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Cobalt

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In 2023, U.S. cobalt production was a byproduct of nickel and copper mine production in Michigan and recovered from tailings generated by previous mining of lead and other metals in Missouri. The total quantity of U.S. cobalt production was an estimated 500 metric tons (t), unchanged from that in 2022 (table 1).

In 2023, world production of mined cobalt increased by 20% to 238,000 t, owing mostly to increased production at multiple operations in the Democratic Republic of the Congo [Congo (Kinshasa)] and new production in Indonesia. Congo (Kinshasa) remained the leading producer of mined cobalt, supplying 74% of world production (tables 1, 7).

The United States did not refine cobalt ores or concentrates in 2023. World production of refined cobalt was 180,000 t, a 12% increase from 161,000 t (revised) in 2022. China remained the leading producer of refined cobalt, supplying 82% of the world total (tables 1, 8).

In 2023, U.S. apparent consumption of cobalt was 6,440 t, a 10% decrease from apparent consumption in 2022 of 7,150 t (revised). The decrease was owing mostly to a decrease in imports of cobalt sulfates, acetates, oxides, and hydroxides (tables 1, 3). Globally, world consumption of refined cobalt increased in 2023 from that in 2022, owing largely to an increase in cobalt use in rechargeable batteries for electric vehicles (EVs). Cobalt consumption in superalloys for the aerospace sector also increased in 2023 as the aerospace sector continued to rebound from the effects of the global coronavirus disease 2019 (COVID-19) pandemic. Despite growth in consumption, increased global cobalt mine and refined production resulted in an oversupplied market in 2023 and markedly decreased cobalt prices compared to those in 2022 (Yu, 2023; Cobalt Institute, 2024, p. 6–7, 19–20; Darton Commodities Ltd., 2024, p. 31, 37, 39, 58; International Energy Agency, 2024, p. 79–80; Project Blue Group Ltd., The, 2024a, p. 7, 11).

Cobalt is a metallic element used in numerous diverse commercial, industrial, and military applications. Globally, beginning in 2021, the leading use of cobalt was lithium-ion batteries for EVs. The second-ranked use was other lithium-ion battery applications, such as drones, energy storage, laptops and tablets, and mobile phones. The third-ranked use was superalloys, which were used to make parts for gas turbine engines used in commercial and defense applications. Other metallurgical uses for cobalt included cemented carbides (also called hardmetals) and diamond tools, controlled-expansion alloys, corrosion- and wear-resistant alloys, high-speed and maraging steels, and magnets. Chemical uses for cobalt included animal feed additives; catalysts in the chemical and petroleum industries; drying agents for inks, paints, and varnishes; dyes and pigments; glass decolorizers; ground coats for porcelain enamels; humidity indicators; magnetic recording media; rubber adhesion promoters for steel-belted radial tires; and as a component of vitamin B12 (Cobalt Institute, 2024, p. 5; Darton Commodities Ltd., 2024, p. 35; Project Blue Group Ltd., The, 2024b, p. 13).

Government Actions and Legislation

Domestic cobalt supply chain vulnerabilities and import reliance have been documented in several recent Government reports including the 100-day supply chain reviews conducted under Executive Order 14017 (White House, The, 2021, p. 7, 86, 102–104), a U.S. Geological Survey (USGS) critical mineral assessment (Nassar and Fortier, 2021, p. 6–7, 10–11), and a U.S. Department of Defense (DOD) assessment of the defense industrial base (U.S. Department of Defense, 2022, p. 20–21). Through the Infrastructure Investment and Jobs Act of 2021, Inflation Reduction Act of 2022, and 2022 expansion of the Defense Production Act, the Government put multiple funding programs in place or expanded existing funding programs to support domestic cobalt extraction, processing, and recycling.

In June 2023, the DOD, through the Defense Production Act, awarded $15 million to Jervois Mining USA (a subsidiary of Jervois Global Ltd., headquartered in Australia) to support resource definition studies at its Idaho Cobalt Operations (ICO) Mine and conduct a feasibility study for a U.S. cobalt refinery. Jervois planned to evaluate costs for a U.S. refinery with a capacity of 6,000 metric tons per year (t/yr) of cobalt in sulfate to supply the EV industry (Jervois Global Ltd., 2023; U.S. Department of Defense, 2023).

In February 2023, the Department of Energy (DOE) announced $2.4 billion in conditional loan commitments to support lithium-ion battery recycling and recovery of critical minerals like cobalt from lithium-ion battery scrap. The loan commitments were awarded as part of the Advanced Technology Vehicles Manufacturing Program to Redwood Materials, Inc. (NV) and Li-Cycle US Holdings, Inc., a subsidiary of Li-Cycle Holdings Corp. headquartered in Canada. Redwood Materials, Inc. received a $2 billion loan commitment to advance construction of its battery materials plant in McCarran, NV. The company planned to manufacture 10,000 t/yr of cathode-active material (containing cobalt) from battery scrap. Li-Cycle received a $375 million loan commitment to advance construction of its resource recovery plant in Rochester, NY, where it planned to produce battery-grade cobalt chemicals from battery scrap. In October 2023, Li-Cycle paused construction of the Rochester plant, citing rising project costs. Further work on the plant was pending reevaluation of project scope, budget, and construction strategy (Li-Cycle Holdings Corp., 2023; U.S. Department of Energy, 2023a, b).

In January 2023, the U.S. Department of the Interior withdrew 91,258 hectares (225,504 acres) in northeastern Minnesota from mineral leasing for a period of 20 years. The action was taken to protect the Boundary Waters Canoe Area Wilderness and surrounding Rainy River watershed from potential environmental

impacts of mining. Withdrawn acreage encompassed parts of the Duluth Mineral Complex and included an estimated 27,382 hectares (67,663 acres) containing leasable cobalt, copper, nickel, and platinum-group metals (PGM). This action affected the Twin Metals Minnesota project, which included a proposed underground mine and concentrator within the withdrawal area. Twin Metals Minnesota LLC (MN) had submitted a mine plan of operations to the U.S. Bureau of Land Management in 2019 that outlined a schedule to produce 18,000 t of cobalt in concentrate over a mine life of 25 years (Twin Metals Minnesota LLC, 2019, p. 2–3, Table 2-11; U.S. Forest Service, 2022, p. 1, 6, 25; U.S. Department of the Interior, 2023).

The land withdrawal did not affect other Minnesota projects targeting similar mineralization, including the NorthMet Project, operated by NewRange Copper Nickel LLC (MN), or the Tamarack Project operated by Talon Metals Corp. (MN). The NorthMet project in northeastern Minnesota included a proposed open pit mine, beneficiation plant, and hydrometallurgical plant that would produce nickel-cobalt hydroxide. In 2023, NewRange Copper Nickel continued to face legal challenges to the NorthMet project and had one permit revoked by the U.S. Army Corps of Engineers and one permit remanded by the Minnesota State Supreme Court. The Tamarack project included an underground mine in central Minnesota and an ore-processing facility in North Dakota, which was supported by a $115 million DOE award granted in 2022 (PolyMet Mining Corp. 2022; 2023a, p. 20, 25; 2023b; Talon Metals Corp., 2022; U.S. Department of Energy, 2022, p. 22; State of Minnesota in Supreme Court, 2023, p. 2–3, 12; U.S. Army Corps of Engineers, undated).

In 2023, the White House announced support for the development of the Lobito Corridor, a railway connecting mining districts in Congo (Kinshasa) and Zambia to the Port of Lobito in Angola. The railway would provide a direct route to export minerals, like cobalt, that were mined and processed in Congo (Kinshasa) and Zambia to Europe and the United States. Railway development would include refurbishing existing rail lines connecting Congo (Kinshasa) to Angola and constructing new rail lines connecting Angola and Zambia. The White House announced plans for a $250 million funding package (to be administered through the U.S. International Development Finance Corporation) for rail line development and the launch of a rail line expansion feasibility study for the new section of line connecting northern Zambia. In October 2023, the U.S. Department of State announced a memorandum of understanding with the European Union, the African Development Bank, and Africa Finance Corporation, expressing intent for continued collaboration with the Governments of Angola, Congo (Kinshasa), and Zambia on the development of the Lobito Corridor. Rail infrastructure would be operated by Lobito Atlantic Railway, a joint venture among Trafigura Group Pte. Ltd. (Singapore), Mota-Engil SGPS SA (Portugal), and Vecturis SA (Belgium), who were awarded the concession in July 2023. In December 2023, a trial shipment of copper concentrate from Kolwezi, Congo (Kinshasa), by Ivanhoe Mines Ltd. to the Port of Lobito took 8 days using the railway. This was less than half of the travel time by truck to the commonly used Port of Durban, South Africa (Trafigura Group Pte. Ltd., 2023; U.S. Department of State, 2023b; White House, The, 2023 a, b; Ivanhoe Mines Ltd., 2024).

The Minerals Security Partnership (MSP) was founded in 2022 by the United States and nine partner countries committed to building robust global critical mineral supply chains and driving investment to production, processing, and recycling projects that meet high environmental, social, and governance standards. In 2023, the MSP grew to include 14 member countries and announced ongoing work to advance 17 projects that furthered the development of responsible, global critical mineral supply chains. One of the projects was focused primarily on cobalt, though no additional details on project scope or location were provided. MSP membership at yearend 2023 included the European Union, Australia, Canada, Finland, France, Germany, India, Italy, Japan, the Republic of Korea, Norway, Sweden, the United Kingdom, and the United States (U.S. Department of State, 2022, 2023a).

Production

In 2023, two companies produced recoverable cobalt-bearing ore concentrates in the United States. A third operation commenced ore extraction, but suspended construction and concentrator commissioning in March, citing low prices and unfavorable market conditions. Estimated U.S. mine production was 500 t, unchanged from that in 2022 (table 1).

