding Corp., 2015, p. 8–10; Befesa S.A., 2021).

In 2021, AMG Vanadium continued development of a plant to recycle spent petroleum catalysts in Zanesville, OH, similar to the company's existing plant in Cambridge, OH. The company used proprietary roasting and pyrometallurgical processing to produce ferrovanadium and ferronickel-molybdenum, which typically were sold to carbon-steel and stainless-steel producers. The new plant would effectively double the company's catalyst recycling and ferroalloy production capacity. In 2021, AMG Vanadium began its first phase of hiring (Newbanks, 2019; Couch, 2021).

Consumption

The USGS annual nickel consumption survey was sent to domestic consumers of primary nickel products. Reported primary nickel consumption in the United States was 77,900 t in 2021, a 9% decrease from 85,900 t (revised) in 2020 (table 1). The estimated value of reported primary nickel consumption was \$1.44 billion, a 22% increase from that in 2020. The increase in value of consumption was attributed to a 34% increase in the annual average LME cash price. U.S. industry consumed 11,100 t of ferronickel in 2021, a decrease of 5% from that in 2020 (table 3).

Stainless Steel and Low-Alloy Steels.—In 2021, stainless-steel producers accounted for 45% of reported primary nickel consumption, 71% of total nickel consumption, and 91% 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 and heat-resisting steel in the United States

increased by 10% to 2.37 Mt. Nickel-bearing grades increased by 6% to 1.61 Mt from that in 2020 and accounted for 68% of total stainless and heat-resisting steel (American Iron and Steel Institute, 2021, 2022). Leading domestic stainless-steel producers included AK Steel Holding Corp. (West Chester Township, OH) [a subsidiary of Cleveland-Cliffs Inc. (Cleveland, OH)], Allegheny Technologies Inc. (ATI) (Pittsburgh, PA), North American Stainless (Ghent, KY) [a subsidiary of Acerinox, S.A. (Madrid, Spain)], and Outokumpu Stainless USA, LLC (Calvert, AL) [a subsidiary of Outokumpu Oyj (Helsinki, Finland)].

Superalloys and Related Nickel-Base Alloys.—Of the primary nickel consumed in the United States in 2021, approximately 41% was used to make high-performance superalloys and related other nickel-containing alloys, primarily for the aerospace, electric power, and petrochemical industries (table 4). Leading domestic producers of these products included ATI, Carpenter Technology Corp. (Philadelphia, PA), Haynes International Inc. (Kokomo, IN), Precision Castparts Corp. (Lake Oswego, OR) [a subsidiary of Berkshire Hathaway Inc. (Omaha, NE)], and Special Metals Corp. (Huntington, WV) (a subsidiary of Berkshire Hathaway).

In December, Carpenter Technology announced a forging press outage at its Reading, PA, facility. The press was used mainly in the production of specialized materials for the aerospace market. The company already had most of the parts needed for repair and expected the outage to last up to 60 days (Carpenter Technology Corp., 2021).

Batteries.—Nickel began to be more widely used in batteries beginning with nickel-cadmium (NiCd) batteries in the 1980s. This trend accelerated in the 1990s when Toyota Motor Corp. adopted nickel-metal-hydride (NiMH) batteries for use in the hybrid-powered Prius (Nickel Institute, undated). According to Project Blue Group Ltd. (2024), batteries accounted for an estimated 9% of global primary nickel consumption in 2021, compared with an estimated 7% in 2020.

Nickel was used increasingly in the cathodes of many lithium-ion batteries. In 2021, global lithium-ion battery consumption accounted for an estimated 76% for all nickel-based batteries, followed by NiMH, 22%, and NiCd, 2%. The primary advantage of nickel-containing battery cathodes is higher energy density compared with most non-nickel-containing alternatives, which is especially important for larger capacity batteries used in applications such as electric vehicles and stationary energy storage. Two of the most common nickel-containing cathode formulations are lithium-nickel-cobalt-aluminum (NCA) and lithium-nickel-cobalt-manganese (NCM). Initially, NCM cathodes contained approximately equal amounts of cobalt, nickel, and manganese. In efforts to increase energy density, cathode manufacturers have been increasing the proportion of nickel in the cathode. In 2017, the estimated distribution of nickel use in NCM cathodes was estimated as 55% low nickel and 45% mid-nickel. By 2021, the estimated distribution was 72% mid-nickel, 16% high nickel, and 12% low nickel. Consumption of lithium iron phosphate (LFP), which does not use any nickel, continued to grow in 2021. LFP cathodes accounted for an estimated 26% of all battery consumption in 2021 and increased by an estimated 114% from that in 2020.

In October 2021, Tesla, Inc. (Austin, TX) announced that it would switch the batteries in all of its standard range vehicles to LFP chemistries owing to rising material costs (Argus Metals International, 2021e; Benchmark Mineral Intelligence Ltd., 2024a, b).

Stocks

Global stocks of nickel metal held in LME-approved warehouses decreased by 59% to 101,256 t at yearend 2021 from 247,980 t at yearend 2020. All stocks in LME-approved warehouses were Class I material (refined products with a nickel content of 99% or greater) (London Metal Exchange Ltd., 2021, 2022).

Data collected by the INSG indicated that world nickel producers held 89,600 t of primary nickel stocks at yearend 2021, a 4% increase compared with stocks at yearend 2020 (International Nickel Study Group, 2023, p. A–1). At yearend 2021, U.S. consumer stocks of primary nickel totaled 6,930 t, a 5% decrease from 7,290 t (revised) in 2020 (tables 1, 5).

Prices

According to S&P Global Platts Metals Week, the LME average annual cash price for nickel was \$18,476 per metric ton, a 34% increase from \$13,772 per metric ton in 2020 (table 1). The price increase was attributed to expectations of increased nickel consumption from the battery industry and continued consumption from stainless-steel production (McRae, 2022).

World Review

In 2021, global mine production increased by 11% to 2.73 Mt (table 10). Production from laterite deposits increased by 23% and accounted for 70% of global mine production. Production from sulfide deposits decreased by 14%, and production from undifferentiated or other deposits decreased by 4% from that in 2020. Global primary nickel production was 2.56 Mt, an increase of 3% from that in 2020. Production of ferronickel, including NPI, was 1.57 Mt, a 9% increase from that in 2020, and accounted for 61% of total primary nickel production. Production of chemicals was 117,000 t, an increase of 23%, and accounted for 5% of total nickel primary production. Production of all other forms of primary nickel decreased in 2021 compared with production in 2020 (table 12).

