



2013 Minerals Yearbook

COBALT [ADVANCE RELEASE]

COBALT

By Kim B. Shedd

Domestic survey data and tables were prepared by Annie Hwang, statistical assistant, and the world production tables were prepared by Lisa D. Miller and Glenn J. Wallace, international data coordinators.

In 2013, world production of refined cobalt increased by 10% to reach a record level of 86,000 metric tons (t) (table 9). China's production more than recovered from the low level in 2012 and production from Madagascar quadrupled as the Ambatovy nickel-cobalt operation ramped up production. The United States did not refine cobalt in 2013. A negligible amount of byproduct cobalt was produced domestically in an intermediate product from the mining and refining of platinum-group metals (PGM) ore. No cobalt has been sold from the National Defense Stockpile (NDS) since 2009.

According to the Cobalt Development Institute (2014a), preliminary data indicate that in 2013, world apparent consumption of cobalt decreased by about 1,000 t to approximately 71,000 t. Cobalt prices trended upward during the first half of 2013, then downward during the second half of the year, resulting in annual averages less than those of 2012. Salient U.S. and world cobalt statistics for 2009–13 are listed in table 1.

Cobalt is a metal used in numerous diverse commercial, industrial, and military applications. On a global basis, the leading use of cobalt is in rechargeable battery electrodes. Superalloys, which are used to make parts for gas turbine engines, are another major use for cobalt. Other metallurgical uses for cobalt include cemented carbides (also called hardmetals) and diamond tools, controlled-expansion and corrosion- and wear-resistant alloys, high-speed and maraging steels, and magnets. With regard to other chemical uses, cobalt is used to make animal feed additives; catalysts for chemical, petroleum, and other 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 vitamin B12.

Legislation and Government Programs

Defense Logistics Agency Strategic Materials (DLA Strategic Materials), U.S. Department of Defense, did not sell or ship cobalt during 2013. The program under which cobalt sales were authorized expired in 2011 and had not been reauthorized (U.S. Department of Defense, 2014, p. 8).

Production

With the exception of negligible amounts of byproduct cobalt produced from Stillwater Mining Co.'s PGM operations in southeastern Montana, the United States did not mine or refine cobalt in 2013. Stillwater produced cobalt-bearing nickel sulfate from its mining and refining operations, which it sold to other companies (Stillwater Mining Co., 2014, p. 25).

Lundin Mining Corp. (Toronto, Ontario, Canada) acquired the Eagle project from Rio Tinto Nickel Co. The project comprised a nickel-copper mine northwest of Marquette, MI, and a mill in Humboldt Township. Planned nickel production during the first 3 years was forecast to be 23,000 metric tons per year (t/yr) and, based on the nickel-to-cobalt ratio in the ore reserves, the nickel concentrate could contain an estimated 700 t/yr of cobalt. Lundin Mining expected to begin shipping nickel concentrates in late 2014 (table 7) (Lundin Mining Corp., 2013; 2014, p. 3, 6).

In December, the Minnesota Department of Natural Resources, U.S. Army Corps of Engineers, and U.S. Forest Service published the supplemental draft environmental impact statement for PolyMet Mining Corp.'s NorthMet project and, shortly thereafter, the Army Corps of Engineers published notice of the project's wetland permit application. The NorthMet project was to be developed in two phases. Phase 1 comprised open pit mining of the NorthMet polymetallic deposit in the Duluth Complex of northeastern Minnesota and refurbishing the crushing and grinding equipment in the company's nearby Erie plant (table 7). During phase 2, a new beneficiation circuit and a hydrometallurgical plant for the production of nickel-cobalt hydroxide and precious metals precipitate would be added. Once the environmental review process was completed, Polymet could begin a land exchange with the U.S. Forest Service and apply for construction and operating permits for the project (PolyMet Mining Corp., 2014, p. 14, 27).

Formation Metals Inc.'s fully permitted Idaho Cobalt Project comprised an underground cobalt-copper-gold mine and mill complex in the Idaho Cobalt Belt in Lemhi County and a hydrometallurgical plant in Kellogg, ID, to refine the concentrates to cobalt cathode. The project was on care-and-maintenance status pending conclusion of financing. Once financing was completed, Formation planned to begin underground mine development and to construct the beneficiation and hydrometallurgical plants. The first shipment of concentrates from the mine to the refinery was expected to take place about 13 months after commencing underground development (table 7) (Formation Metals Inc., 2014, p. 10, 16, 23–24).

U.S. processors made cobalt chemicals and cobalt metal powder from refined cobalt materials and (or) cobalt-bearing scrap. U.S. Geological Survey (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 table 2. The sole producer of cobalt metal powder, Global Tungsten & Powders Corp. of Towanda, PA, produced the cobalt powder as a byproduct of tungsten recovery from cemented carbide scrap. U.S. production

and shipments of cobalt metal powder were withheld to avoid disclosing company proprietary data.

Consumption

U.S. reported consumption of cobalt in 2013 was 7% less than that of 2012. Metallurgical industries used 8% less cobalt than they did in 2012, and cobalt consumption for chemical uses was 4% less than that of 2012. Reported consumption statistics were derived by the USGS from voluntary surveys of U.S. operations. Most of the cobalt chemical-use data were obtained from the cobalt processors survey. A second survey covered a broad range of metal-consuming companies, such as cemented carbide, magnetic alloy, and superalloy producers. For this survey, more than 60 cobalt consumers were canvassed on a monthly or annual basis. Reported consumption and stocks data in tables 1 and 2 include estimates to account for nonrespondents.

U.S. apparent consumption for 2013, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 9% less than that in 2012 (table 1). The decrease was caused by a decrease in net imports in 2013 compared with those in 2012 and a buildup of industry stocks.

Prices

The annual average U.S. spot price for cathode (minimum of 99.8% cobalt), as reported by Platts Metals Week, was 8% less than that of 2012 (table 1). The overall price trend was upward during the first half of the year, then downward during the second half. The lowest price range was \$10.80 to \$11.80 per pound in the first week of January, and the highest price range was \$14.00 to \$15.25 per pound in early July. The year ended at a price range of \$11.75 to \$12.75 per pound.

Trends in Platts' prices for Zambian cobalt (minimum 99.6% cobalt) and Russian cobalt (minimum 99.3% cobalt) were similar to those for U.S. spot cathode. The annual average of weekly prices for Zambian cobalt was \$12.33 per pound, and the annual average of weekly prices for Russian cobalt was \$12.31 per pound.

In 2013, cobalt from Chambishi Metals plc (Kitwe, Zambia) was approved for delivery on the London Metal Exchange (LME) cobalt futures contract, bringing the total number of cobalt producers accepted by the LME to 15. In November, the LME announced that cobalt from Kasese Cobalt Co. Ltd. (Kasese, Uganda) would no longer be accepted after February 12, 2014, and the brand would be delisted after all stocks were depleted. An increasing number of producers are expected to use the LME cobalt price as a benchmark for their spot and (or) contract sales in 2014–15. The annual average mean of cash buyer and cash seller prices and yearend LME inventory levels are listed in table 1 (Sherritt International Corp., 2014a, p. 7; London Metal Exchange Ltd., The, undated; 2013).

Electrolytic cobalt was also traded on China's Fanya Metal Exchange (Fanya Metal Exchange Co. Ltd., undated).

Foreign Trade

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic production

to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes. Releases from stocks, including shipments from the NDS, were counted as part of import reliance, regardless of whether they were originally imported or produced in the United States. In 2013, net import reliance as a percentage of apparent consumption was 75%. Because there was no measurable U.S. primary cobalt production in 2013, this indicates that 75% of U.S. cobalt supply was from imports and stock releases of primary cobalt and 25% was from domestic or imported scrap.

In 2013, the United States imported 10,500 t of cobalt contained in metal and chemical compounds, valued at \$291 million, 5% less by weight than the 11,100 t imported in 2012 (tables 3, 4). On the basis of cobalt content, 10 countries supplied 86% of U.S. imports. China was the leading supplier, followed by Norway, Finland, Russia, Japan, the United Kingdom, Zambia, Madagascar, Australia, and Belgium. The United States also imported unwrought cobalt alloys (967 t, gross weight, valued at \$30.3 million), cobalt waste and scrap (703 t, gross weight, valued at \$11.0 million), and wrought cobalt and cobalt articles (250 t, gross weight, valued at \$26.9 million).