Lundin Mining Corp. (Canada) produced copper and nickel sulfide concentrates from the underground Eagle nickel-copper mine, northwest of Marquette, MI, and a mill in Humboldt Township, MI. Eagle's nickel concentrates, which contained cobalt, were sent by rail to be smelted in Canada. In 2023, the expected mine life for this mine was extended to 2029 (Lundin Mining Corp., 2024a, p. 17, 19; 2024b, p. 23).

U.S. Strategic Metals, LLC (USSM) produced a bulk concentrate containing cobalt, copper, and nickel by reprocessing tailings from previous mining of lead and other metals at the Madison Mine near Fredericktown, Madison County, MO. In 2023, the company progressed construction of a commercial-scale hydrometallurgical plant in Fredericktown with the flexibility to process mineral concentrate and shredded lithium-ion battery scrap to produce cobalt sulfate, nickel sulfate, copper cathode, and lithium carbonate (M.R. Hollomon II, Commercial Director, U.S. Strategic Metals, LLC, written commun., August 2024; U.S. Strategic Metals, LLC, 2024).

In late March 2023, Jervois suspended construction and concentrator commissioning at ICO near Salmon, ID, citing low cobalt prices and increased construction costs. Jervois had begun plant commissioning in October 2022. Underground stoping activities had commenced and generated more than 27,000 t of ore, which was stored for processing. Jervois intended to finish construction and concentrator commissioning when cobalt prices recovered. During the year, the company continued drilling and studies to increase ICO's mineral resources and reserves and progressed a bankable feasibility study for a U.S. cobalt refinery. These efforts were backed by a DOD Defense Production Act Title III award in the amount of $15 million. ICO production guidance was previously estimated at 1,500 to 1,700 t of cobalt in concentrate in 2023 and 1,900 to 2,100 t of cobalt in concentrate in 2024. The mine would be one of only two mines in the world where cobalt was the principal product (Jervois Global Ltd., 2022, p. 25; 2024, p. 14–15).

U.S. processors produced intermediate or marketable cobalt chemicals from refined cobalt materials and (or) cobalt-bearing scrap. USGS data on chemical and metal powder production, shipments, and stocks were derived from a monthly voluntary survey of U.S. cobalt processors. Information from this survey was used to prepare the statistics on cobalt consumption and stocks in tables 1 and 2.

Consumption

U.S. estimated consumption of cobalt in 2023 increased by 4% to 7,840 t from that in 2022 (tables 1, 2). Cobalt consumption by metallurgical industries was estimated to have increased by 5% and cobalt consumption by chemical industries was estimated to have decreased to 2,010 t in 2023 from 2,040 t in 2022. Estimated consumption statistics were derived by the USGS from voluntary surveys of U.S. operations. Cobalt chemical-use data were estimated using data obtained from the cobalt processors survey that included three companies. A second survey covered a broad range of metal-consuming companies, such as cemented carbide, magnetic alloy, and superalloy producers. For this survey, 49 cobalt consumers were canvassed on a monthly or annual basis. Consumption and stocks data in tables 1 and 2 include reported data and estimates based on prior reports or industry trends to account for nonrespondents.

Prices

In 2023, cobalt prices declined significantly from highs in 2022 owing to increased global mined and refined production and oversupplied market.

The annual average U.S. spot price for electrolytic cobalt (cobalt cathode, minimum of 99.8% cobalt), as reported by S&P Global Platts Metals Week, was $17.20 per pound, 44% less than that in 2022 (table 1). During the first half of the year, the monthly average spot price continued to decrease from highs near $40 per pound in 2022 and reached a minimum of $14.44 per pound in May 2023. Prices recovered to a high of $18.84 per pound in November.

Cobalt metal with a minimum of 99.8% cobalt in the form of briquettes, broken and cut cathode, coarse-grain metal powder, and rounds was traded under a physically settled futures contract on the London Metal Exchange Ltd. (LME). The annual average mean of monthly cash buyer and cash seller prices was $15.48 per pound, 46% less than that in 2022. During the year, the monthly LME cash mean price declined from a maximum of $22.06 per pound in January to a minimum value of $13.12 per pound in June and remained below $15 per pound for the rest of the year. The annual average mean of cash buyer and cash seller prices and yearend LME inventory levels are listed in table 1.

Foreign Trade

Net import reliance as a percentage of apparent consumption is one measure of the adequacy of current domestic supply to meet demand. Net import reliance is defined as imports minus exports plus adjustments for industry stock changes. Releases from stocks were counted as part of import reliance regardless of whether they were originally imported or produced in the United States. In 2023, net import reliance as a percentage of apparent consumption for cobalt was 69%. Because U.S. cobalt mine production was exported to be refined, this indicated that 69% of the U.S. cobalt supply was from imports and stock releases of refined cobalt and 31% was from purchased scrap.

The cobalt content of U.S. imports and exports was estimated based on gross weight data reported by the U.S. Census Bureau. In 2023, the cobalt content of U.S. imports of metal and chemical compounds was 9,500 t, valued at $357 million, a 10% decrease in quantity from the 10,500 t of material imported in 2022 and a 40% decrease in the value of material imported in 2022 (table 3). On the basis of cobalt content, six countries supplied 88% of U.S. imports in 2023. Norway was the leading supplier, followed by Canada, Japan, Finland, Madagascar, and Morocco (table 4).

The cobalt content of U.S. exports of unwrought cobalt and chemical compounds was 5,110 t, valued at $168 million, 5% less in quantity than the 5,360 t exported in 2022. On the basis of cobalt content, Canada was the leading destination for these exports, followed by Ireland, France, Germany, and the United Kingdom, each of which imported more than 300 t of cobalt from the United States (table 5).

World Review

In 2023, world cobalt mine production totaled 238,000 t, an increase of 20% compared with revised production in 2022 (table 7). The increase was mainly the result of a 22% increase in estimated production in Congo (Kinshasa), the leading global producer of mined cobalt. World cobalt refinery production was 180,000 t, a 12% increase compared with that in 2022 (table 8).

Cobalt was produced as a byproduct of copper, nickel, and other metals, and as a primary product (the principal product of a mining or processing operation). Primary cobalt production included mine and refinery production in Morocco, artisanal mining of the mineral heterogenite (a trivalent cobalt oxyhydroxide mineral) in Congo (Kinshasa), and recovery of cobalt from previously stockpiled intermediate materials [for example, tailings in Congo (Kinshasa)], which were processed primarily to recover cobalt.

Refinery capacity by country is listed in table 6. Depending on vertical integration and the processes used, these plants consumed mainly ores, concentrates, and (or) partially refined intermediate materials; they also may have consumed some secondary (scrap) materials. The table does not include plants that reprocessed refined cobalt, plants that used scrap as their main source of feed, or plants that produced a partially refined intermediate material that required further refining by another plant.

Australia.—In 2023, Australia was the fourth-ranked cobalt-producing country or locality in the world in terms of mine output, with mine production of 5,222 t (5,793 t in 2022). Australia's refinery production was 2,400 t, a 27% decrease from that in 2022. At least six companies mined cobalt as a byproduct from cobalt-bearing nickel ore or from nickel-copper ores in Western Australia. Glencore plc's (Switzerland) Murrin Murrin nickel-cobalt laterite mining and refining operation was Australia's leading producer of mined cobalt and the sole producer of refined cobalt, which was in the form of coarse powder and briquettes. In 2023, refined cobalt production at Murrin Murrin's nickel-cobalt refinery was less than in prior

years owing to scheduled routine maintenance. Glencore's total refined cobalt production (including third-party feed) at Murrin Murrin was 2,400 t, a 27% decrease from production in 2022 (tables 7, 8; Glencore plc, 2024, p. 98, 293).

Canada.—In 2023, Canada's cobalt mine production, which was a byproduct of nickel mining, increased by 18% from that in 2022 to 4,219 t. Canada was the third-ranked producer of refined cobalt in 2023. Production of refined cobalt from domestic and imported concentrates decreased by 17% from that in 2022 to 4,835 t (tables 7, 8).

Vale S.A. (Brazil) produced 1,959 t (2,434 t in 2022) of refined cobalt metal at its Long Harbour refinery in Newfoundland and Labrador and its Port Colborne refinery in Ontario. Most of Vale's refined cobalt was produced from company-owned nickel-sulfide and nickel-copper-sulfide mines in Canada. In 2023, 637 t (1,169 t in 2022) of refined cobalt production was from ore mined at Voisey's Bay in northeastern Labrador, 365 t (367 t in 2022) was from ore mined at Sudbury, Ontario, and 94 t (143 t in 2022) was from ore mined at Thompson, Manitoba. Mine production (and subsequent refined production) from Voisey's Bay decreased in 2023 compared to that in 2022 as Vale ramped down production at the open pit mine and transitioned production to two underground mines, the Reid Brook and Eastern Deeps Mines. This mine replacement project would extend the life of its Voisey's Bay operations and increase the average annual peak production to an estimated 2,600 t/yr of cobalt. Vale achieved first ore production at its Reid Brook Mine in 2021 and expected to begin production at the Eastern Deeps Mine in 2024 (Vale S.A., 2023, p. 108–109; 2024, p. 92–93, 138).

Glencore's Integrated Nickel Operations included nickel-copper sulfide mines at Sudbury, Ontario, and Raglan, Quebec; a smelter at Sudbury, which processed ore concentrates and secondary (scrap) materials; and its Nikkelverk refinery in Norway. Glencore's Raglan Mine output in 2022 was significantly affected by an employee strike that lasted from May 27, 2022, through September 9, 2022. Increased Canadian mine production in 2023 was likely owing, in part, to a rebound in mining activity at the Raglan Mine following the conclusion of the employee strike. Decreased mine production at the Raglan Mine in 2022 also affected 2023 production of refined cobalt from Canadian source materials at Glencore's Nikkelverk refinery (Creamer Media Reporter, 2022; Glencore plc, 2024, p. 98).