According to the INSG, world consumption of primary nickel was 2.78 Mt, a 16% increase from that in 2020 (International Nickel Study Group, 2023, p. A–7). World production of stainless and heat-resisting steel was 58.3 Mt in 2021, a 13% increase compared with 51.8 Mt in 2020. China was the leading producer of stainless steel, accounting for 56% of world output, and as a result, was also the leading nickel consumer (International Stainless Steel Forum, 2022, p. 8, 13). On a global basis, stainless steel accounted for about 70% of primary nickel use; batteries, 9%; plating, 7%; alloy steels and castings, 6%; nonferrous alloys, 6%; and other applications, 2% (Project Blue Group Ltd., 2024).

Australia.—Australia was the fifth-ranked nickel-producing country in the world in terms of mine output. Mine production was 150,876 t, an 11% decrease from that in 2020 (table 10).

Australia ranked sixth in primary nickel output, and its output decreased by 15% to 98,970 t in 2021 (table 12).

BHP Nickel West Pty Ltd. (Perth, Western Australia) [a subsidiary of BHP Group Ltd. (Melbourne, Victoria)] mined sulfide ore at the open pit mines of Mt Keith and the Cliffs and Leinster underground mines. Ore was processed into nickel concentrate at Mt Keith and Leinster. The company also operated a concentrator in Kambalda, which processed ore purchased from third parties. Nickel concentrate was further processed into nickel matte at the Kalgoorlie smelter. In 2021, BHP commissioned the Kwinana nickel refinery, with first production taking place in December. At full capacity, BHP planned to produce 100,000 tons per year (t/yr) of nickel sulfate from the new facility (BHP Group Ltd., 2022, p. 25).

In December, IGO Ltd. (Perth, Western Australia) announced it would acquire Western Areas Ltd. (West Perth, Western Australia) in an all-cash deal. IGO operated the nickel-copper-cobalt Nova Mine in the State of Western Australia since 2015. Through the acquisition, IGO gained ownership of the Forrester operation, consisting of the Spotted Quoll and Flying Fox nickel mines in Western Australia. Additionally, Western Areas had been developing the Cosmos nickel operation with the Odysseus Mine, scheduled to begin production in 2022 (Jamasmie, 2021; IGO Ltd., undated a, b).

In July, Panoramic Resources Ltd. (Perth, Western Australia) restarted production at the Savannah nickel-copper-cobalt mine, which had been in care-and-maintenance status since April 2020 owing to low prices and the effects of the global coronavirus disease 2019 (COVID-19) pandemic. The mine was originally commissioned in 2004 as an open pit mine, before being transitioned to underground after 18 months. The mine was also placed into care-and-maintenance status in 2015 owing to low nickel prices but restarted in 2018. In 2021, estimated proven and probable reserves were 8.27 Mt at 1.23% nickel with an estimated 102,000 t of nickel content (Panoramic Resources Ltd., 2022, p. 7, 9, 11; undated).

In November, Chalice Mining Ltd. (West Perth, Western Australia) released results of the pit-constrained maiden mineral resource estimate for the Julimar nickel-copper-PGM project located about 70 km northeast of Perth in Western Australia. Indicated resources at Julimar were estimated to be 150 Mt at 0.17% nickel with an estimated 250,000 t of nickel content, and inferred resources were estimated to be 180 Mt at 0.16% nickel with an estimated 280,000 t of nickel content (Chalice Mining Ltd., 2022, p. 2, 6).

Mincor Resources NL (West Perth, Western Australia) continued development of the Cassini and Northern Operations nickel projects in 2021. At Northern Operations, the company extracted the first ore in December, whereas Cassini production was expected to begin by early 2022. Ore mined at both operations would be destined for the Kambalda nickel concentrator operated by BHP Nickel West Pty Ltd. (Perth, Western Australia) (Mincor Resources NL, 2021, p. 14–15; 2022, p. 10).

In 2021, Queensland Pacific Metals Ltd. (QPM) (Brisbane, Queensland) continued development of the Townsville Energy Chemicals Hub (TECH). The TECH project was a battery materials refinery that would produce nickel sulfate, cobalt

sulfate, and other products. In June, the company announced that it had received equity investments from LG Energy Solution, Ltd. (LGES) (Seoul, Republic of Korea) and POSCO International (Pohang, Republic of Korea). The company also signed offtake agreements for nickel and cobalt from the TECH project. Under the agreements, LGES would purchase 7,000 t/yr of nickel and 700 t/yr of cobalt, and POSCO would purchase 3,000 t/yr of nickel and 300 t/yr of cobalt for a period of 7 years (Queensland Pacific Metals Ltd., 2021, undated).

Brazil.—In 2021, Brazil's nickel mine production was 75,988 t and total primary production was 60,809 t (tables 10, 12). Atlantic Nickel Mineração Ltda. (Belo Horizonte), a subsidiary of Appian Capital Advisory LLP (London, United Kingdom), produced 14,500 t of nickel concentrate at the Santa Rita nickel sulfide mine in 2021. The mine had reopened in 2020 after having been on care-and-maintenance status since 2018. The mine was expected to operate as an open pit for 8 years, before transitioning to underground mining for 27 years (Atlantic Nickel and Appian Capital Advisory LLP, 2022).

In 2021, Centaurus Metals Ltd. (West Perth, Western Australia, Australia) continued to develop the Jaguar nickel project, located in the Carajas mineral province in northern Brazil. In May, the company announced the results of a scoping study that concerned the production of approximately 20,000 t/yr of nickel in sulfate and 9,600 t/yr of mixed sulfide precipitate during an initial 13 years. In December, Centaurus updated the combined indicated and inferred mineral resource estimate to 80.6 Mt at 0.91% nickel with an estimated 731,000 t of nickel content. The company began a definitive feasibility study, with expected completion by the end of 2022 (Centaurus Metals Ltd., 2022, p. 4, 6).