U.S. exports of unwrought cobalt and cobalt contained in chemicals were 3,850 t, valued at \$103 million, slightly more by weight than the 3,760 t exported in 2012. As listed in table 5, on the basis of cobalt content, the leading destinations for these exports were Canada, Ireland, France, Belgium, the United Kingdom, Germany, and Japan. The United States also exported 2,200 t, gross weight, of wrought metal and cobalt articles valued at \$114 million.

World Industry Structure

In early 2013, OM Group, Inc. (OMG) (Cleveland, OH) announced that it was exiting the advanced materials business and would be divesting its cobalt assets in Congo (Kinshasa) and Finland. In May, multinational commodity trading and production company Glencore International plc merged with multinational commodity production company Xstrata plc to form Glencore Xstrata plc.

World Review

World cobalt mine and refinery production increased in 2013 compared with production in 2012, mainly owing to an increase in estimated refinery production from China and a coincident increase in China's imports of cobalt ores and concentrates from Congo (Kinshasa) and increases in mine and refinery production in Madagascar. Cobalt was produced as a byproduct of copper, nickel, and other metals, and as a primary product. Primary cobalt production included the mine and refinery production of Morocco, the artisanal mining of the mineral heterogenite in Congo (Kinshasa), and the recovery of cobalt from previously stockpiled intermediate materials [for example, slags in Congo (Kinshasa)], which were processed primarily to recover cobalt.

Refinery capacity by country is listed in table 6. The table does not include plants that processed refined cobalt, plants that used secondary materials (scrap) as their main source of

feed, or plants that produced a cobalt product that required further refining.

The following review by country focuses on operations that produced cobalt in 2013. Expansions to those operations, operation restarts, and greenfield projects that were forecast to begin producing between 2014 and 2018 are listed in table 7.

Australia.—In 2013, Western Australian cobalt mine production increased by 9% (table 8). Most of the increase was from the Murrin Murrin and Ravensthorpe operations described below.

The Palmer Nickel and Cobalt Refinery (owned by Australian businessman Clive Palmer, operated by Queensland Nickel Pty. Ltd.) in Townsville, Queensland, produced 2,281 t of refined cobalt as cobalt oxide hydroxide, 4% less than the 2,369 t produced in 2012. The refinery processed lateritic ore from the Brolga Mine in central Queensland; lateritic ore imported from Indonesia, New Caledonia, and the Philippines; and an intermediate cobalt compound from Vale S.A.'s New Caledonia operation (Cobalt Development Institute, 2014a; Darton Commodities Ltd., 2014, p. 18).

BHP Billiton's Nickel West operations in Western Australia comprised nickel sulfide mines; concentrators, which processed ores mined by BHP Billiton and other companies; the Kalgoorlie smelter, where nickel matte was produced; and the Kwinana nickel refinery, which produced cobalt in intermediate nickel-cobalt sulfide. Darton Commodities Ltd. estimated that BHP Billiton shipped 698 t of cobalt contained in intermediate nickel-cobalt sulfide from Kwinana to Jinchuan Group Ltd. in China for refining in 2013 (673 t in 2012) (Darton Commodities Ltd., 2014, p. 23).

Glencore Xstrata had three nickel assets in Western Australia—Minara Resources Ltd.'s Murrin Murrin nickel-cobalt laterite mining and pressure-acid leaching operation and XNA's (the former Xstrata Nickel Australasia) Cosmos and Sinclair nickel sulfide mines. In 2013, Murrin Murrin produced 2,700 t of cobalt metal (2,500 t in 2012). The increase in production was attributed to debottlenecking and consistent plant availability. Approximately 100 t of Murrin Murrin's production each year was from third party feed. The XNA mines produced 100 t of cobalt in concentrates in 2013 compared with 300 t in 2012. The decrease in production was because the mines were placed on care-and-maintenance status in response to low nickel prices and a strong Australian dollar—Cosmos in late 2012 and Sinclair in mid-2013 (Bell, 2013; Glencore Xstrata plc, 2014, p. 9, 18).

First Quantum Minerals Ltd. (Vancouver, British Columbia, Canada) increased production from its Ravensthorpe nickel-cobalt laterite mine and hydrometallurgical processing plant in Western Australia. In 2013, the plant produced intermediate nickel-cobalt hydroxide containing 38,103 t of nickel and, based on the hydroxide containing 40% nickel and 1.4% cobalt, an estimated 1,300 t of cobalt (32,884 t nickel and an estimated 1,100 t cobalt in 2012). First Quantum expected to produce an average of approximately 36,000 t/yr of nickel during 2014–18 and 28,000 t/yr during the expected mine life of 28 years (First Quantum Minerals Ltd., 2014a, p. 32, 35).

Panoramic Resources Ltd. produced concentrates containing 412 t of cobalt (401 t in 2012) from its Savannah underground

nickel-copper sulfide mine operation in Western Australia. The concentrates were shipped to Jinchuan's operations in China under a long-term offtake agreement (Panoramic Resources Ltd., 2013, p. 3; 2014, p. 3, 41).

In April, OJSC MMC Norilsk Nickel suspended mining and beneficiation at its Lake Johnston nickel operations in Western Australia, and placed them on care-and-maintenance status (OJSC MMC Norilsk Nickel, 2014, p. 58).

Belgium.—According to the Cobalt Development Institute (2014a), n.v. Umicore s.a.'s 2013 cobalt refinery production increased by 29% to 5,415 t of contained cobalt from 4,200 t produced in 2012. Umicore converted various cobalt materials into a wide range of chemicals and metal powders at refineries in Olen, Belgium, and Ganzhou, China. The company also had cobalt processing plants, which made specialty chemicals or metal powders from refined cobalt or scrap, in Arab, AL; Bruges, Belgium; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. At yearend, Umicore acquired Palm Commodities International, Inc., a LaVergne, TN, producer of cobalt and nickel plating chemicals (n.v. Umicore, s.a., 2014, p. 73).

Botswana.—Tati Nickel Mining Co. Pty. Ltd. (a Norilsk subsidiary) mined the Phoenix open pit and produced nickel-copper sulfide concentrates containing cobalt, which were toll-smelted to high-grade matte by BCL Ltd. in Botswana. The matte was sent to Norilsk's refineries in Finland and Russia and to third-party customers. BCL also smelted concentrate from its Selebi-Phikwe operation in Botswana. Matte produced by BCL was refined by RioZim Ltd. in Zimbabwe and Glencore Xstrata in Norway (OJSC MMC Norilsk Nickel, 2014, p. 60).

Brazil.—Votorantim Metais S.A. produced cobalt cathode at its Sao Miguel Paulista, Sao Paulo State, refinery from lateritic nickel-cobalt ore mined from Niquelandia, Goias State, and nickel sulfide concentrate from Mirabela Nickel Ltd. Votorantim also produced nickel matte, primarily from sulfide ores mined and smelted at Fortaleza de Minas, Minas Gerais State. In September, Votorantim temporarily suspended matte production at Fortaleza de Minas after determining that it was not economically viable (Votorantim Industrial S.A., 2014, p. 120).

Mirabela Nickel produced 277 t of cobalt in nickel sulfide concentrate (335 t in 2012) from its Santa Rita open pit mine and concentrator in Bahia State. The concentrate was sold to Norilsk, Votorantim, and an international trading firm (Mirabela Nickel Ltd., 2014).

Canada.—Vale's global cobalt production was 3,532 t in 2013, 51% more than the 2,343 t produced in 2012. Vale produced 1,550 t of refined cobalt metal at its Port Colborne, Ontario, refinery; 685 t of cobalt in a cobalt intermediate product at its nickel operations in Canada and New Caledonia; and 1,297 t of cobalt contained in other intermediate products and nickel concentrates. Vale's cobalt originated from company-owned nickel sulfide mines at Sudbury, Ontario, Thompson, Manitoba, and Voisey's Bay in northeastern Labrador; from a company-owned nickel laterite mine in New Caledonia; and from purchased feedstock materials. Vale reported that 853 t (589 t in 2012) of cobalt came from Ontario, 292 t (96 t in 2012) came from Manitoba, 1,256 t (1,221 t in 2012) came from Voisey's Bay, 1,117 t (385 t in 2012) came from New Caledonia,

and 13 t (52 t in 2012) came from external sources (Vale S.A., 2014, p. 38–39, 48–49).