In 2023, Glencore progressed Phase II of the Sivumut Project at the Raglan Mine property in Quebec. The project included expansion of the existing Qakimajurk Mine, which was completed in 2021, and the opening of an additional underground mine, which was ongoing at yearend 2023. The project was expected to enable continued mining activity at the Raglan Mine through 2040 (Glencore plc, undated).

In 2023, The Cobalt Refinery Company Inc. [part of a 50–50 joint venture of Sherritt International Corp. (Toronto, Ontario, Canada) and General Nickel Co. S.A. (Cuba)] produced 2,876 t of cobalt as metal at its refinery in Fort Saskatchewan, Alberta, a 15% decrease from the 3,368 t of cobalt produced in 2022. The decreased refinery production in 2023 compared to that in 2022 was due to lower feed availability. Approximately 95% of the refinery feed originated from the Cuban mining and processing plant operated by Moa Nickel S.A., also a 50–50 joint venture of Sherritt and General Nickel. Moa Nickel's 2023 cobalt mine production decreased 13% from 2022, owing to equipment maintenance and lower ore grades. During the year, the Moa Joint Venture completed construction of a new slurry preparation plant and progressed construction of a processing plant expansion, to be completed in 2024. The slurry preparation plant and processing plant expansion were designed to increase mine production by 20%, which would fully utilize existing capacity at the Alberta refinery and increase refined cobalt production (table 7; Sherritt International Corp., 2023, p. 6; 2024, p. 6, 17).

China.—While only an estimated 2,000 t of cobalt was mined in China, it was the world's leading producer and consumer of refined cobalt. In 2023, China's estimated production of refined cobalt increased by 18% from that in 2022 and represented 82% of world production. Most of the production was in the form of cobalt salts and oxides (82%), with the remainder as metal and metal powder (18%). China's refined metal production increased by 83% compared with that in 2022. The State Reserve Board (SRB) tendered 8,700 t of cobalt metal for stockpiling, the largest volume tendered by SRB in a single year. In 2023, the majority of China's consumption of refined cobalt was used to make cathode materials for rechargeable batteries (table 8; Darton Commodities Ltd., 2024, p. 24, 27).

Numerous companies refined and (or) processed cobalt in China. In 2023, the leading producers of refined cobalt, listed in descending order of estimated production, were Zhejiang Huayou Cobalt Co., Ltd. (Huayou), Shenzhen GEM High-Tech Co. Ltd., and CNGR Advanced Material Co. Ltd. Multiple companies worked to increase total refinery production capacity or add metal production lines to convert refined cobalt chemicals to metal. Nanjing Hanrui Cobalt Co. Ltd., increased refinery capacity from 3,000 to 5,000 t/yr of cobalt metal powder during 2022. During 2023, Tengyuan Cobalt added 13,500 t/yr of refining capacity to produce electrowinning cobalt (Nanjing Hanrui Cobalt Co. Ltd., 2022, p. 9; SMM Information & Technology Co., Ltd., 2022; Ganzhou Tengyuan Cobalt New Materials Co., Ltd., 2024, p. 30).

Only a small portion of China's cobalt production originated from domestic sources. Domestic mine production was estimated to represent less than 1% of China's cobalt raw material supply, recycled scrap was estimated to represent 8%, and imported raw materials, 91%. Most of China's refinery production was from imported intermediate cobalt chemical compounds, the majority of which was sourced from Congo (Kinshasa). In 2023, China imported 158,400 t of cobalt in concentrate and intermediate materials produced from copper and nickel operations, a 27% increase from that imported in 2022. The increase in imported intermediate materials was due, in part, to increased imports of mixed hydroxide precipitate (MHP) from Indonesia as high-pressure acid leaching (HPAL) projects started up and increased production. China imported 3,729 t of cobalt metal, a 41% increase from that imported in 2022 (Darton Commodities Ltd., 2024, p. 15, 24, 28, 30).

Congo (Kinshasa).—Congo (Kinshasa) was the world's leading producer of mined cobalt in 2023. Estimated production was 175,000 t, representing 74% of global mine production,

and a 22% increase from that in 2022. Most of the country's cobalt mine production was from copper-cobalt ores mined using industrial or mechanized methods. The rest was gathered by tens of thousands of artisanal miners handpicking cobalt-rich ores. Analysts estimated artisanal mining decreased in 2023 compared to that in 2022, owing to low cobalt prices and market oversupply. The Project Blue Group Ltd. estimated artisanal mining produced 4,500 t in 2023, representing 3% of Congo (Kinshasa)'s mine production. The majority of ores and concentrates produced in Congo (Kinshasa) were processed domestically into crude cobalt hydroxide, an intermediate material that was mostly exported for further refinement. Some concentrates were also exported (table 7; Project Blue Group Ltd., The, 2024a, p. 18).

In 2023, three companies accounted for more than one-half of Congo (Kinshasa)'s estimated cobalt mine production. CMOC Group Ltd. (China), Glencore, and Eurasian Resources Group S.a.r.l. (ERG) of Luxembourg (40% of which was owned by the Government of Kazakhstan) were the top three producers in 2023, listed in decreasing order of estimated production (Darton Commodities Ltd., 2024, p. 9).

CMOC had majority ownership of Tenke Fungurume and Kisanfu copper-cobalt mining and processing operations in Lualaba Province. In 2023, CMOC commissioned three new production lines in the central and eastern areas of the Tenke Fungurume Mine, which brought the operating capacity to 37,000 t/yr of cobalt in hydroxide. Tenke Fungurume produced 21,700 t of cobalt in hydroxide, 7% more than was produced in 2022. The Kisanfu project, which started up in the first quarter of 2023 and reached full production in the second quarter of 2023, produced 33,900 t of cobalt in hydroxide for the year. The startup of the Kisanfu project accounted for the majority of growth in Congo (Kinshasa) mine output in 2023 (CMOC Group Ltd., 2024, p. 10, 43, 324).

On April 18, CMOC and state-owned La Générale des Carrières et des Mines SA (Gécamines) reached an agreement regarding royalty payments for reserves at the Tenke Fungurume Mine. A dispute over calculating reserves and corresponding royalty payments had been ongoing since 2021. Exports of production from the mine resumed in 2023 after being halted since the third quarter of 2022 (CMOC Group Ltd., 2023, p. 41; 2024, p. 67; Liu and Njini, 2023).

Glencore had majority ownership in two copper-cobalt mining and refining operations in Congo (Kinshasa)—KCC and Mutanda, both in Lualaba Province. In 2023, KCC produced 27,600 t of cobalt in concentrates and hydroxides, an 8% increase in production from that in 2022. Mutanda produced 11,200 t of cobalt in concentrates and hydroxides, a 24% decrease in production from that in 2022. Owing to the oversupplied market, Glencore operated Mutanda at lower rates than planned and began stockpiling cobalt from August through yearend 2023 (Chalale, 2024; Glencore plc, 2024, p. 93, 96, 290).

ERG had majority ownership in two copper-cobalt operations in Congo (Kinshasa)—Boss Mining SAS and Metalkol Roan Tailings Reclamation. ERG and joint-venture partner Gécamines restarted the Boss Mining SAS Kakanda operation in Lualaba Province in November 2022 after nearly 4 years of being on care-and-maintenance status. At the mine's reopening, ERG announced it would ramp up to a full capacity of 300 metric tons per month of cobalt hydroxide by March 2023. In late May, ERG was notified by the Congo (Kinshasa) Minister of Mines of a suspension of Boss Mining after heavy rains in late March flooded a tailings dam and sparked concerns of environmental pollution in the Kakanda River. The initial suspension period of 3 months was extended for an additional 3 months, and there were no reports that operations had restarted before yearend (Eurasian Resources Group Africa, 2022; Agence Congolaise de Presse, 2023; Kavanagh, 2023a, b; Njini and Rolley, 2023).

In the fourth quarter of 2023, MMG Ltd. (China) completed construction and commissioning of a cobalt plant at the Kinsevere copper mine in Haut-Katanga Province, Congo (Kinshasa). The cobalt plant was part of a mine expansion project that also included construction of a sulfide plant to produce copper cathode from sulfide ore. This was in addition to ongoing copper production from oxide ore. The expansion project was expected to extend the Kinsevere Mine's life to 2035 and add 4,000 to 6,000 t/yr of cobalt production in hydroxide (MMG Ltd., 2024, p. 42).

Finland.—Cobalt was recovered as a byproduct from two mining operations (one in central Finland and one in northern Finland) and a smelter (in southern Finland), and was refined at plants in Harjvalta, Kokkola, and Sotkamo. Finland's mine production decreased by 14% to 1,057 in 2023 from that in 2022. Finland continued to be the second-ranked global producer of refined cobalt. Refined cobalt production in 2023 was 10,627 t, a 17% decrease in production from that in 2022 (tables 7, 8).

Boliden AB (Sweden) produced 513 t of cobalt in nickel concentrate from its open pit Kevitsa nickel-copper-PGM sulfide mine and beneficiation plant in Sodankyla, northern Finland, compared with 624 t in 2022. The company processed nickel concentrates from its Kevitsa operations and elsewhere at its Harjavalta smelter and sold the resulting nickel matte. In 2023, cobalt production was affected by lower ore grades mined at the Kevitsa Mine (Boliden AB, 2024, p. 45, 133).