Canada.—Globally, Canada ranked sixth in nickel mine production and fifth in primary nickel production. Mine production was 133,581 t, a decrease of 20% from that in 2020. Primary production was 109,298 t, a decrease of 12% from that in 2020 (tables 10, 12). In 2021, Vale Canada Ltd. (Toronto, Ontario), a subsidiary of Vale S.A. (Rio de Janeiro, Brazil), produced finished nickel from ores mined at Sudbury, Ontario; Thompson, Manitoba; and Voisey's Bay, Labrador. At Sudbury, production of finished nickel decreased by 26% owing to a strike and a shaft-blocking event. Decreased production was partially offset by an underground extension project at Voisey's Bay, which would replace open pit mining production with production from new underground mines and increase nickel production at Voisey's Bay to about 45,000 t/yr. The company began production at the underground Reid Brook Mine in the second quarter of 2021, and continued development at the underground Eastern Deep Mine, which was about 67% complete at yearend (Vale S.A., 2022a, p. 68, 99; 2022b, p. 6, 88).

China.—China ranked second in production of primary nickel, and ranked seventh in mine production (tables 10, 12). China relied on large quantities of imported nickel ore, concentrate, and intermediate products such as matte, nickel-cobalt hydroxide (often called mixed hydroxide product or MHP by industry), and nickel-cobalt sulfide (often called mixed sulfide product or MSP by industry) to supply its primary production. Imports of nickel ore and concentrate were 43.5 Mt (gross weight) in 2021, an increase of 11% from those in 2020.

The Philippines and New Caledonia were the leading suppliers, accounting for 90% and 5%, respectively (International Nickel Study Group, 2023, p. B).

In 2021, China's total primary nickel production was 675,000 t, a decrease of 9% from that in 2020, and accounted for 26% of world primary nickel production. Production of NPI, a form of ferronickel with a nickel content less than 15%, decreased by 14% and accounted for 64% of China's production of primary nickel. Production of nickel-based chemicals increased by 31%, and nickel metal decreased by 9% (table 12).

According to INSG data, China was the world's leading consumer of nickel. Consumption was 1.54 Mt of primary nickel, a 9% increase from 1.41 Mt in 2020, and accounted for 55% of world consumption in 2021. China's imports of unwrought, unalloyed nickel (Harmonized System code 7502.10) were 261,000 t, double the amount in 2020. Imports from Australia accounted for 49%, followed by Russia (18%) and Norway (14%). Gross weight imports of ferronickel, which likely included NPI, were 3.7 Mt, an 8% increase from that in 2020. Ferronickel imports from Indonesia increased by 15% and accounted for 84% of China's ferronickel imports (International Nickel Study Group, 2023, p. A–7, B).

In 2021, a number of companies continued to develop nickel sulfate facilities in China. In June, GEM Co., Ltd. (Shenzhen) announced that it would build a facility in Jingmen, Hubei Province, capable of producing up to 33,000 t/yr of nickel sulfate. Construction was expected to take approximately 9 months. In September, Chengtun Mining Group Co., Ltd. (Xiamen) announced plans to build a production plant for battery-grade materials in Fuquan, Guizhou Province. The facility would be completed in two phases over 3 years and would have the capacity to produce 300,000 t/yr of battery-grade nickel sulfate (Argus Metals International, 2021b, d).

Finland.—Mine production in Finland was 42,163 t, compared with 41,429 t in 2020 (table 10). Nickel matte production decreased by 24% to 19,000 t in 2021 from 25,000 t in 2020. Decreased production of nickel matte at the Harjavalta smelter was due to startup delays following planned maintenance, in addition to process disruptions related to expansion of the nickel line. On December 24, an explosion took place in the electric nickel furnace's slag tapping system. Production at the nickel line remained on hold at yearend (Boliden AB, 2022, p. 9).

Terrafame Ltd. (Sotkamo, Finland) [a subsidiary of Suomen Malmijalostus Oy (Helsinki)] produced 28,582 t of nickel content in 2021, compared with 28,740 t in 2020. In June, the company began ramping up production of a new battery chemicals plant, with a production capacity of 170,000 t/yr of nickel sulfate (Terrafame Ltd., 2021, 2022).

Indonesia.—In 2021, Indonesia was the leading global producer of mined nickel, with production of 1,036,000 t, a 34% increase from 771,000 t in 2020 (table 10). The country also was the leading global producer of primary nickel and a globally significant producer of stainless steel. Primary nickel production was 795,818, an increase of 36% from 585,970 t (revised) in 2020 (table 12). Increased primary production was the result of the continued development and commissioning of smelters which had been stimulated through implementation of a ban on

the export of unprocessed ore. Most primary production was in the form of nickel pig iron.

In 2021, a number of companies continued development of nickel materials for the battery industry since the ban on exports of unprocessed ore went into place. In May, Lygend Resources & Technology Co., Ltd. (Ningbo, China) announced first production of MHP at its facility in North Maluku on the island of Obi. It was the first project using high-pressure acid-leaching (HPAL) technology to reach production in Indonesia. First phase capacity was up to 37,000 t/yr of MHP. In December, Tsingshan Holding Group Co., Ltd. (Wenzhou, China) began production at its facility in Sulawesi. Production capacity was 100,000 t/yr of nickel matte with greater than 75% nickel content. Nickel matte is an intermediate material used to produce nickel sulfate, which is used in the cathodes of lithium-ion batteries. In 2021, Chengtun Mining Group announced a joint venture called PT ChengMach Nickel Indonesia (Jakarta), that would develop a nickel matte facility at Weda Bay. The facility, the second nickel matte project the company was involved with, would have the capacity to produce 40,000 t/yr of nickel content in matte. In April, CNGR Advanced Material Co., Ltd. (Tongren, China) announced a joint venture with Rigueza International Pte. Ltd. (Singapore) to construct a facility in Morowali to produce up to 30,000 t/yr of nickel content in matte (Argus Metals International, 2021a, c, f; Daly and others, 2021).

Madagascar.—Operations at the Ambatovy nickel mine and plant, a joint venture between Ambatovy Minerals S.A., Korea Resources Co., Ltd. (Gangwon-do, Republic of Korea), and Sumitomo Corp. (Tokyo, Japan), restarted in March 2021 after being shut down for almost a year as a result of the global COVID-19 pandemic. The plant produced 29,285 t of nickel, in the form of metal briquettes, compared with 9,874 t in 2020. Production was 33,733 t in 2019, prior to the shutdown (table 12; Ambatovy Minerals S.A., 2022, p. 14, 20).