In 2013, Vale completed the construction of its hydrometallurgical facility in Long Harbour, Newfoundland and Labrador, Canada, and began commissioning (table 7). Concentrates from Voisey's Bay were smelted and refined at Sudbury and Thompson while the Long Harbour refinery was being built and commissioned. Vale was considering phasing out smelting and refining at Thompson, owing to Canadian sulfur dioxide emission standards that were expected to come into effect in 2015 (Vale S.A., 2014, p. 19, 38).

Glencore Xstrata reported that 700 t of the cobalt produced at its Nikkelverk refinery in Norway originated from concentrates produced from its mines at Sudbury, Ontario, and Raglan, Quebec. This was an increase from the 600 t produced from its Canadian operations in 2012 (Glencore Xstrata plc, 2014, p. 18).

The Fort Saskatchewan refinery, a joint venture of Sherritt International Corp. and General Nickel Co. S.A., produced 3,319 t of cobalt as metal powder and briquettes in 2013, 12% less than the 3,792 t produced in 2012, owing to reduced availability of intermediate nickel-cobalt sulfides from the joint venture's operations at Moa Bay, Cuba. Approximately 97% of the cobalt was from Cuba; the remainder was from purchased materials. As a result of a United States embargo on imports of products originating from Cuba, cobalt and nickel produced by Sherritt cannot be sold to customers in the United States. In 2013, Sherritt decided against a future expansion of the Fort Saskatchewan refinery, but planned to continue to debottleneck the refinery over time (Sherritt International Corp., 2014a, p. 9, 15; 2014b, p. 14).

Canadian Royalties Ltd. started producing concentrates from its Nunavik Nickel project in Nunavik, Quebec. Average production of cobalt in nickel concentrate was forecast to be 425 t/yr (Canadian Royalties Inc., 2008, p. 14; Tetra Tech, Inc., undated).

China.—China was the world's leading producer and consumer of refined cobalt. In 2013, China's imports of raw materials, production, and consumption recovered from the low levels in 2012 and exceeded those of 2011. China's total production, including an estimate for Umicore's Ganzhou Yi Hao plant, represented nearly one-half of world refined cobalt production. Sixty-nine percent of China's consumption was used to make cathode materials for rechargeable batteries, primarily lithium cobalt oxide lithium-ion batteries (Wu, 2013, p. 16; Darton Commodities Ltd., 2014, p. 7, 23–24; Xu, 2014, p. 3–4, 9–10).

Numerous companies refined and (or) processed cobalt in China. Only a small portion of China's cobalt production originated from domestic mines and recycled scrap. Most of the production was from imported cobalt concentrate and intermediate chemical compounds, the majority of which was sourced from Congo (Kinshasa). With regard to imported feed materials, in 2013, China consumed more cobalt concentrate, intermediate cobalt compounds, and nickel raw materials (concentrates and intermediate chemical compounds), and less of the cobalt-copper-iron alloy called alliage blanc, than in 2012. During 2009–11, a surplus of raw materials and refined

cobalt accumulated in China, resulting in stocks estimated to contain 20,000–25,000 t of cobalt by yearend 2011. The stocks decreased during 2012; opinions were mixed, however, as to whether China's stocks increased or decreased by yearend 2013 (Darton Commodities Ltd., 2014, p. 8, 26, 41–42; Xu, 2014, p. 3, 19–20).

Congo (Kinshasa).—Congo (Kinshasa) was the world's leading producer of mined cobalt and was estimated to represent approximately one-half of global production. Some of the country's cobalt mine production was from copper-cobalt ores mined by traditional methods, and some was gathered by tens of thousands of artisanal miners by hand-picking cobalt-rich ores. Some of Congo (Kinshasa)'s ores and concentrates were exported, some were processed to intermediate materials (crude cobalt carbonate, crude cobalt hydroxide, or cobalt-bearing alloys, such as alliage blanc), and some were refined to cobalt metal. China was the leading destination for Congo (Kinshasa)'s cobalt exports. At yearend, the Government of Congo (Kinshasa) announced that it planned to postpone a proposed ban on the export of copper and cobalt concentrates to December 2014. The Government increased the export duty on concentrates from \$60 per metric ton to \$100 per metric ton effective from November 2013 (Eurasian Natural Resources Corp. Ltd., 2014, p. 89).

State-owned La Générale des Carrières et des Mines (Gécamines) held a minority interest in most of the copper-cobalt operations in Congo (Kinshasa) and acquired full control of Compagnie Minière du Sud Katanga and its Luiswishi copper-cobalt mine in late 2012. In 2013, Gécamines produced 700 t of refined cobalt at its Shituru refinery in Likasi, down from 870 t in 2012 (Cobalt Development Institute, 2014a).

Kamoto Copper Company SARL (KCC) (Katanga Mining Ltd., Gécamines, and La Société Immobilière du Congo) produced 2,297 t of cobalt cathode in 2013 (2,129 t in 2012). The increase was attributed to record tonnages of mined and milled ore. The company's Luilu refinery processed concentrates produced at its Kamoto concentrator from ore extracted from its Kamoto underground mine and KOV and T17 open pits. KCC continued commissioning the phase 4 expansion of its operations and ramped up plant production. The phase 4 expansion increased the capacity of the Luilu refinery to 8,000 t/yr of cobalt cathode and 22,000 t/yr of cobalt as hydroxide. Glencore Xstrata was KCC's majority shareholder and had offtake agreements for all of KCC's copper and cobalt output. KCC also sold copper concentrates to Mopani Copper Mines plc and Sable Zinc Kabwe Ltd. in Zambia (van der Schyff, 2012, p. 22, 64, 112; Katanga Mining Ltd., 2014, p. 2, 11, 29–30).

Boss Mining Sprl [70% Eurasian Resources Group B.V. (ERG), which acquired Eurasian Natural Resources Corp. Plc. (ENRC) in late 2013, and 30% Gécamines] mined copper-cobalt ore from Mukondo Mountain and produced oxide and sulfide concentrates at the Kakanda concentrator. Boss Mining's oxide concentrates were exported, primarily to China; all of its sulfide concentrates were sent to the Chambishi Metals refinery in Zambia. ENRC reported a slight increase in its production of saleable cobalt from 9,600 t in 2012 to 9,700 t in 2013. These data include cobalt in concentrate mined in Congo (Kinshasa)

and cobalt in metal produced in Zambia (Darton Commodities Ltd., 2014, p. 13; Eurasian Natural Resources Corp. Ltd., 2014, p. 14).

Tenke Fungurume Mining S.A.R.L. [Freeport-McMoRan Copper & Gold Inc. (FCX), Lundin Mining, and Gécamines] essentially completed the phase 2 expansion at its mining and processing operation, bringing the operation's production capacity to 15,000 t/yr of cobalt in hydroxide. In 2013, Tenke Fungurume produced 12,751 t of cobalt in hydroxide, up from 11,669 t in 2012; the company forecast that it would sell 13,600 t of cobalt in 2014. Early in the year, the partners formed a new joint venture and acquired OMG's Kikkola refinery in Finland, which they intended to use to refine increasing volumes of Tenke Fungurume's cobalt hydroxide (as discussed in the Finland section of this report) (Lundin Mining Corp., 2014, p. 21–22; Darton Commodities Ltd., 2014, p. 12).

OMG transferred its interest in the Groupement du Terril de Lubumbashi (GTL) joint venture to Groupe Forrest International and Gécamines, its joint-venture partners. In 2013, GTL (also known as the Big Hill smelter) processed stockpiled slag to produce 4,330 t of cobalt in alliage blanc, which was refined at Freeport Cobalt's refinery in Finland (OM Group, Inc., 2013; Groupe Forrest International, 2014).

Mutanda Mining SPRL (Glencore Xstrata and Fleurette Mumi Holding Ltd.) mined copper-cobalt oxide ore from open pits near Kolwezi and produced 13,700 t of cobalt in concentrate and hydroxide, 61% more than the 8,500 t produced in 2012. The increase in production was the result of an increase in the operation's production capacities for copper and cobalt (Glencore Xstrata plc, 2014, p. 7, 14).

Chemaf SPRL mined copper-cobalt oxide ores from the Etoile open pit mine, and processed run-of-mine ore, concentrates, and ore purchased from third parties at its solvent extraction–electrowinning (SX–EW) plant at Usoke in Lubumbashi. In 2013, Chemaf produced 1,170 t cobalt in hydroxide or carbonate, 8% less than the 1,278 t produced in 2012. The company also operated a pilot cobalt electrowinning plant, which had the capacity to produce 50 t/yr of cobalt (Shalina Resources Ltd., undated a, b).