In 2023, Terrafame Ltd. [majority owned by Finnish Minerals Group Ltd. (Government of Finland)] continued to ramp up production at its nickel-cobalt refinery that started up in 2021. In 2023, production was interrupted by a scheduled maintenance shutdown in May that was extended through July owing to low nickel prices. The refinery was located in Sotkamo, adjacent to and vertically integrated with Terrafame's mining and processing operations. The refinery was designed to convert mixed sulfide precipitate produced at the Terrafame polymetallic mining and bioheap-leaching operation into nickel sulfate and cobalt sulfate for battery applications. The refinery had a full production capacity of 7,400 t/yr of cobalt sulfate (Terrafame Ltd., 2021, p. 3, 13–14, 23; 2023).

Indonesia.—In 2023, Indonesia was the second-ranked mined cobalt-producing country in the world. Indonesia's estimated cobalt mine production was 19,000 t, nearly double the amount produced in 2022 (table 7). The sharp increase in production was due to the rampup of four new HPAL plants that started operations in 2021, all of which were under majority Chinese ownership. The plants processed laterite ore to produce MHP, an intermediate product containing nickel and cobalt.

The MHP could be further refined to nickel sulfate and cobalt sulfate, which were key chemicals for the battery industry. The four plants that produced cobalt in 2023 were operated by PT Halmahera Persada Lygend and PT Huayue Nickel Cobalt, which both began production in 2021; PT QMB New Energy Materials Co., Ltd., which began production in 2022; and PT Huafei Nickel Cobalt, which began production in June 2023. PT Huafei Nickel Cobalt's plant ramped up to its design capacity of 15,000 t/yr cobalt in MHP before yearend. PT Vale Indonesia Tbk continued to produce cobalt-bearing nickel matte from laterite ores at its integrated mining and smelting operation (Zhejiang Huayou Cobalt Co., Ltd., 2021; 2024, p. 14; Gem Co., Ltd., 2023, p. 34; Darton Commodities Ltd., 2024, p. 11; PT Trimegah Bangun Persada Tbk, 2024, p. 34).

PT Halmahera Persada Lygend, a joint venture among Lygend Resources, Technology Co., Ltd. (China), and PT Trimegah Bangun Persada Tbk (Indonesia), was the leading Indonesian cobalt producer in 2023. Lygend ramped up HPAL production beginning in 2021 with two production lines and a design capacity of 4,500 t/yr of cobalt in MHP. An additional production line with a design capacity of 2,250 t/yr of cobalt in MHP commenced in 2023. The company also began producing and exporting cobalt sulfate in July 2023 (PT Trimegah Bangun Persada Tbk, 2024, p. 34, 102, 106).

Japan.—In 2023, Japan ranked fourth in terms of global production of refined cobalt. Cobalt was produced at two refineries operated by Sumitomo Metal Mining Corp. The Niihama nickel refinery in Ehime Prefecture produced cobalt metal, and the Harima refinery in Hyogo Prefecture produced cobalt chemical precursors for battery materials. Both refineries processed mixed nickel-cobalt sulfides produced at HPAL plants in the Philippines owned by subsidiaries Coral Bay Nickel Corp. (Philippines) and Taganito HPAL Nickel Corp. (Philippines). The Niihama nickel refinery additionally processed nickel matte (containing cobalt) from PT Vale in Indonesia, and additional cobalt-bearing nickel raw materials from elsewhere (Sumitomo Metal Mining Co., Ltd., 2024, p. 63–64, 138, 141).

Morocco.—Compagnie de Tifnout Tighanimine (CTT) (a subsidiary of Groupe Managem) mined cobalt arsenide ores and produced crude cobalt hydroxide at the Bou-Azzer Mine. The hydroxide was refined to cobalt metal at CTT's Guemassa hydrometallurgical refinery north of Marrakech. In 2023, CTT produced 1,506 t of refined cobalt from mined and secondary (scrap) materials, an 11% decrease from the 1,690 t of refined cobalt produced in 2022. Mine production and subsequent refinery production were intentionally reduced owing to low cobalt prices (tables 7, 8; Groupe Managem, 2024, p. 122–123).

Russia.—In 2023, Russia ranked third in global cobalt mine production, and produced an estimated 8,700 t of mined cobalt (9,200 t in 2022). PJSC MMC Norilsk Nickel (Moscow) was the main producer of mined cobalt in Russia and the sole producer of Russia's refined cobalt. The company recovered cobalt from copper-nickel sulfide ores mined and beneficiated at its Norilsk division on the Taymyr Peninsula and its Kola division on the Kola Peninsula. Concentrates from the Kola and Norilsk divisions were smelted at the Nadezhda Metallurgical Plant on the Taymyr Peninsula and sent for refining at the Kola MMC refinery. The Kola MMC refinery produced cobalt metal and a cobalt chemical intermediate that was sent to the Harjavalta refinery in Finland for the production of cobalt sulfate. There was a 5% decrease in estimated mine production of cobalt in concentrates compared with that in 2022, which was attributed primarily to equipment testing and replacement of mining machinery during the year (table 7; PJSC MMC Norilsk Nickel, 2024, p. 28, 58–63).

Outlook

Several industry analysts forecast that global cobalt mine and intermediate production will continue to increase significantly in the near to medium term, particularly from mines and processing plants in Congo (Kinshasa) and Indonesia. Cobalt from recycling end-of-life lithium-ion batteries also is expected to increase over time. Supply of refined cobalt is forecast to increase with increased availability of mined and intermediate feed supplies. Cobalt demand is expected to increase into the 2030s, mostly as a result of increased use of lithium-ion batteries. Analysts estimate that increased mine and refinery production will maintain an oversupplied market in 2024 that could persist into the 2030s before increasing demand will result in a deficit between cobalt supply and consumption. Substitution of low- or no-cobalt battery chemistries could slow global cobalt demand growth and remains a key uncertainty in cobalt demand forecasts. Lithium iron phosphate (LFP) batteries for EVs held a majority market share in China in 2023, and it is unclear how growing EV markets in North America and Europe will adopt LFP and lower cobalt content batteries. Currently, multiple analysts expect cobalt-containing chemistries to maintain significant, if not majority, global market share into 2030 (Argus Media Group, 2024; Cobalt Institute, 2024, p. 12–16, 40–42; Darton Commodities Ltd., 2024, p. 9, 11, 22, 45–46, 64; Project Blue Group Ltd., The, 2024c, p. 4, 17, 25–26, 30–37).

References Cited

Agence Congolaise de Presse, 2023, Lualaba—Suspension temporaire des activités d'une entreprise minière [Lualaba—Temporary suspension of mining company activities]: Kolwezi, Congo (Kinshasa), Agence Congolaise de Presse, June 2. (Accessed July 12, 2023, at https://acp.cd/economie/lualaba-suspension-temporaire-des-activites-dune-entreprise-miniere/.) [In French.]

Argus Media Group, 2024, Argus battery materials analytics April 2024 V2: London, United Kingdom, Argus Media Group, April 16. (Accessed July 18, 2024, via https://direct.argusmedia.com.)

Boliden AB, 2024, Annual and sustainability report 2023: Stockholm, Sweden, Boliden AB, 141 p. (Accessed October 23, 2024, at https://investors.boliden.com/sites/boliden-ir/files/pr/202403050637-1.pdf.)

Chalale, Reitumetse, 2024, Glencore suspends cobalt "stockpiling" in the DRC: London, United Kingdom, Project Blue Group, Ltd., The, August 18. (Accessed August 26, 2024, via https://www.projectblue.com/.)

CMOC Group Ltd., 2023, 2022 annual report: Luoyang City, China, CMOC Group Ltd., 372 p. (Accessed September 11, 2024, at https://www1.hkexnews.hk/listedco/listconews/sehk/2023/0428/2023042804425.pdf.)

CMOC Group Ltd., 2024, 2023 annual report: Luoyang City, China, CMOC Group Ltd., 388 p. (Accessed September 11, 2024, at https://www1.hkexnews.hk/listedco/listconews/sehk/2024/0425/2024042500972.pdf.)

Cobalt Institute, 2024, Cobalt market report 2023: Guildford, United Kingdom, Cobalt Institute, May, 60 p. (Accessed August 28, 2024, at https://www.cobaltinstitute.org/wp-content/uploads/2024/05/Cobalt-Market-Report-2023_FINAL.pdf?v=082806.)