New Caledonia.—New Caledonia ranked fourth in global nickel mine production and ninth in primary production. Mine production was 186,284 t, a decrease of 7% compared with that in 2020 (table 10). Total primary production was 56,603 t, a decrease of 22% compared with that in 2020, of which 56,372 t was in the form of ferronickel and 231 t was nickel oxide sinter (table 12). Decreased production was likely a result of bad weather, blockades, and an increase of COVID-19 cases in the region. New Caledonia also produced 16,810 t of MHP, which was exported for further processing (table 11; Eramet S.A., 2022, p. 57).

Russia.—Russia ranked third in global nickel mine production and fourth in primary production in 2021. Mine production decreased by 12% to 204,814 t from that in 2020, and primary production was 145,817 t, a decrease of 15% from that in 2020 (tables 10, 12). All production was from the operations of PJSC MMC Norilsk Nickel (Moscow). Decreased production was due to an accident that took place in February at the Norilsk concentrator and flooding at the Oktyabrsky and Taimyrsky Mines (PJSC MMC Norilsk Nickel, 2021a, b).

South Africa.—In 2021, mine production was 31,800 t, a decrease of 9% from that in 2020, and primary production was 41,527 t, an increase of 23% from that in 2020 (tables 10, 12).

In March 2021, African Rainbow Minerals Ltd. (ARM) (Sandton) placed the Nkomati Mine on care-and-maintenance status in preparation for the closure of the mine. Nickel production during the first 9 months of ARM's 2021 fiscal year (ending June 30, 2021) totaled 8,016 t, compared with 10,638 t in ARM's fiscal year 2020. In early 2021, Thakadu Group (Johannesburg) began production of high-purity nickel sulfate for the battery market. The new facility, located in Marikana, planned to produce 16,000 t in 2021 with a rampup to 25,000 t/yr. The feedstock, a crude nickel sulfate, would be extracted from a PGM concentrate from the adjacent base-metal refinery operated by Sibanye Stillwater (African Rainbow Minerals Ltd., 2021, p. 66; Cape Business News, 2021).

Outlook

Stainless steel has been and is expected to continue to be the leading end use of primary nickel, although its share of primary nickel consumption is likely to decrease as a shift to electric vehicles results in increased consumption of nickel in lithium-ion batteries. The LME annual average cash price for nickel increased by 34% in 2021, likely owing to anticipation of increased use from the lithium-ion battery market. In 2021, battery producers continued to increase the proportion of nickel in nickel-containing cathodes, although some producers planned to use non-nickel battery chemistries for standard range vehicles (table 1; Backeberg and others, 2020, p. 13; Argus Metals International, 2021e; McRae, 2022; Benchmark Mineral Intelligence Ltd., 2024a, b).

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TABLE 1
SALIENT NICKEL STATISTICS¹

(Metric tons, nickel content, unless otherwise specified)

	2017	2018	2019	2020	2021
United States:					
Production, concentrate	22,100	17,600	13,500	16,700	18,400
Secondary recovery from purchased scrap:					
From ferrous scrap	83,000	72,200	68,900 ^r	97,100	93,200
From nonferrous scrap	6,110 ^r	5,870 ^r	5,450 ^r	4,050	6,060
Exports:					
Ores and concentrates ²	20,000	18,000	14,300	13,400	14,900
Primary	11,000	9,780	12,800	11,300	11,600
Secondary	51,500	59,400	47,800	34,100	29,600
Imports for consumption:					
Ores and concentrates ²	64	3	4	95	18
Primary	150,000	144,000	119,000	105,000	108,000
Secondary	38,100	45,100	37,700	31,800	34,400
Consumption:					
Reported:					
Primary	105,000	107,000	105,000	85,900 ^r	77,900
Secondary, purchased scrap	133,000	123,000	113,000	101,000 ^r	99,300
Total	237,000	230,000	218,000	187,000 ^r	177,000
Apparent, primary	140,000	136,000	106,000	95,500 ^r	96,900
Apparent primary plus reported secondary	273,000	259,000	219,000	197,000	196,000
Stocks, yearend:					
London Metal Exchange Ltd. (LME), U.S. warehouses	3,780	2,270	1,970	1,730	1,300
Consumer, primary	6,550	6,780	6,860	7,290 ^r	6,930
Consumer, secondary	8,030	9,550	8,390	6,730 ^r	6,970
Total	18,400	18,600	17,200	15,800 ^r	15,200
Price: ³					
Cash, LME:					
Average annual dollars per metric ton	10,403	13,114	13,903	13,772	18,476
Average annual dollars per pound	4.719	5.948	6.306 ^r	6.247	8.381
Type 18-8 stainless-steel scrap, gross weight:					
Average annual dollars per metric ton	1,120 ^r	1,170 ^r	1,190 ^r	1,230 ^r	2,010
Average annual dollars per long ton	1,140 ^r	1,180 ^r	1,210 ^r	1,250 ^r	2,040
World, mine production ⁴	2,120,000 ^r	2,320,000 ^r	2,540,000 ^r	2,460,000 ^r	2,730,000

^rRevised.

¹Table includes data available through May 11, 2023. Data are rounded to no more than three significant digits, except "Price"; may not add to totals shown.

²Nickel ores and concentrates (Harmonized Tariff Schedule of the United States code 2604.00.0040). Source: U.S. Census Bureau.

³Source: S&P Global Platts Metals Week.

⁴May include estimated data.

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

(Metric tons, nickel content)

	2020	2021
Type of scrap:		
Aluminum-base	1,780	2,100
Copper-base	W	W
Ferrous-base ²	97,100	93,200
Nickel-base ³	2,270	3,960
Total	101,000	99,300
Form of recovery:		
Aluminum-base alloys	1,780	2,100
Copper-base alloys	W	W
Ferrous alloys	97,100	93,200
Nickel-base alloys	2,270	3,960
Total	101,000	99,300

W Withheld to avoid disclosing company proprietary data; not included in total.

¹Table includes data available through May 11, 2023. 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.

³Includes copper-nickel scrap.

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

(Metric tons, nickel content)

Form	2020	2021
Primary: ²		
Metal	71,900 ^r	65,700
Ferronickel	11,700	11,100
Oxide and oxide sinter ³	W	W
Other ⁴	2,250 ^r	1,050
Total	85,900 ^r	77,900
Secondary, scrap ⁵	101,000	99,300
Grand total	187,000 ^r	177,000

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

¹Table includes data available through May 11, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.