Ruashi Mining Sprl (75% Jinchuan, 25% Gécamines) produced 3,045 t of cobalt in cobalt hydroxide (3,035 t in 2012) from its Ruashi operation east of Lubumbashi. Ruashi comprised a copper-cobalt oxide open pit mine, a mill, and an SX–EW refinery. The cobalt hydroxide was sold to Jinchuan (Jinchuan Group International Resources Co. Ltd., 2014, p. 26).

Société Minière du Katanga sprl (Somika) mined and beneficiated copper-cobalt ore, and refined the concentrate at its hydrometallurgical copper refinery in Lubumbashi. In 2013, the refinery produced 1,968 t of cobalt hydroxide (Province du Katanga Division Provinciale de Mines, 2014).

China Railway Group Ltd. started commercial production at two copper-cobalt mines in Katanga Province—Luishia and Minière de Kalumbwe Myunga. The company was also a partner in La Sino-Congolaise des Mines S.A. (Sicomines) (table 7) (China Railway Group Ltd., 2014, p. 21, 28).

Cuba.—Moa Nickel S.A. (part of the 50–50 joint venture between Sherritt and General Nickel) mined nickel-cobalt laterites at Moa Bay, Holguin Province, and produced

intermediate nickel-cobalt sulfides, which were sent to the joint venture's Fort Saskatchewan refinery in Canada. In 2013, the sulfides contained 36,374 t of nickel and cobalt, 4% less than the 38,054 t produced in 2012. The decrease was attributed to failure of a rake mechanism in one of the ore thickeners and a change in the processing characteristics of ore from a new mining concession (Sherritt International Corp., 2014b, p. 14).

In late 2012, the Government of Cuba closed its oldest and least productive nickel plant, the Rene Ramos Latour plant in Nicaro, Holguin Province (Frank, 2012). The Ernesto Che Guevara operation in Moa, Holguin Province, continued to mine and process nickel-cobalt laterites. Nickel and cobalt originating in Cuba cannot be imported into the United States because of a United States embargo on imports from Cuba (Sherritt International Corp., 2014b, p. 44–45).

Finland.—OMG sold its Kikkola cobalt refinery and related sales and marketing business to a newly formed joint venture held by FCX, 56%; Lundin Mining Corp., 24%; and Gécamines, 20%. FCX was to be the operator of the joint venture, which was named Freeport Cobalt. Freeport Cobalt produced inorganic cobalt compounds and coarse cobalt metal powder. Feed for the refinery included scrap and raw materials sourced from Congo (Kinshasa), Finland, and Russia. Gécamines' Compagnie Minière du Sud Katanga reportedly sold concentrates to the refinery and GTL reportedly agreed to continue to supply alliage blanc from its Big Hill smelter under a 2-year agreement signed in early 2013. FCX stated that the refinery could process most of the cobalt hydroxide produced from the joint-venture partners' Tenke Fungurume operation in Congo (Kinshasa); the proportion of feed from Tenke Fungurume was expected to increase after pre-existing sales agreements with other refineries expired. Norilsk Nickel reportedly supplied crude cobalt hydroxide from its Monchegorsk nickel refinery in Russia and cobalt sulfate solution from its Harjavalta nickel refinery in Finland (Darton Commodities Ltd., 2014, p. 6, 12, 15, 17–18; Freeport-McMoRan Copper & Gold Inc., 2014, p. 24; Freeport Cobalt Oy, undated).

Norilsk's Harjavalta nickel refinery produced two cobalt products—an intermediate cobalt sulfate solution, some of which was sent to the Freeport Cobalt refinery, and cobalt sulfate, which was produced from a new 1,500-t/yr circuit that was added in 2013. The Harjavalta refinery processed the following feed materials: high-grade matte, which was toll-produced at the Boliden Harjavalta smelter from nickel concentrates from Norilsk's Nkomati Mine in South Africa and other sources, including Mirabela Nickel in Brazil; nickel-cobalt sulfide from Talvivaara Mining Co. Plc's operation in Finland; and nickel matte from Votorantim's Fortaleza smelter in Brazil and BHP Billiton's Kalgoorlie smelter in Australia (Darton Commodities Ltd., 2014, p. 18; OJSC MMC Norilsk Nickel, 2014, p. 56–57, 69, 97).

First Quantum ramped up production at its Kevitsa open pit nickel-copper-PGM sulfide mine and beneficiation plant. In 2013, the plant produced nickel concentrate containing 8,963 t of nickel and, based on an estimated nickel-to-cobalt ratio of 21:1 in the ore reserves, an estimated 430 t of cobalt (3,875 t nickel and an estimated 185 t cobalt in 2012) (First Quantum Minerals Ltd., 2014b).

Talvivaara Mining Co. Plc's production from its polymetallic sulfide mine and bioheap-leaching operation in Sotkamo in central Finland decreased for the second consecutive year. The decrease was mainly the result of excess water, which caused mining to be suspended from September 2012 to May 2013 and diluted the metal grades of the bioleach solution. In November, as a result of low production levels and weak nickel prices, Talvivaara and its operating subsidiary had to apply for corporate reorganization and suspended mining for a second time. In 2013, Talvivaara sold nickel-cobalt sulfide containing 286 t of cobalt to Norilsk for processing at Harjavalta (355 t in 2012) (Talvivaara Mining Co. Plc, 2014, p. 2, 8, 103).

In June, Belvedere Resources Ltd. ceased production at its Hitura nickel mine in response to low nickel prices. Prior to the shutdown, Belvedere produced less than 40 t of cobalt in nickel-copper-cobalt concentrate, which was sold to Jinchuan. Belvedere planned to sell the underground mining equipment from Hitura and use the mill to process ore from a nearby gold-copper mine (Belvedere Resources Ltd., 2014, p. 2–11).

Altona Mining Ltd.'s Outokumpu copper operation comprised the Kylylahti underground polymetallic base metal sulfide mine and Luikonlahti beneficiation plant. In 2013, the mine achieved its design production rate. At full production, the operation was expected to produce approximately 80,000 t/yr of cobalt-nickel concentrate, containing an average of 940 t/yr of cobalt. Altona was stockpiling the concentrate while it studied the potential for producing a marketable cobalt-nickel hydroxide product (Altona Mining Ltd., 2013, p. 2, 17).

France.—The Eramet Group's production of cobalt chloride from its refinery at Sandouville was 6% less than that produced in 2012. Feed for the refinery was nickel matte imported from Eramet subsidiary Société Le Nickel's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2014a).

India.—According to an estimate by the Cobalt Development Institute (2014a), India's cobalt production decreased by 63% from that of 2012. The decrease was because Rubamin ceased production in mid-2012, leaving Nicomet Industries Ltd. as India's leading cobalt producer (Ryan's Notes, 2012; Nicomet Industries Ltd., undated).

Indonesia.—PT Vale Indonesia Tbk produced cobalt-bearing nickel matte from lateritic ores at its integrated mining and smelting operation near Sorowako on Sulawesi Island. Vale Indonesia sold the matte to Vale Canada Ltd. (80%) and Sumitomo Metal Mining Co., Ltd. (20%) under life-of-mine agreements. The matte was primarily sent to nickel refineries in Japan (Vale S.A., 2014, p. 39).

PT Antam Tbk exported lateritic nickel-cobalt ore to the Palmer Nickel and Cobalt Refinery in Queensland for processing (CRU International Ltd., 2013, p. 4).

Japan.—Sumitomo's production of electrolytic cobalt at its Niihama nickel refinery increased by 8% from that of 2012. The refinery processed intermediate nickel-cobalt sulfide from the Coral Bay Nickel Corp. and Taganito HPAL Nickel Corp. plants in the Philippines and nickel matte from PT Vale in Indonesia. During the year, Sumitomo completed an expansion to the refinery that increased its production capacity to 4,500 t/yr of cobalt (Ritzema, 2013; Cobalt Development Institute, 2014a).

Madagascar.—Sherritt ramped up production from its Ambatovy project, which comprised mining nickel-cobalt laterite ore in eastern central Madagascar and transporting slurried ore by pipeline to a processing plant and refinery located near the Port of Toamasina. In 2013, Ambatovy produced 29,248 t of nickel and cobalt in intermediate sulfide (8,972 t in 2012) and 2,083 t of cobalt metal (493 t in 2012). Sherritt's partners in the project were Sumitomo Corp., Korea Resources Corp., and SNC-Lavalin Group Inc. (Sherritt International Corp., 2014b, p. 16).