Creamer Media Reporter, 2022, New collective agreement ends 100-day Raglan strike: Mining Weekly [Johannesburg, South Africa], September 9. (Accessed September 9, 2022, via https://www.miningweekly.com/.)
Darton Commodities Ltd., 2024, Cobalt market review 2024: Guildford, United Kingdom, Darton Commodities Ltd., 72 p.
Eurasian Resources Group Africa, 2022, ERG and Gécamines restart operations at Boss Mining in the DRC: Johannesburg, South Africa, Eurasian Resources Group Africa news release, December 6, 2 p. (Accessed July 5, 2023, at https://www.ergafrica.com/wp-content/uploads/Media-Release-ERG-and-Gecamines-restart-operations-at-Boss-Mining-in-the-DRC.pdf.)
Ganzhou Tengyuan Cobalt New Materials Co., Ltd., 2024, 2023 annual report: Ganzhou City, China, Ganzhou Tengyuan Cobalt New Materials Co., Ltd., 216 p. (Accessed September 10, 2023, via https://en.tycogz.com/.)
Gem Co., Ltd., 2023, 2022 annual report: Shenzen, China, Gem Co., Ltd., April 27, 409 p. (Accessed May 2, 2024, at https://en.gem.com.cn/uploadfiles/2023/04/20230429002359523.pdf.)
Glencore plc, 2024, Annual report 2023: Baar, Switzerland, Glencore plc, March 20, 299 p. (Accessed September 17, 2024, at https://www.glencore.com/.rest/api/v1/documents/static/d09d8212-4a9f-4034-b2d4-49152e5a0aff/GLEN-2023-Annual-Report.pdf.)
Glencore plc, [undated], Sivumut project: Baar, Switzerland, Glencore plc. (Accessed April 12, 2024, at https://www.glencore.ca/en/raglan/what-we-do/sivumut-project.)
Groupe Managem, 2024, Rapport financier annuel 2023 [Annual financial report 2023]: Casablanca, Morocco, Groupe Managem, 243 p. (Accessed July 18, 2024, at https://www.managemgroup.com/sites/default/files/2024-04/MANAGEM%20RFA%202023%2030-04-2024%2021H45.pdf.) [In French.]
International Energy Agency, 2024, Global EV outlook 2024: Paris, France, April, 172 p. (Accessed August 28, 2024, at https://origin.iea.org/reports/global-ev-outlook-2024.)
Ivanhoe Mines Ltd., 2024, Ivanhoe Mines exports commence from Kamoa-Kakula copper complex along Lobito Atlantic rail corridor: Vancouver, British Columbia, Canada, Ivanhoe Mines Ltd. news release, January 2. (Accessed September 4, 2024, at https://www.ivanhoemines.com/wp-content/uploads/20240102-shipments-commence-along-Lobito-Corridor-VF-1.pdf.)
Jervois Global Ltd., 2022, Building a leading independent cobalt and nickel company—São Miguel Paulista restart—Final investment decision and equity capital raising: Cremorne, Victoria, Australia, Jervois Global Ltd. presentation, November 10, 64 p. (Accessed September 5, 2024, at https://wcsecure.weblink.com.au/pdf/JRV/02596266.pdf.)
Jervois Global Ltd., 2023, Jervois pivots Kokkola refinery expansion BFS to United States: Cremorne, Victoria, Australia, Jervois Global Ltd. news release, April 18, 3 p. (Accessed August 29, 2024, at https://wcsecure.weblink.com.au/pdf/JRV/02655319.pdf.)
Jervois Global Ltd., 2024, Annual report 2023: Cremorne, Victoria, Australia, Jervois Global Ltd., 127 p. (Accessed September 5, 2024, at https://wcsecure.weblink.com.au/pdf/JRV/02786058.pdf.)
Kavanagh, M.J., 2023a, Congo Government extends suspension of ERG's Boss Mining: Bloomberg, December 4. (Accessed October 23, 2024, at https://www.mining.com/web/congo-government-extends-suspension-of-ergs-boss-mining/.)
Kavanagh, M.J., 2023b, Congo halts ERG's copper mining project after waste leakage: Bloomberg, June 2. (Accessed July 18, 2023, at https://www.bloomberg.com/news/articles/2023-06-02/congo-halts-operations-at-erg-s-boss-mining-for-enormous-environmental-damage.)
Li-Cycle Holdings Corp., 2023, Li-Cycle announces review of the Rochester Hub Project: Toronto, Ontario, Canada, Li-Cycle Holdings Corp. news release, October 23. (Accessed December 13, 2023, at https://li-cycle.com/press-releases/li-cycle-announces-review-of-the-rochester-hub-project/.)
Liu, Siyi, and Njini, Felix, 2023, China's CMOC agrees to pay Congo's Gecamines $800 million to end spat: Thomson Reuters, July 18. (Accessed July 21, 2023, at https://www.reuters.com/article/markets/currencies/chinas-cmoc-agrees-to-pay-800-million-to-end-row-with-congos-gecamines-idUSKBN2YY0JC/.)
Lundin Mining Corp., 2024a, Annual information form for the year ended December 31, 2023: Toronto, Ontario, Canada, Lundin Mining Corp., February 21, 122 p. (Accessed September 3, 2024, at https://www.sedarplus.ca/csa-party/records/document.html?id=8b12f766b6b0f21ede9571e8bb79cd33b6fb4df659f6d2877fd79d92b7d15aed.)
Lundin Mining Corp., 2024b, Management's discussion and analysis for the year ended December 31, 2023: Toronto, Ontario, Canada, Lundin Mining Corp., February 21, 40 p. (Accessed September 3, 2024, at https://lundinmining.com/site/assets/files/9240/2023-lmc-annual-mda-and-financial-statements-sedar.pdf.)
MMG Ltd., 2024, Annual report 2023: Kowloon, Hong Kong, China, MMG Ltd., 209 p. (Accessed October 23, 2024, at https://www.mmg.com/wp-content/uploads/2024/04/MMG-Annual-Report-2023-Full.pdf.)
Nanjing Hanrui Cobalt Co., Ltd., 2022, 2022 semi-annual report of Nanjing Hanrui Cobalt Co., Ltd.: Nanjing City, China, Nanjing Hanrui Cobalt Co., Ltd., August, 151 p. (Accessed May 5, 2023, via https://www.hrcobalt.com/en/.)
Nassar, N.T., and Fortier, S.M., 2021, Methodology and technical input for the 2021 review and revision of the U.S. critical minerals list: U.S. Geological Survey Open-File Report 2021—1045, 31 p. (Accessed June 29, 2023, at https://pubs.usgs.gov/of/2021/1045/ofr20211045.pdf.)
Njini, Felix, and Rolley, Sonia, 2023, ERG asks Congo to lift copper unit ban, denies pollution charge: Thomson Reuters, June 7. (Accessed July 5, 2023, at https://www.reuters.com/markets/commodities/erg-asks-congo-lift-copper-unit-ban-denies-pollution-charge-2023-06-07/#:~:text=June%207%20%28Reuters%29%20-%20Eurasian%20Resources%20Group%20has-,government%20accused%20the%20miner%20of%20polluting%20the%20environment.)
PJSC MMC Norilsk Nickel, 2024, Annual report 2023: Moscow, Russia, PJSC MMC Norilsk Nickel, June 28, 297 p. (Accessed October 23, 2024, at https://ar2023.nornickel.com/download/full-reports/ar_en_annual-report_pages_nornickel_2023.pdf.)
PolyMet Mining Corp., 2022, PolyMet Mining releases updated NI 43-101 technical report on NorthMet copper-nickel-PGM deposit: Toronto, Ontario, Canada, PolyMet Mining Corp. news release, December 30. (Accessed August 4, 2023, at https://polymetmining.com/investors/news/polymet-mining-releases-updated-ni-43-101-technical-report-on-northmet-copper-nickel-pgm-deposit/.)
PolyMet Mining Corp., 2023a, Annual information form for the year ended December 31, 2022: Toronto, Ontario, Canada, PolyMet Mining Corp., March 23, 71 p. (Accessed April 22, 2024, at https://www.sedarplus.ca/csa-party/records/document.html?id=cefaf1e22ca8adf33aac3fbc3309ee91e247458bf4cba6d45ca14321dbdfdd1f.)
PolyMet Mining Corp., 2023b, PolyMet closes NewRange Copper Nickel joint venture with Teck Resources: Toronto, Ontario, Canada, PolyMet Mining Corp. news release, February 15. (Accessed August 4, 2023, at https://polymetmining.com/investors/news/polymet-closes-newrange-copper-nickel-joint-venture-with-teck-resources/.)
Project Blue Group, Ltd., The, 2024a, Cobalt analysis: London, United Kingdom, Project Blue Group Ltd., The, June, 31 p. (Accessed August 28, 2024, via https://www.projectblue.com/.)
Project Blue Group Ltd., The, 2024b, Cobalt background: London, United Kingdom, Project Blue Group Ltd., The, May, 17 p. (Accessed August 28, 2024, via https://www.projectblue.com/.)
Project Blue Group Ltd., The, 2024c, Cobalt medium-term outlook: London, United Kingdom, Project Blue Group Ltd., The, April, 41 p. (Accessed August 28, 2024, via https://www.projectblue.com/.)
PT Trimegah Bangun Persada Tbk, 2024, 2023 annual report: Jakarta, Indonesia, PT Trimegah Bangun Persada Tbk, 458 p. (Accessed May 2, 2024, at https://tbpnickel.com/files/pdf_assets/2023%20Annual%20Report.pdf.)
SMM Information & Technology Co., Ltd., 2022, Today, Tengyuan Cobalt Industry successfully raised 5.478 billion yuan to increase its main business by "cloud listing": Shanghai, China, SMM Information & Technology Co., Ltd., March 16. (Accessed September 17, 2024, at https://news.metal.com/newscontent/101779637/Today-Tengyuan-Cobalt-Industry-successfully-raised-5478-billion-yuan-to-increase-its-main-business-by-.)
Sherritt International Corp., 2023, 2022 annual information form: Toronto, Ontario, Canada, Sherritt International Corp., March 31, 81 p. (Accessed October 24, 2024, at https://s2.q4cdn.com/343762060/files/doc_financials/2022/ar/sic-2022-aif-03-31-23-sedar.pdf.)
Sherritt International Corp., 2024, 2023 annual information form: Toronto, Ontario, Canada, Sherritt International Corp., March 31, 81 p. (Accessed October 24, 2024, at https://s2.q4cdn.com/343762060/files/doc_financials/2023/ar/2023-aif-sedar-2024-03-22-_.pdf.)

State of Minnesota in Supreme Court, 2023, In the matter of the denial of contested case hearing requests and issuance of national discharge elimination system / state disposal system permit No. MN0071013 for the proposed NorthMet Project St. Louis County Hoyt Lakes and Babbitt Minnesota: St. Paul, MN, State of Minnesota Office of Appellate Courts, August 2, 68 p. (Accessed October 23, 2024, via https://www.mncourts.gov/SupremeCourt.aspx.)

Sumitomo Metal Mining Co., Ltd., 2024, Integrated report 2024: Tokyo, Japan, Sumitomo Metal Mining Co., Ltd., 160 p. (Accessed October 23, 2024, at https://www.smm.co.jp/en/ir/library/integrated_report/pdf/2024/2024_All_EN.pdf?241011.)