²Primary nickel refers to a nickel product produced from the beneficiation and processing of mined ore that is ready for use in a downstream consuming industry.

³Includes chemical-grade oxide.

⁴Includes base-master alloys, nickel salts, and other forms of nickel not included above.

⁵Based on gross weight of purchased scrap consumed and estimated average nickel content.

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

(Metric tons, nickel content)

Use	2021			Grand total in 2020
	Total primary ²	Secondary (scrap)	Grand total	
Chemicals and chemical uses ³	425	--	425	1,020
Nickel alloys:				
Superalloys	21,700	2,840	24,600	22,000 ^r
Other ⁴	10,500	3,350	13,800	17,500 ^r
Plating	7,170	--	7,170	7,180
Steel:				
Stainless and heat resistant	35,100	89,900	125,000	133,000
Alloys, excludes stainless	2,950	3,140	6,100	6,200 ^r
Total	77,900	99,300	177,000	187,000 ^r

^rRevised. -- Zero.

¹Table includes data available through May 11, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.

²Primary nickel refers to a nickel product produced from the beneficiation and other processing of mined ore that is ready for use in a downstream consuming industry.

³Includes batteries, catalysts, and ceramics.

⁴Includes cast iron; cemented carbides; coinage; copper-nickel and nickel-copper alloys; electrical, magnetic, expansion, and wear-resistant alloys; and powder alloys.

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

(Metric tons, nickel content)

Form	2020	2021
Primary: ²		
Metal	6,090 ^r	6,000
Ferronickel	W	W
Oxide and oxide sinter	W	W
Chemicals	W	W
Other	1,210 ^r	925
Total	7,290 ^r	6,930
Secondary, scrap	6,730 ^r	6,970
Grand total	14,000 ^r	13,900

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

¹Table includes data available through May 11, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.

²Primary nickel refers to a nickel product produced from the beneficiation and other processing of mined ore that is ready for use in a downstream consuming industry.

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

Class	2020		2021	
	Quantity (metric tons, nickel content)	Value (thousands)	Quantity (metric tons, nickel content)	Value (thousands)
Primary: ²				
Unwrought:				
Cathodes, pellets, briquettes, shot	1,580	\$22,200	1,280	\$23,500
Ferronickel	24	897	96	2,610
Powder and flakes	1,380	57,800	1,430	64,100
Metallurgical-grade oxide ³	604	7,940	1,930	11,000
Chemicals:				
Catalysts ⁴	6,600	434,000	5,860	401,000
Salts ⁵	1,080	17,600	1,040	20,700
Total	11,300	540,000	11,600	523,000
Secondary: ⁶				
Stainless-steel scrap	23,500	276,000	22,800	341,000
Waste and scrap	10,500	79,900	6,750	66,500
Total	34,100	355,000	29,600	407,000
Grand total	45,400	895,000	41,200	930,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	650	13,100	448	10,600
Sheets, strip, foil	184	6,850	154	6,420
Tubes and pipes	27	687	20	821
Total	861	20,700	622	17,900
Alloyed, gross weight:				
Unwrought alloyed ingot	6,560	154,000	4,930	139,000
Bars, rods, profiles, wire	19,200	631,000	15,800	565,000
Sheets, strip, foil	11,900	349,000	12,100	358,000
Tubes and pipes	1,720	182,000	1,750	150,000
Other alloyed articles	2,920	511,000	3,790	514,000
Total	42,300	1,830,000	38,400	1,730,000

¹Table includes data available through June 1, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.

²Primary nickel refers to a nickel product produced from the beneficiation and other processing of mined ore that is ready for use in a downstream consuming industry.

³Nickel content is assumed to be 77%.

⁴Typical catalyst is assumed to have a nickel content of 22%.

⁵Nickel contents are as follows: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, assumed to be 22%.

⁶Waste and scrap content is assumed to be 50% nickel and stainless-steel scrap, 7.5%.

Source: U.S. Census Bureau.

TABLE 7
U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY OR LOCALITY¹
(Metric tons, nickel content)²

Country or locality ³	2021										Wrought nickel in 2021 ⁵
	Cathodes, pellets, and briquettes (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide ⁴	Waste and scrap	Stainless- steel scrap	Chemicals	Total in 2021	Total in 2020		
Australia	3	6	--	--	348	3	1	361	712	(6)	
Bahrain	--	--	--	--	--	--	281	281	(6)	--	
Belgium	(6)	(6)	--	--	29	38	144	210	800	--	
Brazil	(6)	56	--	--	--	4	149	209	217	(6)	
Canada	63	139	1	1,830	4,230	3,670	1,280	11,200	11,500	8	
Cayman Islands	--	--	--	--	--	139	1	140	38	--	
China	18	162	(6)	12	--	51	1,470	1,710	1,250	27	
Denmark	--	--	--	--	--	4	84	88	326	--	
Finland	--	(6)	--	--	10	11	441	462	404	(6)	
France	(6)	7	--	8	56	--	55	127	183	7	
Germany	--	266	--	7	180	26	343	821	849	15	
Hong Kong	--	11	--	1	6	25	(6)	42	273	31	
India	--	60	85	(6)	214	10,900	149	11,400	9,660	3	
Indonesia	--	1	--	22	--	--	25	48	598	1	
Italy	--	7	--	--	121	19	193	341	197	122	
Japan	--	55	--	--	872	267	123	1,320	1,700	3	
Korea, Republic of	(6)	76	--	(6)	69	506	930	1,580	1,560	12	
Kuwait	--	--	--	--	--	--	61	61	156	--	
Malaysia	--	(6)	--	--	--	569	2	572	437	3	
Mexico	1,180	114	--	7	10	2,980	37	4,330	4,030	344	
Netherlands	--	2	--	--	125	82	29	237	370	(6)	
Nigeria	--	--	--	--	--	--	156	156	23	--	
Pakistan	--	1	--	--	3	1,320	6	1,330	1,540	--	
Russia	--	4	--	--	--	20	163	187	138	(6)	
Saudi Arabia	--	4	--	--	--	--	106	110	81	1	
Singapore	(6)	173	--	(6)	--	17	16	206	185	6	
Spain	--	2	--	--	13	26	1	42	130	6	
Sweden	--	21	--	--	2	60	4	87	326	--	
Taiwan	1	26	--	--	103	1,790	213	2,130	4,990	2	
Thailand	(6)	49	--	--	1	180	34	264	527	3	
United Arab Emirates	--	9	--	--	--	65	44	118	176	--	
United Kingdom	4	80	--	10	361	7	25	488	943	4	
Vietnam	--	5	--	--	--	--	52	57	190	6	
Other ⁷	11	99	10	31	7	96	287	542	830 ^r	19	
Total	1,280	1,440	95	1,930	6,750	22,800	6,900	41,200	45,400	622	

See footnotes at end of table.