Morocco.—Cie. de Tifnout Tighanimine (CTT) [a subsidiary of Groupe Managem (Casablanca)] mined cobalt arsenide ores and produced cobalt hydroxide at Bou-Azzer. The hydroxide was refined to cobalt cathode and oxide at CTT's Guemassa hydrometallurgical refinery north of Marrakech. Managem planned an exploration program to expand its reserves and was considering producing value-added cobalt products such as lithium-cobalt and cobalt oxides (Groupe Managem, 2014, p. 47).

New Caledonia.—Vale continued to ramp up production at its Vale New Caledonia project in the southern tip of New Caledonia's main island. The project comprised a nickel-cobalt laterite mine, a high-pressure acid-leaching processing plant, and a refinery. In 2013, Vale produced 1,117 t of cobalt from New Caledonia (385 t in 2012). Statistics from the Government of New Caledonia indicated that Vale produced 503 t of cobalt in carbonate (151 t in 2012). Following rampup, Vale New Caledonia was expected to have a nominal production capacity of 60,000 t/yr of nickel contained in nickel oxide and 4,600 t/yr of cobalt contained in an intermediate cobalt carbonate (Direction de l'Industrie, des Mines et de l'Energie, 2014; Vale S.A., 2014, p. 39, 49).

Lateritic nickel-cobalt ore was exported to the Palmer Nickel and Cobalt Refinery in Queensland for processing. Nickel matte from Société Le Nickel's Doniambo smelter was sent to Eramet's refinery in Sandouville, France, where nickel products and cobalt chloride were produced.

Norway.—Glencore Xstrata's production of cobalt cathode at its Nikkelverk refinery was 15% more than that of 2012. The cobalt originated from matte produced at Glencore Xstrata's Sudbury smelter in Canada and custom feed, which included matte from Botswana processed under a long-term agreement with BCL and reportedly also intermediate cobalt compounds from Norilsk (CRU International Ltd., 2013, p. 4; Darton Commodities Ltd., 2014, p. 18; Glencore Xstrata plc, 2014, p. 18).

Papua New Guinea.—The Ramu Nickel joint venture (operated by majority owner Metallurgical Corporation of China Ltd.) ramped up production from its nickel-cobalt laterite mine, beneficiation plant, and high-pressure acid-leaching processing plant. In 2013, the operation increased its production to 1,013 t of cobalt in intermediate nickel-cobalt hydroxide from 469 t in 2012. Ramu planned to bring the operation to full capacity (3,300 t/yr of cobalt) in 2015. The hydroxide was exported to China for refining (Highlands Pacific Ltd., 2014, p. 5, 10–11).

Philippines.—Coral Bay Nickel (a joint venture between Sumitomo, Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba

Nickel Mining Corp., listed in order of share) produced intermediate nickel-cobalt sulfide from its high-pressure acid-leaching operation at the Rio Tuba nickel laterite mine on Palawan Island.

Taganito HPAL Nickel Corp. (Sumitomo, Nickel Asia Corp., and Mitsui, listed in order of share) completed construction of a high-pressure acid-leaching processing plant at Nickel Asia's Taganito laterite mine in the northeastern region of Mindanao Island. The plant, which had the capacity to produce 2,600 t/yr of cobalt in intermediate nickel-cobalt sulfide, was in commercial operation by yearend. Sulfides from Coral Bay and Taganito were sent to Sumitomo's Niihama refinery in Japan (Sumitomo Metal Mining Co., Ltd., 2013).

Russia.—According to the Cobalt Development Institute (2014a), Norilsk produced 2,368 t of refined cobalt, 8% more than the 2,186 t produced in 2012. Norilsk mined and beneficiated nickel-copper sulfide ores, smelted the concentrates, and refined the matte on the Taimyr and Kola Peninsulas. On the Taimyr Peninsula, Norilsk's Polar Division's Nickel Plant produced cobalt ingot and oxide from local ores. At Norilsk's nickel refinery at Monchegorsk on the Kola Peninsula, the company processed cobalt-bearing nickel materials from Kola, the Polar Division, and elsewhere. In 2013, some of the intermediate cobalt hydroxide product was reportedly sent to the Kokkola refinery in Finland. Norilsk continued to build a cobalt refinery at Monchegorsk for converting its hydroxide to high-grade cobalt cathode, and reportedly produced about 200 t of cathode at the associated pilot plant (table 7) (Darton Commodities Ltd., 2013, p. 12; 2014, p. 6, 17–18; OJSC MMC Norilsk Nickel, 2014, p. 37, 52–55, 90, 94).

South Africa.—The Nkomati nickel sulfide mine (a joint venture of African Rainbow Minerals Ltd. and Norilsk) produced 1,159 t of cobalt in nickel concentrate in 2013, 16% more than the 998 t produced in 2012. The concentrate was processed at Norilsk's Harjavalta refinery in Finland (African Rainbow Minerals Ltd., 2014a, p. 65; 2014b, p. 64; OJSC MMC Norilsk Nickel, 2014, p. 60).

Cobalt was also produced as a byproduct from some of South Africa's PGM operations. Two companies produced refined cobalt. Rustenburg Base Metals Refiners (Proprietary) Ltd. (a subsidiary of Anglo American plc) produced cobalt sulfate at its base-metals refinery near Rustenburg, Northwest Province. Impala Platinum Ltd. produced cobalt metal powder at its base-metals refinery near Springs, Gauteng Province. Some of the cobalt produced by Impala was recovered from concentrates produced at the Mimosa platinum mine in Zimbabwe. Two other platinum producers—Lonmin plc and Northam Platinum Ltd.—operated base-metals refineries and produced intermediate nickel sulfate containing cobalt.

Spain.—Lundin Mining Corp. mined nickel-copper sulfide ore from its Aguablanca open pit in Badajoz Province and produced concentrate containing metal levels close to those before the slope failure that occurred in 2010 (Lundin Mining Corp., 2014, p. 2).

Uganda.—Kasese Cobalt Co. Ltd. increased the rate at which it was processing stockpiled pyrite concentrates and depleted the stockpile in August. Majority owner MFC Industrial Ltd. was

considering options to dismantle or dispose of the plant (MFC Industrial Ltd., 2013).

Vietnam.—Asian Mineral Resources Ltd. began production from its Ban Phuc nickel-copper sulfide mine and beneficiation plant in Son La Province. At full production, Ban Phuc is expected to produce about 200 t/yr of cobalt in nickel-copper-cobalt concentrate (Asian Mineral Resources Ltd., 2013).

Zambia.—Cobalt is present in many of Zambia's copper deposits, but not all copper operations report their cobalt output. Estimated Zambian cobalt mine production increased in 2013 compared with that of 2012, mainly owing to increases in estimated cobalt production from Mopani Copper Mines and Barrick Gold Corp.'s Lumwana copper mine. Production of refined cobalt decreased, however, owing to decreased output from the Chambishi refinery and no production at the Nkana refinery.

According to the Cobalt Development Institute (2014a), Chambishi Metals plc (90% ERG and 10% ZCCM Investments Holdings Plc) produced 5,000 t of cobalt metal at its Chambishi refinery, 8% less than the 5,435 t produced in 2012. The decrease was attributed to electricity shortages, a blown transformer late in the year that resulted in the plant operating at 50% of normal levels, and reduced supply of copper-cobalt sulfide concentrate from Boss Mining's Mukondo Mine in Congo (Kinshasa). Because of its heavy reliance on feed materials from Congo (Kinshasa), this refinery would be significantly affected if the Government of Congo (Kinshasa) imposed its proposed ban on the export of copper and cobalt concentrates (Cobalt Development Institute, 2014a; Darton Commodities Ltd., 2014, p. 7, 13, 16).

Mopani Copper Mines (Glencore Xstrata, First Quantum, and ZCCM Investment Holdings, listed in order of share) kept its Nkana cobalt refinery on care-and-maintenance status in 2013. Cobalt production was not expected to restart until cobalt prices increased significantly. Mopani was upgrading the refinery to increase its cobalt production capacity (table 7) (Darton Commodities Ltd., 2014, p. 17; Glencore Xstrata plc, 2014, p. 14).