Talon Metals Corp., 2022, Talon Metals battery minerals processing facility selected by U.S. Department of Energy for $114 million in Bipartisan Infrastructure Law funding: Tamarack, MN, Talon Metals Corp. press release, October 19. (Accessed April 19, 2024, at https://talonmetals.com/wp-content/uploads/2022/10/Bipartisan-Infrastructure-Law-DOE-Talon-Funding-FINAL.pdf.)

Terrafame Ltd., 2021, Creating responsible battery value chain—Sustainability review June 2021: Tuhkakyla, Finland, Terrafame Ltd., June, 34 p. (Accessed May 7, 2024, at https://issuu.com/terrafame/docs/terrafame-sustainable-review-june-2021.)

Terrafame Ltd., 2023, A drop in the nickel sulphate market in China decreased Terrafame's operating result while basic production remained at a good level: Tuhkakyla, Finland, Terrafame Ltd. news release, July 38. (Accessed October 23, 2024, at https://www.terrafame.com/newsroom/media-releases/a-drop-in-the-nickel-sulphate-market-in-china-decreased-terrafameaposs-operating-result-while-basic-production-remained-at-a-good-level.html?p461=4.)

Trafigura Group Pte. Ltd., 2023, Concession for railway services transferred to Lobito Atlantic Railway in Angola: Lobito, Angola, Trafigura Group Pte. Ltd. press release, July 4. (Accessed September 4, 2024, at https://www.trafigura.com/news-and-insights/press-releases/2023/concession-for-railway-services-transferred-to-lobito-atlantic-railway-in-angola/.)

Twin Metals Minnesota LLC, 2019, Mine plan of operations: Ely, MN, Twin Metals Minnesota LLC, December 18, 102 p. (Accessed September 6, 2024, at https://www.twin-metals.com/resource/twin-metals-minnesota-mine-plan-of-operations/.)

U.S. Army Corps of Engineers, [undated], NewRange Copper Nickel, LLC—Section 404 permit status: St. Paul, MN, U.S. Army Corps of Engineers news release. (Accessed September 5, 2024, at https://www.mvp.usace.army.mil/Missions/Regulatory/PolyMet.aspx.)

U.S. Department of Defense, 2022, State of competition within the defense industrial base: Washington, DC, U.S. Department of Defense, 28 p. (Accessed June 27, 2023, at https://media.defense.gov/2022/Feb/15/2002939087/-1/-1/1/STATE-OF-COMPETITION-WITHIN-THE-DEFENSE-INDUSTRIAL-BASE.PDF.)

U.S. Department of Defense, 2023, DOD enters agreement to expand domestic manufacturing and strengthen U.S. cobalt supply chains: Washington, DC, U.S. Department of Defense press release, June 15. (Accessed August 28, 2024, at https://www.defense.gov/News/Releases/Release/Article/3429442/dod-enters-agreement-to-expand-domestic-manufacturing-and-strengthen-us-cobalt/.)

U.S. Department of Energy, 2022, Bipartisan Infrastructure Law battery materials processing and battery manufacturing & recycling funding opportunity announcement (DE-FOA-0002678) selections: Washington, DC, U.S. Department of Energy, 22 p. (Accessed August 12, 2024, at https://www.energy.gov/sites/default/files/2022-11/DOE%20BIL%20Battery%20FOA-2678%20Selectee%20Fact%20Sheets.pdf.)

U.S. Department of Energy, 2023a, LPO announces a conditional commitment for loan to Li-Cycle's U.S. battery resource recovery facility to recover critical electric vehicle battery materials: Washington, DC, U.S. Department of Energy Loan Programs Office. (Accessed August 28, 2024, at https://www.energy.gov/lpo/articles/lpo-announces-conditional-commitment-loan-li-cycles-us-battery-resource-recovery.)

U.S. Department of Energy, 2023b, LPO offers conditional commitment to Redwood Materials to produce critical electric vehicle battery components from recycled materials: Washington, DC, U.S. Department of Energy Loan Programs Office. (Accessed August 28, 2024, at https://www.energy.gov/lpo/articles/lpo-offers-conditional-commitment-redwood-materials-produce-critical-electric-vehicle.)

U.S. Department of the Interior, 2023, Biden-Harris administration protects Boundary Waters area watershed: Washington, DC, U.S. Department of the Interior press release, January 26. (Accessed September 6, 2024, at https://www.doi.gov/pressreleases/biden-harris-administration-protects-boundary-waters-area-watershed.)

U.S. Department of State, 2022, Minerals security partnership: Washington, DC, U.S. Department of State press release, June 14. (Accessed September 3, 2024, at https://www.state.gov/minerals-security-partnership-june-14-2022/.)

U.S. Department of State, 2023a, Joint statement on the minerals security partnership announce support for mining, processing, and recycling projects: Washington, DC, U.S. Department of State press release, October 10. (Accessed September 3, 2024, at https://www.state.gov/joint-statement-on-the-minerals-security-partnership-announce-support-for-mining-processing-and-recycling-projects/.)

U.S. Department of State, 2023b, Signing of the memorandum of understanding on the development of the Lobito Corridor and the Zambia-Lobito rail line: Washington, DC, U.S. Department of State press release, October 26. (Accessed September 3, 2024, at https://www.state.gov/signing-of-the-memorandum-of-understanding-on-the-development-of-the-lobito-corridor-and-the-zambia-lobito-rail-line/.)

U.S. Forest Service, 2022, Mineral potential report for the Rainy River withdrawal: Washington, DC, U.S. Forest Service, 85 p. (Accessed September 6, 2024, via https://www.fs.usda.gov/project/?project=60916.)

U.S. Strategic Metals, LLC, 2024, U.S. Strategic Metals—Solving the critical battery materials supply chain puzzle: St. Louis, MO, U.S. Strategic Metals, LLC press release, March 20. (Accessed September 5, 2024, at https://www.usstrategicmetals.com/us-strategic-metals-solving-the-critical-battery-materials-supply-chain-puzzle/.)

Vale S.A., 2023, Form 20–F—For the fiscal year ended December 31, 2022: Washington, DC, U.S. Securities and Exchange Commission, April 12, 213 p. (Accessed September 17, 2024, at https://api.mziq.com/mzfilemanager/v2/d/53207d1c-63b4-48f1-96b7-19869fae19fe/85440251-62c0-75e6-a679-fdf485c9b3d3?origin=1.)

Vale S.A., 2024, Form 20–F—For the fiscal year ended December 31, 2023: Washington, DC, U.S. Securities and Exchange Commission, April 19, 221 p. (Accessed September 17, 2024, at https://api.mziq.com/mzfilemanager/v2/d/53207d1c-63b4-48f1-96b7-19869fae19fe/f98febfb-c3b8-33b4-e623-8cc22340a64d?origin=1.)

White House, The, 2021, Building resilient supply chains, revitalizing American manufacturing, and fostering broad-based growth—100-day reviews under Executive Order 14017: Washington, DC, The White House, 250 p. (Accessed August 28, 2024, at https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.)

White House, The, 2023a, Fact sheet—Partnership for global infrastructure and investment at the G7 summit: Washington, DC, The White House press release, May 20. (Accessed September 3, 2024, at https://www.whitehouse.gov/briefing-room/statements-releases/2023/05/20/fact-sheet-partnership-for-global-infrastructure-and-investment-at-the-g7-summit/.)

White House, The, 2023b, Joint statement from the United States and the European Union on support for Angola, Zambia and the Democratic Republic of the Congo's commitment to further develop the Lobito Corridor and the U.S.-EU launch of a greenfield rail line feasibility study: Washington, DC, The White House press release, September 9. (Accessed September 3, 2024, at https://www.whitehouse.gov/briefing-room/statements-releases/2023/09/09/joint-statement-from-the-united-states-and-the-european-union-on-support-for-angola-zambia-and-the-democratic-republic-of-the-congos-commitment-to-further-develop-the-lobito-corridor-and-the/.)

Yu, Alice, 2023, Lithium and cobalt CBS December 2023—Market surpluses weighing on prices: New York, NY, S&P Global Market Intelligence, December 21. (Accessed August 28, 2024, via https://www.capitaliq.spglobal.com/apisv3/spg-webplatform-core/news/article?id=79858548&redirected=1.)

Zhejiang Huayou Cobalt Co., Ltd., 2021, Indonesia Huayue, the first batch of qualified products!: Zhejiang Province, China, Huayou Cobalt Co., Ltd. news release, December 24. (Accessed December 19, 2023, at https://en.huayou.com/news/609.html.)

Zhejiang Huayou Cobalt Co., Ltd., 2024, 2023 annual report of Zhejiang Huayou Cobalt Co., Ltd.: Zhejiang Province, China, Huayou Cobalt Co., Ltd., April, 327 p. (Accessed October 23, 2024, at https://www.huayou.com/Public/Uploads/uploadfile2/files/20240423/2023AnnualReportofHuayouCobalt1.pdf.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Cobalt. Ch. in Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply, Professional Paper 1802, 2017.
Cobalt. Ch. in Mineral Commodity Summaries, annual.
Cobalt. International Strategic Minerals Inventory Summary Report, Circular 930–F, 1987.
Cobalt. Mineral Industry Surveys, monthly.
Cobalt (Co). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.
Cobalt Deposits in the United States, Data release, 2018.
Cobalt—For Strength and Color. Fact Sheet 2011–3081, 2011.
Cobalt Recycling in the United States in 1998. Ch. in Flow Studies for Recycling Metal Commodities in the United States, Circular 1196–A–M, 2004.
Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.

Other

Cobalt. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Cobalt. Mineral Profile, British Geological Survey, 2009.
Cobalt Institute (formerly known as the Cobalt Development Institute).
Defense Logistics Agency Strategic Materials.
Materials Flow of Cobalt in the United States, The. U.S. Bureau of Mines Information Circular 9350, 1993.