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

¹ Revised. -- Zero.
² Table includes data available through June 1, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.
³ 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% nickel; chlorides, 25% nickel; sulfates, 22% nickel; and other salts and various catalysts are assumed to be 22% nickel.
⁴ Countries and (or) localities listed were the leading export recipients in 2021 in terms of quantity (nickel content).
⁵ Chemical-grade oxide is included in the “Chemicals” category.
⁶ Not included in total in 2021.
⁷ Less than 1/2 unit.
⁸ Includes 60 countries and (or) localities with less than 100 metric tons total in 2021.

Source: U.S. Census Bureau.

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

Class	2020		2021	
	Quantity (metric tons, nickel content)	Value (thousands)	Quantity (metric tons, nickel content)	Value (thousands)
Primary: ²				
Unwrought:				
Cathodes, pellets, briquettes, shot	87,500	\$1,190,000 ^r	77,600	\$1,410,000
Ferronickel	11,200	145,000	19,400	325,000
Powder and flakes	3,840 ^r	83,400 ^r	8,100	184,000
Metallurgical-grade oxide ³	412	7,550	308	4,070
Chemicals:				
Catalysts ⁴	1,810 ^r	75,600 ^r	1,840	86,600
Salts ⁵	665	12,700	1,110	26,100
Total	105,000	1,520,000	108,000	2,040,000
Secondary: ⁶				
Stainless-steel scrap	16,500	197,000	20,100	368,000
Waste and scrap	15,300	180,000	14,300	220,000
Total	31,800	377,000	34,400	588,000
Grand total	137,000	1,900,000	143,000	2,630,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	304	5,080	114	2,340
Sheets, strip, foil	524	13,500	491	14,200
Tubes and pipes	327	14,400	747	34,400
Total	1,160	33,000	1,350	50,900
Alloyed, gross weight:				
Unwrought alloyed ingot	3,420 ^r	54,300 ^r	5,170	55,900
Bars, rods, profiles, wire	11,800	305,000 ^r	10,700	288,000
Sheets, strip, foil	3,530	90,800	3,620	114,000
Tubes and pipes	2,350 ^r	166,000	2,090	166,000
Other alloyed articles	5,120	280,000	5,200	263,000
Total	26,300	896,000 ^r	26,800	887,000

^rRevised.

¹Table includes data available through June 28, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.

²Primary nickel refers to a nickel product produced from the beneficiation and processing of mined ore that is ready for use in a downstream consuming industry.

³Nickel content from Australia, 90%, and elsewhere, 77%.

⁴Typical catalyst is assumed to have a nickel content of 22%.

⁵Nickel 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.

⁶Waste and scrap is assumed to have 50% nickel and stainless-steel scrap, 7.5%.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY OR LOCALITY¹
(Metric tons, nickel content)²

Country or locality ³	2021										Wrought nickel in 2021 ⁵
	Cathodes, pellets, and briquettes (unwrought)	Powder and flakes	Ferronickel	Metallurgical- grade oxide ⁴	Waste and scrap	Stainless- steel scrap	Chemicals	Total in 2021	Total in 2020		
Australia	7,840	216	--	--	218	(6)	1	8,270	5,330	(6)	
Belgium	--	63	--	--	18	1	265	346	264	3	
Brazil	--	--	8,070	--	373	8	--	8,450	6,190	--	
Canada	42,700	6,530	--	--	4,320	10,700	268	64,500	70,800	561	
China	--	21	53	220	366	3	194	856	917	40	
Colombia	--	--	1,660	--	7	148	--	1,810	56	(6)	
Czechia	--	(6)	--	--	132	151	--	283	66	--	
Denmark	--	--	--	--	--	--	507	507	421	--	
Dominican Republic	--	--	2,060	--	--	91	--	2,150	1,830	--	
Estonia	--	--	--	--	179	35	--	214	194	130	
Finland	2,460	108	--	--	--	--	42	2,610	8,190	420	
France	--	7	--	3	279	4	188	481	613	--	
Germany	24	126	--	--	307	1	181	639	832	58	
Guatemala	--	--	2,200	--	2	7	--	2,210	365	3	
India	--	--	--	--	62	--	275	337	323	32	
Italy	--	--	2	(6)	136	(6)	(6)	138	220	1	
Japan	672	4	--	--	543	28	170	1,420	2,870	--	
Korea, Republic of	--	--	--	17	113	1	118	249	190	--	
Macedonia	--	--	2,800	--	--	--	--	2,800	792	13	
Mexico	--	2	--	--	1,180	8,150	--	9,330	7,830	4	
Netherlands	504	--	--	2	17	1	159	683	633	--	
New Caledonia	--	--	2,450	--	31	--	--	2,480	2,120	--	
Norway	10,300	--	--	--	15	1	6	10,400	9,230	--	
Philippines	--	--	--	--	--	--	172	172	113	--	
Poland	--	--	--	--	70	338	28	436	77	--	
Russia	4,690	293	--	--	2,060	64	(6)	7,110	8,160	2	
Saudi Arabia	--	--	--	--	246	--	29	275	377	--	
Singapore	--	--	--	--	408	--	--	408	438	5	
South Africa	7,840	239	59	--	--	(6)	35	8,170	2,050 ^r	(6)	
Trinidad and Tobago	--	--	--	--	159	8	--	167	2	2	
Turkey	--	--	--	--	202	--	--	202	106	(6)	
United Kingdom	458	469	8	14	2,390	4	220	3,560	4,660	31	
Other ⁷	89	15	26	52	433	371	91	1,080	908 ^r	49	
Total	77,600	8,100	19,400	308	14,300	20,100	2,950	143,000	137,000	1,350	

See footnotes at end of table.

See footnotes at end of table.