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga and Konkola operations. Cobalt in concentrate, mainly from the Nchanga open pit, was processed to a copper-iron-cobalt alloy at the company's Nchanga copper smelter in Chingola. Most of this alloy reportedly was exported to China for refining. Darton Commodities Ltd. (2014, p. 17, 20) estimated that KCM's production increased to 1,900 to 2,000 t of contained cobalt, from 1,600 t in 2012.

China Nonferrous Mining Corp. Ltd. (CNMC) mined and processed copper-cobalt ore in the Zambian Copperbelt through four majority-owned subsidiaries—NFC Africa Mining Plc. (NFCA), CNMC Luanshya Copper Mines Plc. (CLM), Chambishi Copper Smelter Ltd. (CCS), and Sino-Metal Leach Zambia Ltd. CCS smelted copper concentrates from NFCA, CLM, and other miners. CNMC began the preliminary design work for the recovery of cobalt from the CCS's smelter slag (table 7) (China Nonferrous Mining Corp. Ltd., 2014, p. 17, 36).

Glencore Xstrata's Sable Zinc Kabwe Ltd. copper electrowinning plant processed feed from third party sources

and produced 400 t of cobalt in hydroxide in 2013 (700 t in 2012) (Glencore Xstrata plc, 2014, p. 14).

Albidon Ltd.'s Munali nickel mine in southern Zambia remained on care-and-maintenance status. During the year, the mine was purchased by Jin Tuo Investment Ltd., a subsidiary of majority shareholder Jinchuan (Albidon Ltd., 2013).

Zimbabwe.—The Mimosa platinum mine (Aquarius Platinum Ltd. and Impala Platinum Holdings Ltd.) produced 89 t of cobalt in concentrate (88 t in 2012). The concentrate was refined by Impala in South Africa (Aquarius Platinum Ltd., 2013, p. 11; 2014, p. 12). The Bindura Nickel Corp. (BNC) restarted operations at its Trojan nickel sulfide mine and shipped concentrate to offtake partner Glencore Xstrata. BNC's Shangani nickel sulfide mine, smelter, and refinery remained on care-and-maintenance status (Mwana Africa PLC, 2013, p. 10).

Outlook

Trends in cobalt consumption closely follow those of global industrial production. Increasing consumption, particularly for chemical applications such as rechargeable batteries, is forecast to result in increases in cobalt consumption of about 6% per year from 2014 through 2018. During the first half of 2014, the world production of refined cobalt was estimated to be 10% higher than that of the first half of 2013. China showed a large increase in production; significant increases in production from Freeport Cobalt in Finland, Sherritt's Ambatovy operation in Madagascar, and Sumitomo in Japan also contributed to supply. In the next few years, global increases in supply from existing producers and new projects are forecast to continue to outpace increases in consumption (Cobalt Development Institute, 2014b; Bedder, 2014, p. 10–11).

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TABLE 1
SALIENT COBALT STATISTICS¹

(Metric tons, cobalt content, unless otherwise specified)

	2009	2010	2011	2012	2013	
United States:						
Consumption:						
Reported	7,640 ^r	8,130 ^r	9,180 ^r	8,660 ^r	8,090	
Apparent	7,580	10,300	9,230	9,520	8,670	
Imports for consumption	7,680	11,100	10,600	11,100	10,500	
Exports	2,440	2,640	3,390	3,760	3,850	
Stocks, December 31:						
Industry ²	525	630	784	721	812	
London Metal Exchange (LME), U.S. warehouse	XX	23	43	51	41	
U.S. Government ³	293	301	301	301	301	
Price, metal						
U.S. Spot ⁴	dollars per pound	17.86	20.85	17.99	14.07	12.89
LME, cash ⁵	do.	XX	XX	16.01	13.06	12.26
World:						
Production:						
Mine	80,200 ^r	107,000	108,000 ^r	101,000 ^r	110,000 ^e	
Refinery	62,100 ^r	79,500	82,400	78,100 ^r	86,000	
Stocks, December 31, LME ⁶	XX	278	304	429	560	

^eEstimated. ^rRevised. do. Ditto. XX Not applicable.

¹Data are rounded to no more than three significant digits, except prices.

²Stocks held by cobalt processors and consumers.

³Defense Logistics Agency Strategic Materials. Data are uncommitted material only.

⁴Annual average U.S. spot price for minimum 99.8% cobalt cathode reported by Platts Metals Week or Platts Metals Daily.

⁵Annual average mean of the cash buyer price and cash seller price, minimum 99.3% cobalt briquettes, cathode, ingot, or rounds, converted from dollars per metric ton.

⁶Stocks held in Asia, Europe, and the United States.

TABLE 2
U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT^{1,2}

(Metric tons, cobalt content)

	2012	2013
Consumption by end use:		
Steels	548	547
Superalloys	4,190 ^r	3,770
Alloys, excludes steels and superalloys:		
Magnetic alloys	285	303
Other alloys ³	414	397
Cemented carbides ⁴	774	705
Chemical and ceramic uses	2,290 ^r	2,210
Miscellaneous and unspecified	154 ^r	161
Total	8,660 ^r	8,090
Consumption by form:		
Chemical compounds, organic and inorganic ⁵	2,210	2,110
Metal	4,290 ^r	3,810
Purchased scrap	2,160	2,160
Total	8,660 ^r	8,090
Stocks, December 31: ⁶		
Chemical compounds, organic and inorganic ⁵	179	239
Metal	W	W
Purchased scrap	W	W
Total	721	812

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

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

²Includes estimates.

³Includes nonferrous alloys, welding materials, and wear-resistant alloys.

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

⁵Includes oxides.

⁶Stocks held by cobalt processors and consumers.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM¹

Form	2012			2013		
	Gross weight (metric tons)	Cobalt content ² (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content ² (metric tons)	Value (thousands)
Metal ³	8,750	8,750	\$264,000	8,230	8,230	\$222,000
Oxides and hydroxides	2,320	1,670	51,200	2,420	1,740	53,600
Other:						
Acetates	219	53	1,530	156	37	1,220
Carbonates	809	372	13,600	542	249	9,700
Chlorides	89	22	498	98	24	515
Sulfates	689	186	5,360	597	161	4,580
Total	12,900	11,100	336,000	12,000	10,500	291,000

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

²Estimated from gross weights.

³Unwrought cobalt, excluding alloys and waste and scrap.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY¹

Country of origin	Metal ²			Oxides and hydroxides			Other forms ³			Total		
	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)
2012:												
Australia	701	701	\$19,100	--	--	--	--	--	--	701	701	\$19,100
Austria	12	12	727	--	--	--	--	--	--	12	12	727
Belgium	110	110	2,830	529	381	\$14,300	--	--	--	640	491	17,100
Brazil	525	525	14,600	2	1	31	40	13	\$498	567	540	15,200
Canada	425	425	14,300	542	390	7,230	--	--	--	967	815	21,500
China	1,920	1,920	56,100	245	176	5,680	141	59	2,190	2,310	2,160	63,900
Congo (Kinshasa)	81	81	2,190	2	1	48	--	--	--	82	82	2,230
Finland	446	446	17,000	459	331	11,500	955	370	12,200	1,860	1,150	40,700
France	11	11	631	--	--	--	69	17	286	80	28	917
India	47	47	1,450	--	--	--	342	92	2,720	389	140	4,170
Japan	689	689	20,300	(6)	(6)	11	--	--	--	689	689	20,300
Korea, Republic of	52	52	1,510	6	4	169	1	(6)	5	59	56	1,690
Morocco	170	170	4,750	--	--	--	--	--	--	170	170	4,750
Norway	1,140	1,140	34,600	--	--	--	--	--	--	1,140	1,140	34,600
Peru	--	--	--	--	--	--	30	14	669	30	14	669
Philippines	--	--	--	18	13	379	--	--	--	18	13	379
Russia	903	903	27,000	--	--	--	(6)	(6)	3	903	903	27,000
South Africa	368	368	12,500	13	10	404	--	--	--	381	378	12,900
Sweden	14	14	677	--	--	--	--	--	--	14	14	677
Taiwan	16	16	405	--	--	--	32	9	204	48	25	609
Uganda	18	18	466	--	--	--	--	--	--	18	18	466
United Kingdom	32	32	1,700	496	357	11,200	159	49	1,980	687	438	14,900
Zambia	1,070	1,070	31,300	--	--	--	--	--	--	1,070	1,070	31,300
Other	6	6	239	6	4	268	38	9	190	49	19	696
Total	8,750	8,750	264,000	2,320	1,670	51,200	1,810	633	20,900	12,900	11,100	336,000
2013:												
Australia	521	521	12,900	--	--	--	--	--	--	521	521	12,900
Austria	13	13	651	--	--	--	--	--	--	13	13	651
Belgium	21	21	836	609	439	14,300	10	4	192	640	464	15,400
Brazil	328	328	8,000	--	--	--	41	12	475	370	341	8,470
Canada	266	266	9,120	52	37	1,380	--	--	--	317	303	10,500
China	1,860	1,860	48,900	285	205	5,640	135	52	1,780	2,280	2,120	56,400
Congo (Kinshasa)	--	--	--	83	60	1,950	--	--	--	83	60	1,950
Finland	380	380	11,900	369	266	8,590	760	281	9,750	1,510	927	30,300
France	15	15	765	--	--	--	85	21	393	100	36	1,160
Germany	8	8	364	5	3	409	--	--	--	18	13	805
India	6	6	107	--	--	--	126	34	1,250	131	39	1,360
Japan	838	838	21,400	--	--	--	--	--	--	838	838	21,400
Korea, Republic of	33	33	809	28	20	381	--	--	--	60	52	1,190

See footnotes at end of table.