TABLE 1
SALIENT COBALT STATISTICS[1]

(Metric tons, cobalt content, unless otherwise specified)

		2019	2020	2021	2022	2023
United States:						
Mine production[e]		500	600	650	500	500
Consumption:						
Estimated[2]		9,050	7,260	7,270	7,570 [r]	7,840
Apparent[2, 3]		12,500	8,480	6,650	7,150 [r]	6,440
Imports for consumption		13,900	9,740	9,790	10,500	9,500
Exports		4,080	3,430	4,930	5,360	5,110
Stocks, December 31:						
Industry[e, 2, 4]		1,090	952	1,010	946 [r]	925
London Metal Exchange Ltd. (LME), U.S. warehouses		102	82	50	34	34
Price, metal:						
U.S. spot[5]	dollars per pound	16.95	15.70	24.21	30.78	17.20
LME, cash[6]	do.	14.88	14.21	23.17	28.83	15.48
World:						
Production:[7]						
Mine		153,000	147,000	162,000	198,000 [r]	238,000
Refinery		139,000	146,000	166,000 [r]	161,000 [r]	180,000
Stocks, December 31, LME[8]		685	451	256	165	92

[e]Estimated. [r]Revised. do. Ditto.
[1]Table includes data available through October 1, 2024. Data are rounded to no more than three significant digits, except "Price."
[2]Includes reported data and U.S. Geological Survey estimates.
[3]For 2019–21, apparent consumption is defined as imports minus exports plus adjustments for Government and industry stock changes plus secondary production, as estimated from consumption of purchased scrap. Beginning in 2022, Government stocks no longer included.
[4]Stocks held by cobalt processors and consumers.
[5]Annual average U.S. spot price for minimum 99.8% cobalt cathode. Source: S&P Global Platts Metals Week.
[6]Annual average mean of the cash buyer price and cash seller price, cobalt briquettes, cathode, ingot, or rounds, minimum 99.8% purity, converted from dollars per metric ton.
[7]May include estimated data.
[8]Stocks held in Asia, Europe, and the United States.

TABLE 2
U.S. ESTIMATED CONSUMPTION AND STOCKS OF COBALT[1, 2]

(Metric tons, cobalt content)

	2022	2023
Consumption by end use:		
Steels and other alloys, excludes superalloys[3]	1,170 r	1,160
Superalloys	3,640	3,950
Cemented carbides[4]	715	715
Chemical and ceramic uses	2,040 r	2,010
Total	7,570 r	7,840
Consumption by form:		
Chemical compounds, organic and inorganic[5]	2,040 r	2,010
Metal	3,610 r	3,810
Purchased scrap	1,920 r	2,030
Total	7,570 r	7,840
Stocks, December 31:[6]		
Chemical compounds, organic and inorganic[5]	378	378
Metal	W	W
Purchased scrap	W	W
Total	946 r	925

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Table includes data available through August 11, 2024. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes reported data and U.S. Geological Survey estimates.

[3]Includes magnetic alloys, nonferrous alloys, wear- and corrosion-resistant alloys, welding materials, and other metallic uses not listed.

[4]Includes cast carbide dies or parts, cemented and sintered carbides, and diamond tool matrices.

[5]Includes oxides.

[6]Stocks held by cobalt processors and consumers.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF COBALT, BY FORM[1]

Form	Trade code[2]	2022 Gross weight (metric tons)	2022 Cobalt content[3] (metric tons)	2022 Value[4] (thousands)	2023 Gross weight (metric tons)	2023 Cobalt content[3] (metric tons)	2023 Value[4] (thousands)
U.S. imports for consumption:							
Metal	8105.20.6000, 8105.20.9000	7,200	7,200	$458,000	7,670	7,670	$293,000
Oxides and hydroxides	2822.00.0000	1,920	1,380	89,100	1,390	1,000	36,100
Other:							
Acetates	2915.29.3000	1,360	327	11,500	253	61	2,840
Carbonates	2836.99.1000	576	265	14,400	486	224	9,690
Chlorides	2827.39.6000	150	38	1,770 r	55	14	561
Sulfates	2833.29.1000	4,810	1,300	22,500	1,970	531	14,600
Total		16,000	10,500	597,000	11,800	9,500	357,000
U.S. exports of cobalt:[5]							
Metal	8105.20.0000, 8105.30.0000	5,330	5,330	169,000	5,050	5,050	166,000
Oxides and hydroxides	2822.00.0000	43	31	1,770	84	60	2,230
Other:							
Acetates	2915.29.3000	(6)	(6)	5	1	(6)	10
Chlorides	2827.39.6000	1	(6)	11	1	(6)	13
Total		5,370 r	5,360	170,000	5,130	5,110	168,000

rRevised.
[1]Table includes data available through September 18, 2024. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Imports for consumption are represented by Harmonized Tariff Schedule of the United States (HTS) codes. Exports are represented by Schedule B numbers.
[3]Estimated from gross weight using the following percentages: metal, 100%; oxides and hydroxides, 72%; acetates, 24%; carbonates, 46%; chlorides, 25%; and sulfates, 27%.
[4]The value of imports are represented by the customs value. The value of exports are represented by the free alongside ship value.
[5]In addition to the materials listed, the United States exported cobalt ores and concentrates and wrought cobalt and cobalt articles.
[6]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY OR LOCALITY[1]

	Metal[2]			Oxides and hydroxides[3]			Other forms[4]			Total		
	Quantity (metric tons)			Quantity (metric tons)			Quantity (metric tons)			Quantity (metric tons)		
Country or locality	Gross weight	Cobalt content[5]	Value[6] (thousands)	Gross weight	Cobalt content[5]	Value[6] (thousands)	Gross weight	Cobalt content[5]	Value[6] (thousands)	Gross weight	Cobalt content[5]	Value[6] (thousands)
2022:	7,200	7,200	$458,000	1,920	1,380	$89,100	6,900	1,930	$50,200	16,000	10,500	$597,000
2023:												
Australia	58	58	1,920	10	7	307	--	--	--	68	65	2,220
Belgium	13	13	462	86	62	2,530	(7)	(7)	2	99	75	3,000
Brazil	--	--	--	--	--	--	325	105	3,030	325	105	3,030
Canada	1,660	1,660	69,500	--	--	--	60	16	837	1,720	1,680	70,300
China	62	62	925	51	37	1,030	76	21	750	190	120	2,700
Finland	168	168	8,390	980	705	24,600	1,960	593	19,000	3,110	1,470	52,000
France	8	8	379	--	--	--	10	4	216	18	13	594
Germany	136	136	10,600	4	3	160	--	--	--	140	139	10,800
Japan	1,670	1,670	60,300	6	4	179	--	--	--	1,680	1,680	60,500
Madagascar	925	925	32,600	--	--	--	--	--	--	925	925	32,600
Mexico	30	30	1,020	2	2	63	2	(7)	25	35	33	1,110
Morocco	222	222	7,250	--	--	--	--	--	--	222	222	7,250
Netherlands	--	--	--	24	17	592	--	--	--	24	17	592
Norway	2,380	2,380	88,400	--	--	--	--	--	--	2,380	2,380	88,400
Philippines	--	--	--	16	12	169	--	--	--	16	12	169
Russia	50	50	1,850	--	--	--	--	--	--	50	50	1,850
South Africa	137	137	1,450	--	--	--	--	--	--	137	137	1,450
Taiwan	(7)	(7)	28	67	48	2,190	208	50	2,340	276	99	4,560
Turkey	16	16	286	3	2	69	--	--	--	19	18	355
United Kingdom	66	66	5,270	137	99	4,000	97	32	1,270	300	197	10,500
Zambia	63	63	2,120	--	--	--	--	--	--	63	63	2,120
Other	4	4	417	5	3	229	24	7	180	33	14	825
Total	7,670	7,670	293,000	1,390	1,000	36,100	2,760	829	27,700	11,800	9,500	357,000

-- Zero.

[1]Table includes data available through September 18, 2024. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Unwrought cobalt, excluding alloys and waste and scrap; includes cobalt cathode and cobalt metal powder; may include intermediate products of cobalt metallurgy. Harmonized Tariff Schedule of the United States (HTS) codes 8105.20.6000 and 8105.20.9000.

[3]HTS code 2822.00.0000.

[4]Cobalt acetates, cobalt carbonates, cobalt chlorides, and cobalt sulfates under HTS codes 2827.39.6000, 2833.29.1000, 2836.99.1000, and 2915.29.3000.

[5]Estimated from gross weight using the following cobalt content percentages: metal, 100%; oxides and hydroxides, 72%; carbonates, 46%; sulfates, 27%; chlorides, 25%; and acetates, 24%.

[6]Customs value.