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

¹ Revised. -- Zero.
² Table includes data available through June 22, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.
³ 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% nickel; chlorides, 25% nickel; sulfates, 22% nickel; and 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.
⁴ Countries and (or) localities listed were the leading exporters to the United States in 2020 in terms of quantity (nickel content).
⁵ Primarily oxide, rondelles, and sinter.
⁶ Not included in total in 2021.
⁷ Less than 1/2 unit.
⁸ Includes 43 countries and (or) localities with less than 100 metric tons each in 2021.

Source: U.S. Census Bureau.

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

(Metric tons, nickel content)

Country or locality ³	2017	2018	2019	2020	2021
Albania, laterite ore	4,939	4,204	2,830	3,764 ^r	4,094
Australia, undifferentiated or other	185,466	160,022	158,751	169,344	150,876
Brazil, undifferentiated or other	68,803	65,254	55,744	77,133	75,988
Burma, laterite ore	20,000	21,000	20,000	22,200	20,000
Canada, sulfide ore, concentrate	206,354	177,867	193,057 ^r	167,243	133,581
China, undifferentiated or other	102,300	108,200	108,700 ^r	109,000 ^{r, e}	109,000 ^e
Colombia, laterite ore, dry	45,510	47,700	45,000	39,900 ^{r, e}	43,800 ^e
Cote d'Ivoire	--	3,600	9,100	18,600	22,000
Cuba, laterite ore	52,800	52,200	48,900	49,600 ^r	46,800
Dominican Republic, laterite ore ^c	22,900 ^r	26,000 ^r	40,500 ^r	34,800 ^r	51,600
Finland, undifferentiated or other	34,641	43,572	38,530	41,429	42,163
Greece, laterite ore	19,073	17,925	13,655	7,040	4,700
Guatemala, laterite ore	53,700	39,200	36,300	50,300 ^r	61,600
Indonesia, laterite ore	355,000	606,000	853,000	771,000	1,036,000
Kosovo, laterite ore ^c	7,120	4,790	3,310	3,960	4,740
Madagascar, laterite ore, nickel-cobalt sulfide ⁴	42,000 ^e	39,000 ^e	39,000 ^e	10,800	31,900
Morocco, undifferentiated or other	196	126	131	142	147
New Caledonia, laterite ore	215,382	216,225	208,185	199,375 ^r	186,284
Norway, undifferentiated or other	206	210	200	200	200
Papua New Guinea, laterite ore, nickel-cobalt hydroxide ⁵	34,666	35,355	32,720	33,659	31,594
Philippines, laterite ore	339,377	344,966	323,325	328,372 ^r	387,047
Russia:					
Laterite ore	1,800 ^e	--	--	--	--
Sulfide ore, concentrate	207,989 ^r	216,237 ^r	231,336 ^r	232,945 ^r	204,814
South Africa, sulfide ore, concentrate	48,463	43,236	43,466	34,908	31,800
Turkey, laterite ore	17,000	13,600	4,800	13,200	13,500
United States, sulfide ore, concentrate	22,100	17,600	13,500	16,700	18,400
Zambia, concentrate	--	--	1,110 ^r	3,226 ^r	3,834
Zimbabwe, sulfide ore, concentrate	16,617	17,850	16,593	16,336	16,213
Total	2,120,000 ^r	2,320,000 ^r	2,540,000 ^r	2,460,000 ^r	2,730,000
Of which:					
Laterite ore	1,230,000 ^r	1,470,000 ^r	1,670,000 ^r	1,570,000 ^r	1,920,000
Sulfide ore	502,000 ^r	473,000 ^r	498,000 ^r	468,000 ^r	405,000
Undifferentiated or other	392,000	381,000	372,000 ^r	419,000 ^r	404,000

^cEstimated. ^rRevised. -- Zero.

¹Table includes data available through October 25, 2022. All data are reported unless otherwise noted; totals may include estimated data. 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 data were not available, reported data represent a more highly processed form to provide an indication of the magnitude of mine output.

³In addition to the countries and (or) localities listed, North Korea may have produced nickel, but available information was inadequate to make reliable estimates of output.

⁴Often called mixed sulfide product or MSP.

⁵Often called mixed hydroxide product or MHP.

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

(Metric tons, nickel content)

Country or locality	2017	2018	2019	2020	2021
Matte:					
Australia	36,812	11,400	16,900	21,190	29,430
Canada ^{c, 3}	65,200	57,200	51,200	42,200	41,000
Finland	25,000	31,000	26,000	25,000	19,000
Indonesia ⁴	76,807	74,806	71,025	72,237	65,388
Russia ^{c, 5}	42,700	43,900	53,500	48,400	30,400
Zimbabwe ⁶	4,705	5,187	4,933	5,028	5,173
Total	251,000	223,000^r	224,000	214,000	190,000
Other:					
Cuba ^c					
Ammoniacal liquor precipitate and unspecified	1,800	1,300	780 ^r	730 ^r	730
Nickel-cobalt sulfide ⁷	35,200	34,800	37,000	34,800 ^r	34,400
New Caledonia, nickel-cobalt hydroxide ⁸	6,525	6,723	6,483	18,253	16,810
Papua New Guinea, nickel-cobalt hydroxide ⁸	34,666	35,355	32,720	33,659	31,594
Philippines, nickel-cobalt sulfide ⁷	50,553	48,633	51,144	49,647	43,493
Turkey, nickel-cobalt hydroxide ⁸	4,000	5,001	2,175	4,723	5,300 ^c
Total	133,000	132,000	130,000^r	142,000	132,000
Grand total	384,000	355,000	354,000	356,000	323,000

^cEstimated. ^rRevised.

¹Table includes data available through March 22, 2023. All data are reported unless otherwise noted; totals may include estimated data. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Data represent nickel content of matte and other intermediate materials produced.

³Nickel content of matte and metallurgical-grade nickel oxide as reported by the Global Trade Atlas using Harmonized System chapter number 7501. According to the International Nickel Study Group, the nickel content of matte was 50% and the nickel content of metallurgical-grade oxide was 75.2%.

⁴Represents the nickel output of the Soroako smelter. The Soroako matte was shipped to Japan for further processing and contained on average 78% nickel.

⁵Nickel content of matte, primarily exported to Finland, as reported by the Global Trade Atlas reported using Harmonized System chapter number 7501, with an estimated 40% nickel content.