TABLE 4—Continued
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY¹

Country of origin	Metal ²			Oxides and hydroxides			Other forms ³			Total		
	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)
2013.—Continued												
Madagascar	600	600	15,900	--	--	--	--	--	--	600	600	15,900
Morocco	171	171	4,440	--	--	--	--	--	--	171	171	4,440
Norway	1,310	1,310	\$35,600	--	--	--	--	--	--	1,310	1,310	\$35,600
Russia	877	877	22,600	--	--	--	--	--	--	877	877	22,600
South Africa	328	328	10,100	--	--	--	--	--	--	328	328	10,100
Taiwan	1	1	27	--	--	--	72	19	\$471	72	20	498
Uganda	30	30	709	--	--	--	--	--	--	30	30	709
United Kingdom	15	15	640	986	710	\$20,900	123	37	1,440	1,120	762	23,000
Zambia	600	600	15,200	--	--	--	--	--	--	600	600	15,200
Other	12	12	623	5	3	34	36	10	228	53	25	885
Total	8,230	8,230	222,000	2,420	1,740	53,600	1,390	472	16,000	12,000	10,500	291,000

-- Zero.

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

²Unwrought cobalt, excluding alloys and waste and scrap; includes cobalt cathode and cobalt metal powder; may include intermediate products of cobalt metallurgy.

³Includes cobalt acetates, cobalt carbonates, cobalt chlorides, and cobalt sulfates.

⁴Estimated from gross weights.

⁵Customs value.

⁶Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS OF COBALT, BY COUNTRY^{1,2}

Country of destination	Metal ³		Oxides and hydroxides		Acetates		Chlorides		Total	
	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Cobalt content ⁵ (metric tons)	Value ⁴ (thousands)
2012	3,420	\$106,000	397	\$2,540	205	\$3,350	22	\$238	3,760	\$113,000
2013:										
Argentina	24	887	--	--	--	--	--	--	24	887
Australia	5	129	1	26	--	--	--	--	5	155
Austria	18	383	--	--	--	--	--	--	18	383
Belgium	165	3,850	134	2,540	172	1,470	--	--	303	7,870
Brazil	11	820	37	112	--	--	--	--	38	931
Canada	662	7,790	(6)	12	--	--	--	--	662	7,800
China	37	1,660	155	736	--	--	(6)	4	149	2,400
France	604	14,400	1	30	--	--	--	--	605	14,400
Germany	282	13,500	(6)	10	--	--	--	--	282	13,500
Hong Kong	18	992	--	--	--	--	(6)	5	18	997
India	75	2,780	--	--	57	498	--	--	89	3,280
Indonesia	5	268	--	--	--	--	--	--	5	268
Ireland	625	15,300	1	72	--	--	--	--	626	15,400
Italy	17	510	4	16	--	--	--	--	19	527
Japan	231	9,260	--	--	--	--	--	--	231	9,260
Korea, Republic of	87	3,820	1	5	4	30	--	--	88	3,860
Luxembourg	13	99	--	--	--	--	--	--	13	99
Mexico	7	320	72	634	4	46	5	78	61	1,080
Netherlands	90	2,210	(6)	25	--	--	--	--	90	2,240
Norfolk Island	40	1,210	--	--	--	--	--	--	40	1,210
Singapore	34	2,040	1	25	--	--	--	--	34	2,070
South Africa	9	361	--	--	--	--	--	--	9	361
Switzerland	59	1,190	--	--	--	--	--	--	59	1,190
Taiwan	26	976	--	--	--	--	--	--	26	976
Tunisia	16	527	--	--	--	--	--	--	16	527
Turkey	9	286	--	--	--	--	--	--	9	286
United Kingdom	303	9,760	--	--	--	--	(6)	5	303	9,770
Other	27	1,640	2	5	(6)	11	(6)	6	29	1,660
Total	3,500	97,000	409	4,250	236	2,050	6	98	3,850	103,000

-- Zero.

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

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

³Includes unwrought cobalt, powders, waste and scrap, and mattes and other intermediate products of cobalt metallurgy.

⁴Free alongside ship value.

⁵Estimated from gross weights.

⁶Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 6
 WORLD ANNUAL COBALT REFINERY
 CAPACITY, DECEMBER 31, 2013^{1,2}

(Metric tons, cobalt content)

Country	Capacity
Australia	6,700
Belgium	1,500
Brazil ^c	3,000
Canada ^c	6,420
China ^c	50,000
Congo (Kinshasa) ^c	12,400
Finland ^c	13,000
France	500
India ^c	2,060
Japan	4,500
Madagascar	5,600
Morocco	2,250
Norway	5,200
Russia ^c	6,000
South Africa ^c	1,400
Uganda	720
Zambia	8,800
Total	130,000

^cEstimated.

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

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

TABLE 7
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, 2014–18^{1,2}

Projected year of first production	Country	Project and company	Project type	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2014 ^f	Canada	Voisey's Bay Long Harbour commercial nickel processing plant Vale S.A.	new refinery	nickel	nickel-copper-cobalt sulfide concentrate	2,500	Cobalt cathode.
2014	United States (Michigan)	Eagle Eagle Mine LLC (Lundin Mining Corp.)	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	nickel-copper sulfide ore	900 ^e	Nickel concentrate.
2015 ^f	Australia	Rocklands Group Copper CuDeco Ltd.	new mine and beneficiation plant	copper	copper-cobalt-gold oxide and sulfide ore	NA	Cobaltic-pyrite concentrate.
2015 ^f	Belgium	Olen n.v. Umicore, s.a.	expansion of existing refinery	cobalt	NA	NA	Cobalt metal powder.
2015	China	Quzhou plant Zhejiang Huayou Cobalt Co., Ltd.	new processing plant	do.	NA	10,000	Cobalt salts.
2015	Congo (Kinshasa)	Project Minier, stage 1 La Sino-Congolaise des Mines S.A. (Sicomines) [China Railway Group Ltd., La Générale des Carrières et des Mines (Gécamines), Sinohydro Corp., and Zhejiang Huayou Cobalt Co., Ltd.]	new mine and beneficiation plant	copper	copper-cobalt ore	NA	Copper-cobalt concentrate.
2015 ^f	Mexico	El Boleo Minera y Metalúrgica del Boleo, S.A.P.I. de C.V. (Korean Consortium ³ and Baja Mining Corp.)	new mine and refinery	do.	copper-cobalt-zinc-manganese oxide and sulfide ores	1,700 ^f	Cobalt cathode.
2015	Russia	Monchegorsk OJSC Kola Mining and Metallurgical Co. (OJSC MMC Norilsk Nickel)	new refinery	nickel	cobalt hydroxide	3,000	Do.
2015	Uganda	Kilembe Tibet Hima Industry Co. Ltd. consortium ⁴	reopen former mine	copper	copper-cobalt ore	NA	NA.
2015 ^f	Zambia	Nkana Cobalt Plant Mopani Copper Mines Plc	expansion of existing refinery	cobalt	cobalt concentrates and intermediates	7,000 ⁵	Cobalt cathode.
2015	Do.	Synclinorium Mopani Copper Mines Plc	expansion of existing mine	copper	copper-cobalt ore	NA	Copper-cobalt ore.
2016	Australia	Nova Nickel Sirius Resources NL	new mine and beneficiation plant	nickel	nickel sulfide ore	850 ⁶	Nickel concentrate.
2016 ^f	Congo (Kinshasa)	Etoile Leach SX-EW plant ⁷ Chemaf SPRL	new refinery	copper	copper-cobalt tailings	4,500	Cobalt hydroxide.
2016 ^{f, e}	United States (Idaho)	Idaho Cobalt Formation Metals Inc.	new mine and refinery	cobalt	stratiform cobalt-copper-gold ore	1,525 ⁶	Cobalt cathode.
2016 ^f	United States (Minnesota)	NorthMet, phase 1 PolyMet Mining Corp.	new mine and beneficiation plant	copper	copper-nickel-platinum-group metals sulfide ore	360	Nickel concentrate.
2017 ^f	Canada	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished beneficiation plant, and refinery	gold	gold-cobalt-bismuth-copper ore	1,615 ⁶	Cobalt sulfate.