[7]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS OF COBALT, BY COUNTRY OR LOCALITY[1, 2]

	Metal[3]			Oxides and hydroxides[4]			Acetates[5]			Chlorides[6]			Total		
	Quantity (metric tons)			Quantity (metric tons)			Quantity (metric tons)			Quantity (metric tons)			Quantity (metric tons)		
Country or locality	Gross weight	Cobalt content[7]	Value[8] (thousands)	Gross weight	Cobalt content[7]	Value[8] (thousands)	Gross weight	Cobalt content[7]	Value[8] (thousands)	Gross weight	Cobalt content[7]	Value[8] (thousands)	Gross weight	Cobalt content[7]	Value[8] (thousands)
2022:	5,330	5,330	$169,000	43	31	$1,770	(9)	(9)	$5	1	(9)	$11	5,370	5,360	$170,000
2023:															
Belgium	34	34	493	--	--	--	--	--	--	--	--	--	34	34	493
Brazil	48	48	3,290	11	8	125	--	--	--	--	--	--	59	56	3,420
Canada	1,450	1,450	13,700	56	40	1,440	--	--	--	--	--	--	1,500	1,490	15,200
China	156	156	9,470	6	4	233	--	--	--	--	--	--	161	160	9,700
France	471	471	14,100	--	--	--	--	--	--	--	--	--	471	471	14,100
Germany	394	394	21,600	--	--	--	--	--	--	--	--	--	394	394	21,600
India	205	205	9,360	1	1	58	--	--	--	--	--	--	207	206	9,420
Indonesia	7	7	460	--	--	--	--	--	--	--	--	--	7	7	460
Ireland	1,110	1,110	34,200	--	--	--	--	--	--	--	--	--	1,110	1,110	34,200
Italy	21	21	2,270	--	--	--	--	--	--	--	--	--	21	21	2,270
Japan	138	138	8,370	(9)	(9)	11	--	--	--	--	--	--	139	138	8,380
Korea, Republic of	102	102	6,550	(9)	(9)	4	--	--	--	--	--	--	102	102	6,550
Luxembourg	39	39	1,110	--	--	--	--	--	--	--	--	--	39	39	1,110
Malaysia	10	10	467	--	--	--	--	--	--	--	--	--	10	10	467
Mexico	15	15	3,390	4	3	121	1	(9)	10	1	(9)	9	20	18	3,530
Netherlands	27	27	1,220	--	--	--	--	--	--	--	--	--	27	27	1,220
Philippines	8	8	731	--	--	--	--	--	--	--	--	--	8	8	731
Saudi Arabia	6	6	592	--	--	--	--	--	--	--	--	--	6	6	592
Singapore	52	52	5,380	--	--	--	--	--	--	--	--	--	52	52	5,380
Switzerland	8	8	1,070	--	--	--	--	--	--	--	--	--	8	8	1,070
Taiwan	111	111	4,460	1	1	45	--	--	--	--	--	--	113	112	4,500
Thailand	9	9	933	--	--	--	--	--	--	--	--	--	9	9	933
Tunisia	175	175	5,480	--	--	--	--	--	--	--	--	--	175	175	5,480
Turkey	83	83	4,060	--	--	--	--	--	--	--	--	--	83	83	4,060
United Arab Emirates	6	6	646	--	--	--	--	--	--	--	--	--	6	6	646
United Kingdom	341	341	10,200	(9)	(9)	16	--	--	--	--	--	--	342	342	10,200
Other	22	22	2,110	4	3	177	--	--	--	(9)	(9)	4	26	25	2,300
Total	5,050	5,050	166,000	84	60	2,230	1	1	10	1	(9)	13	5,130	5,110	168,000

-- Zero.

[1]Table includes data available through September 18, 2024. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]In addition to the materials listed, the United States exported cobalt ores and concentrates and wrought cobalt and cobalt articles.

[3]Includes unwrought cobalt, powders, waste and scrap, and mattes and other intermediate products of cobalt metallurgy exported under Schedule B of the United States numbers 8105.20.0000 and 8105.30.0000.

[4]Schedule B number 2822.00.0000.

[5]Schedule B number 2915.29.3000.

[6]Schedule B number 2827.39.6000.

[7]Estimated from gross weight using the following cobalt content percentages: metal, 100%; oxides and hydroxides, 72%; acetates, 24%; and chlorides, 25%.

[8]Free alongside ship value.

[9]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
WORLD ANNUAL COBALT REFINERY
CAPACITY, DECEMBER 31, 2023[1, 2]

(Metric tons, cobalt content)

Country or locality	Capacity
Australia	6,900 e
Belgium	3,000 e
Brazil	2,000
Canada	8,120
China[3]	182,000 e
Congo (Kinshasa)	6,050 e
Finland	18,000 e
France	600
India	1,000 e
Indonesia[4]	2,800 e
Japan	5,500 e
Korea, Republic of	1,200
Madagascar	5,600
Mexico	1,700
Morocco	2,800
Norway	5,200
Russia	3,000
South Africa	3,000 e
Uganda	720
United Kingdom	1,800
Zambia	9,600
Total	271,000

[e]Estimated.

[1]Table includes data available through September 18, 2024. Data are rounded to no more than three significant digits; may not add to total shown.

[2]Includes standby capacity. Refinery products include cobalt metal, metal powders, oxides, and (or) salts.

[3]Increased to include capacity expansions for Hanrui Cobalt Co. Ltd. and Ganzhou Tengyuan Cobalt New Materials Co.

[4]Added to include estimated cobalt in sulfate capacity for PT Halmahera Persada Lygend in 2023.

TABLE 7
COBALT: WORLD MINE PRODUCTION, BY COUNTRY OR LOCALITY[1, 2]

(Metric tons, cobalt content)

Country or locality[3]	2019	2020	2021	2022	2023
Australia[4]	5,746 r	5,631 r	5,232	5,793 r	5,222
Brazil	30 e	160 e	266	291	300 e
Canada[5]	4,365	4,328	3,964	3,573 r	4,219
China	1,742	2,000 e	2,000 e	2,000 e	2,000 e
Congo (Kinshasa)[e, 6]	107,000	100,000	118,000	144,000	175,000
Cuba[e, 7]	3,600	3,800	3,800	3,700	3,300
Finland	1,454	1,559	1,084	1,235	1,057
Indonesia[e, 8]	1,100	1,100	2,700	9,600	19,000
Madagascar[e, 9]	3,400	970	2,500 r	4,000 r	4,000
Mexico[e]	1,100	1,000	1,100	600	300
Morocco[e, 10]	2,200	1,900	1,600	1,700	1,500
New Caledonia[11]	1,700 e	2,200 e	1,100 e	2,000 e	2,572
Papua New Guinea[12]	2,911	2,941	2,953	2,987	3,072
Philippines[e, 13]	4,300	4,100	3,600	3,900	3,800
Russia[14]	9,400	9,700	8,000	9,200	8,700 e
South Africa	1,027	897	355	250	378
Turkey[e, 15]	610	2,550	2,700	2,100	2,500
United States[e, 14]	500	600	650	500	500
Zambia	878	316	247	251	207
Zimbabwe	402	956	345	241	336
Total	153,000	147,000	162,000	198,000 r	238,000

[e]Estimated. [r]Revised.

[1]Table includes data available through October 1, 2024. 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.

[2]Figures represent recoverable cobalt content from ore, concentrate, or intermediate products from cobalt, copper, nickel, platinum, or zinc operations.

[3]Other copper-, iron (pyrite)-, nickel-, platinum-, or zinc-producing countries and (or) localities also may have produced ore containing cobalt as a byproduct component, but recovery was small or zero.

[4]Cobalt content of lateritic nickel ore and nickel concentrate reported by the government of Western Australia.

[5]Recoverable cobalt in concentrate shipped reported by Statistics Canada. Data prior to 2019 are mineral production reported by Natural Resources Canada.

[6]Determined from reported or estimated cobalt content of materials originating from mining and processing operations in Congo (Kinshasa) such as ore, concentrate, refined cobalt metal, and intermediate products including crude cobalt alloys, crude cobalt hydroxide, and crude cobalt carbonate produced from cobalt ore and concentrate, tailings, or slags.

[7]Determined from estimated cobalt content of nickel-cobalt sulfide production and estimated cobalt content of ammoniacal liquor production.

[8]Determined from estimated cobalt content of nickel matte plus estimated cobalt content of nickel-cobalt hydroxide.

[9]Estimated cobalt content of ore production based on reported or estimated cobalt metal powder production and nickel recovery rates.

[10]Cobalt content of concentrate estimated from reported or estimated gross weight.

[11]Cobalt content of nickel hydroxide. Data prior to 2021 include cobalt content of cobalt carbonate.

[12]Cobalt content of nickel-cobalt hydroxide.

[13]Cobalt content of nickel-cobalt sulfide.

[14]Cobalt content of concentrate.

[15]Cobalt content of cobalt carbonate and nickel-cobalt hydroxide.

TABLE 8

COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY OR LOCALITY[1, 2]

(Metric tons, cobalt content)

Country or locality and form	2019	2020	2021	2022	2023
Australia, metal and metal powder	3,700	3,300	2,800	3,300	2,400
Belgium, metal powder, oxide, and hydroxide[e, 3]	1,500	1,300	700	--	700
Canada, metal, metal powder, and oxide	6,075	5,965	6,045	5,802	4,835
China, metal, metal powder, oxide, and salts	95,000 [e]	106,000 [e]	128,000 [r]	125,000 [r, e, 3]	147,000 [e, 3]
Finland, metal powder and salts	14,283	15,148	14,287 [4]	12,781	10,627
France, chloride	90 [e]	90 [e]	110 [e]	153	127
India, metal and salts[5]	NA	NA	NA	NA	NA
Indonesia, cobalt sulfate	NA	NA	NA	NA	400 [e]
Japan, metal[e]	4,000	4,200	3,500 [3]	3,700 [3]	3,800 [3]
Madagascar, metal powder	2,897	833	2,111	3,428 [r]	3,400 [e]
Mexico, metal	215	190 [e]	220 [e]	110 [e]	50 [e]
Morocco, metal	2,397	2,416	1,796	1,690	1,506
Norway, metal	4,354	4,384	4,000	3,100	3,500
Russia, metal	2,000 [e]	1,800 [3]	1,500 [3]	1,000 [e]	1,000 [e]
South Africa, metal powder and sulfate[e]	500 [3]	450 [3]	500	500	500
Zambia, metal	1,500	100	--	-- [e]	-- [e]
Total	139,000	146,000	166,000 [r]	161,000 [r]	180,000

[e]Estimated. [r]Revised. NA Not available. -- Zero.

[1]Table includes data available through September 9, 2024. 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.

[2]Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

[3]Source: Darton Commodities Ltd.

[4]Does not include production of cobalt content of cobalt sulfate at Terrafame Ltd.'s nickel-cobalt refinery, which began production in June 2021.

[5]Refined cobalt may be produced from imported materials, but available information was inadequate to make reliable estimates of output.