⁶Zimplats matte shipped to the Impala Refinery at Springs, South Africa.

⁷Often called mixed sulfide product or MSP.

⁸Often called mixed hydroxide product or MHP.

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

(Metric tons, nickel content)

Country or locality ³	2017	2018	2019	2020	2021
Australia, metal	108,500	114,517	106,470	115,800	98,970
Austria, ferronickel	1,000	1,000	1,000	900	800
Brazil, ferronickel	68,803	65,254	54,221	58,911	60,809
Burma, ferronickel ^c	16,200	15,900	14,900 ^r	17,600 ^r	11,300
Canada, unspecified	154,759	137,411	124,736	124,043	109,298
China:					
Chemicals	39,900	45,200	41,300	64,000	84,000
Ferronickel, nickel pig iron	411,462	476,040	600,340	504,000 ^r	431,000
Metal	202,900	191,100	188,600 ^r	176,000 ^r	160,000
Total	654,262	712,340	830,240 ^r	744,000	675,000
Colombia, ferronickel	40,599	43,048	40,564	36,094	38,300
Cuba, oxide sinter, including oxides ⁴	15,751	14,670	12,900	13,100 ^r	13,800
Cyprus, nickel sulfate hexahydrate	--	--	--	--	227
Dominican Republic, ferronickel	15,632	19,214	28,450	22,005	27,849
Finland:					
Chemicals, including powder, salts, solutions, and other	8,358	10,330	10,608	10,800 ^e	9,600 ^e
Metal, electrolytic, including cathode and briquettes	51,342	50,435	51,792	52,600 ^e	39,200 ^e
Total	59,700	60,765	62,400	63,400 ^e	48,800 ^e
France: ⁵					
Chemicals	1,385	1,797	2,031	1,323	2,125
Metal, cathode	546	1,913	4,946	6,032	6,730
Total	1,931	3,710	6,977	7,355	8,855
Greece, ferronickel	16,781	15,720	11,604 ^r	5,774 ^r	4,000 ^e
Guatemala, ferronickel	12,416	14,688	20,323	22,894	20,000 ^e
Indonesia:					
Ferronickel	21,762	24,868	25,713	25,970	25,818
Ferronickel, nickel pig iron ^c	140,000 ^r	270,000 ^r	380,000 ^r	560,000 ^r	770,000
Total	161,762 ^r	294,868 ^r	405,713 ^r	585,970 ^r	795,818
Japan:					
Chemicals	16,773	15,624	16,132	14,000 ^{r,e}	16,000 ^e
Ferronickel	57,800	62,900	62,500	45,200 ^r	46,200 ^e
Metal	61,377	57,517	58,778	55,368	52,000
Oxide sinter	51,100	50,700	45,000	54,700 ^{r,e}	51,900 ^e
Total	187,050	186,741	182,410	169,268 ^r	166,100
Korea, Republic of, ferronickel	47,400	45,631	46,000	45,600 ^r	46,000 ^e
Kosovo, ferronickel	7,100	5,700	6,000	5,000	4,600
Macedonia, ferronickel	7,175	10,100	15,202	17,747	17,714
Madagascar, metal	35,474	33,183	33,733	9,874	29,285
Morocco, chemicals, nickel hydroxide	196	126	131	142	147
New Caledonia:					
Ferronickel	73,219	82,114	70,654	65,051	56,372
Oxide sinter	30,875	25,800	17,267	7,404	231
Total	104,094	107,914	87,921	72,455	56,603
Norway, metal	86,500	90,800	92,100	91,100	91,200
Russia, metal	157,396	158,005	166,265	172,357	145,817
South Africa:					
Chemicals ⁶	4,966	5,281	5,000 ^e	4,800 ^e	5,000 ^e
Metal	42,362	39,500	39,137 ^r	29,007 ^r	36,527
Total	47,328	44,781	44,137 ^r	33,807 ^r	41,527
Ukraine, ferronickel ⁷	15,300	15,807	14,200	14,719	14,000 ^e
United Kingdom, metal	37,090 ^r	38,211 ^r	34,976 ^r	35,177 ^r	35,000 ^e

See footnotes at end of table.

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

(Metric tons, nickel content)

Country or locality ³	2017	2018	2019	2020	2021
Grand total	2,060,000 ^r	2,250,000 ^r	2,440,000 ^r	2,490,000 ^r	2,560,000
Of which:					
Chemicals	71,600	78,400	75,200	95,000 ^r	117,000
Ferronickel	953,000 ^r	1,170,000 ^r	1,390,000 ^r	1,450,000 ^r	1,570,000
Metal	783,000 ^r	775,000 ^r	777,000 ^r	743,000 ^r	695,000
Oxide sinter	97,700	91,200	75,200	75,200 ^r	65,900
Unspecified	155,000	137,000	125,000	124,000	109,000

^rEstimated. ^rRevised. -- Zero.

¹Table includes data available through March 20, 2023. All data are reported unless otherwise noted; totals may include estimated data. Grand totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Primary nickel refers to a nickel product ready for use by downstream consuming industries such as nickel chemicals and salts, ferronickel, nickel metal in various forms, nickel oxide sinter, and nickel pig iron. The U.S. Geological Survey does not use the terms class I and class II nickel as defined by the International Nickel Study Group (INSG). However, nickel metal reported here is generally equivalent to Class I nickel which is defined by the INSG as nickel with a minimum nickel content of 99% in the form of briquettes, cathodes (in other words, electrolytic nickel), flakes or powders, granules, pellets, and rondelles. Ferronickel, nickel oxide sinter, and nickel pig iron are classified by the INSG as Class II. Chemicals, although typically produced at refineries, are differentiated from production of metal when feasible. Several countries and (or) localities produced nickel-containing matte and other intermediates, but output of nickel in such materials has been excluded from this table to avoid double counting. Countries and (or) localities that produced intermediate products for export are listed in table 11.

³In addition to the countries and (or) localities listed, North Korea was thought to have produced metallic nickel and (or) ferronickel, but information was inadequate to make reliable estimates of output. Several countries and (or) localities produced nickel-containing matte, 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.

⁴Includes cobalt content of nickel oxide and oxide sinter.

⁵Includes metal and nickel chloride.

⁶Primarily in the form of crystalline nickel sulfate.

⁷May include nickel in remelt alloys derived from scrap.