See footnotes at end of table.

TABLE 7—Continued
 COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, 2014–18^{1,2}

Projected year of first production	Country	Project and company	Project type	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2017 ^{3,6}	Zambia	Cobalt converter slag recycling Chambishi Copper Smelter Co., Ltd. (China Nonferrous Mining Corp. Ltd. and Yunnan Copper Industry Group Co. Ltd.) and Hunan Shijiyintianxinye Technology Co., Ltd.	adapt existing smelter	cobalt	copper-cobalt converter slag	500–700 ⁶	Alliage blanc.
2018 ⁶	Australia	Gladstone Nickel, stage 1 Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery ⁸	nickel	nickel-cobalt laterite ore	5,000	Cobalt metal.
2018 ⁶	Congo (Kinshasa)	Project Minier, stage 2 La Sino-Congolaise des Mines S.A. (Sicomines) [China Railway Group Ltd., La Générale des Carrières et des Mines (Gécamines), Sinohydro Corp., and Zhejiang Huayou Cobalt Co., Ltd.]	expansion of new mine and beneficiation plant; add new processing plant	copper	copper-cobalt ore	4,600 ⁶	Cobalt hydroxide.

⁶Estimated. ¹Revised. Do., do. Ditto. NA Not available.

¹Estimated data are rounded to no more than three significant digits.

²Projects in feasibility or later stages of development in 2013. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2018, but not enough information was available to include them.

³The Korean consortium comprises the following companies: Korea Resources Corp., L.S. Nikko Copper Inc., Hyundai Hysco Co. Ltd., SK Networks Co. Ltd., and Iljin Copper Foil Co. Ltd.

⁴The consortium comprises the following companies: Chinalco Luoyang Copper (Aluminum Corp. of China Ltd.), Dongfang Electric Corp., Shanghai Baosteel Group Corp., Tibet Hima Industry Co. Ltd., and Yunnan Copper Industry Co. Ltd.

⁵Total capacity following expansion.

⁶Average production.

⁷SX–EW Solvent extraction–electrowinning.

⁸HPAL High pressure acid leach.

TABLE 8
COBALT: WORLD MINE PRODUCTION, BY COUNTRY^{1,2}

(Metric tons, cobalt content)

Country ³	2009	2010	2011	2012	2013 ^e
Australia ⁴	4,345	3,852	3,848	5,870 ^r	6,398 ⁵
Botswana ⁶	342	272	149	195	248 ⁵
Brazil	2,075	3,139	3,623	2,900 ^r	3,000
Canada ⁷	3,919	4,636	6,836	6,676 ^r	6,916 ^{p,5}
China ^e	6,000	6,380	6,800	7,000	7,200
Congo (Kinshasa) ^{e,8}	40,000	60,000	59,000 ^r	50,000 ^r	54,000
Cuba ^{e,9}	4,600	4,800	5,100	4,900	4,200
Finland ^e	27	140	500	635	750
Indonesia ^{e,10}	1,200	1,600	1,600	1,700	1,700
Madagascar ^{e,11}	--	165	500	630	2,200
Morocco ^{e,12}	2,610 ^r	3,110	2,160 ^r	2,000 ^r	2,000
New Caledonia ^{e,13}	2,000	2,850	3,100	2,670 ^r	3,190
Papua New Guinea ¹⁴	--	--	--	469	1,013 ⁵
Philippines ^e	1,400 ^r	2,100 ^r	2,000 ^r	2,600	3,000
Russia ^{e,15}	6,100	6,200	6,100	6,300	6,300
South Africa ^e	610	1,800	1,600	2,500	3,000
Vietnam ^e	--	--	--	--	20
Zambia ^{e,16}	4,900	6,200	5,400	4,200	5,200
Zimbabwe ¹⁷	74	79	86	88	89 ⁵
Total	80,200 ^r	107,000	108,000 ^r	101,000 ^r	110,000

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

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

²Includes data available through October 9, 2014. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from cobalt, copper, nickel, platinum, or zinc operations.

³In addition to the countries listed, Spain and Turkey are known to produce ores that contain cobalt, but information is inadequate to make reliable estimates of production. Poland produced copper ore containing 1,500 to 5,000 metric tons per year of cobalt, which was not recovered. Other copper-, nickel-, platinum-, or zinc-producing nations may also produce ores containing cobalt as a byproduct component, but recovery is small or nil.

⁴Cobalt content of lateritic nickel ore and nickel concentrate reported by the Government of Western Australia.

⁵Reported figure.

⁶Reported cobalt content of pelletized nickel-copper matte.

⁷Assay content of cobalt in concentrates produced.

⁸Cobalt content of concentrates, tailings, and slags.

⁹Determined from reported cobalt content of nickel-cobalt sulfide production and estimated cobalt content of ammoniacal liquor production.

¹⁰Cobalt content of nickel matte plus estimated cobalt in lateritic ore processed in Australia.

¹¹Data for 2012–13 are estimated cobalt content of reported mixed sulfide production.

¹²Cobalt content of concentrate estimated from reported gross weight.

¹³Cobalt contained in the following materials: cobalt chloride produced in France from New Caledonian matte, cobalt carbonate and nickel hydroxide produced in New Caledonia, and lateritic nickel ore exported to Australia.

¹⁴Cobalt content of nickel-cobalt hydroxide.

¹⁵Cobalt content of concentrates.

¹⁶Cobalt content of concentrates and slags.

¹⁷Cobalt content of intermediate products produced in Zimbabwe from nickel and platinum ores mined in Zimbabwe; excludes some probable unreported mine production in Zimbabwe and cobalt in products produced from materials originating in Botswana.

TABLE 9
COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY^{1,2}

(Metric tons, cobalt content)

Country	2009	2010	2011	2012	2013
Australia, metal powder and oxide hydroxide ^c	4,050	4,120	4,720	4,860	4,980
Belgium, metal powder, oxide, hydroxide ³	2,150	2,600	3,187	4,200	5,415
Brazil, metal	1,012	1,369	1,614	1,750	1,653
Canada, metal, metal powder, oxide	4,918	4,711	6,038	5,994 ^r	4,789 ^p
China, metal, metal powder, oxide, salts ^{c,4}	25,500	35,900	35,000	29,800	36,100
Congo (Kinshasa), metal ⁵	2,950	4,222	3,103	3,021	3,007
Finland, metal powder and salts ⁶	8,970	9,429	10,627	10,562	10,798
France, chloride	368	302	354	326	308
India, metal and salts	1,001	1,187	1,299	800	295
Japan, metal	1,332	1,935	2,007	2,542	2,747
Madagascar, metal powder	--	--	--	493	2,083
Morocco, metal and oxide	1,600	1,615	1,788	1,314	1,353
Norway, metal	3,510	3,208	3,067	2,969	3,400
Russia, metal	2,352	2,460	2,337	2,186	2,368
South Africa, metal powder and sulfate	238	840	862	1,102	1,294
Uganda, metal	673 ^r	624 ^r	661 ^r	556 ^r	376
Zambia, metal	1,506	5,026	5,746	5,665	5,000 ^e
Total	62,100 ^r	79,500	82,400	78,100 ^r	86,000

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

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

²Includes data available through November 25, 2014. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

³Production reported by n.v. Umicore s.a.; includes production from China that is not otherwise included in this table.

⁴Production from domestic and imported ores, concentrates, and intermediate materials; excludes production by n.v. Umicore s.a. that is included under Belgium.

⁵Excludes production of cobalt in alloys, carbonate, hydroxide, and other materials that would require further refining.

⁶Production reported by the Geological Survey of Finland.