



# 2011 Minerals Yearbook

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## COBALT

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In 2011, world production of refined cobalt increased by 3% to a record quantity of more than 82,000 metric tons (t). The increase was the result of increases in production from most countries. The United States did not refine cobalt in 2011. A negligible amount of byproduct cobalt was produced in an intermediate product from the mining and refining of platinum-group metal (PGM) ore. No cobalt was sold from the National Defense Stockpile (NDS) in 2010 or 2011. Prior to 2010, the NDS had sold cobalt every year since cobalt sales began in 1993.

According to the Cobalt Development Institute (2012a), world apparent consumption of cobalt increased by about 15% to approximately 75,000 t, as compared with that of 2010. Based on the Institute's statistics, apparent consumption increased in Asia, Europe, and the United States. In 2011, actual Chinese consumption increased from that of 2010. In addition, some of China's apparent consumption was the result of additions to a stockpile of 20,000 to 30,000 t of contained cobalt that had been accumulating since 2008 (Kotseras, 2012, p. 15; Xu, 2012, p. 10). Cobalt prices trended downward in 2011. Salient U.S. and world cobalt statistics for 2007–11 are listed in table 1.

Cobalt is a metal used in numerous diverse commercial, industrial, and military applications, many of which are considered strategic and critical. 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. Cobalt is also used to make catalysts for the petroleum and chemical industries; cemented carbides (also called hardmetals) and diamond tools; corrosion- and wear-resistant alloys; drying agents for inks, paints, and varnishes; dyes and pigments; ground coats for porcelain enamels; high-speed steels; magnetic recording media; magnets; and rubber adhesion promoters for steel-belted radial tires.

## Legislation and Government Programs

DLA Strategic Materials (DLA), U.S. Department of Defense, did not sell cobalt during 2011 (table 2). Sales of cobalt had been curtailed in fiscal year 2008 in order to hold an inventory goal quantity equivalent to one year's Annual Materials Plan (AMP) amount. The AMP amount for fiscal year 2011 (October 1, 2010, through September 30, 2011) was 301 t (663,709 pounds), which was equal to the total uncommitted cobalt inventory held by DLA since March 31, 2010. The 2011 Biennial Report on Stockpile Requirements listed cobalt as a material that was not required in the NDS (U.S. Department of Defense, 2009, p. 1–2; 2012, p. 6, 57–58).

The U.S. Department of Energy released an update to its strategy on critical materials used in clean energy technologies. Although included in the strategy because of its use in batteries for electric vehicles, cobalt was identified as "not critical" in

terms of risk of supply disruption in the short (0–5 years) or medium (5–15 years) term, owing to a forecast of significant increases in global production capacity (U.S. Department of Energy, 2011, p. 94, 116).

## Production

With the exception of negligible amounts of byproduct cobalt produced from Stillwater Mining Co.'s PGM operation in southeastern Montana, the United States did not mine or refine cobalt in 2011. Cobalt-bearing nickel sulfate produced from Stillwater's mining and refining operations was sold to various companies (Stillwater Mining Co., 2012, p. 20).

Formation Metals Inc. continued to work on financing and constructing its Idaho Cobalt Project. The project entailed an underground cobalt-copper-gold mine and mill complex in the Idaho Cobalt Belt in Lemhi County and a retrofitted Big Creek hydrometallurgical complex near Kellogg, ID, to refine the concentrates (table 8) (Formation Metals Inc., 2012, p. 2–9).

Kennecott Minerals Co., a fully owned subsidiary of Rio Tinto (Melbourne, Australia, and London, United Kingdom), continued construction activities at its Eagle project in Michigan and began underground development in September. The small nickel-copper mine in the Eagle deposit in the Yellow Dog Plains area northwest of Marquette and rehabilitated mill in Humboldt Township was expected to be in production for 6 years (table 8) (Kennecott Eagle Minerals Co., 2012, p. 1, 10).

The Minnesota Department of Natural Resources, U.S. Army Corps of Engineers, and U.S. Forest Service worked on preparing a supplemental draft environmental impact statement for PolyMet Mining Corp.'s NorthMet project. The project entailed open pit mining of the NorthMet polymetallic deposit in the Duluth Complex of northeastern Minnesota, refurbishing the crushing and grinding equipment in the company's nearby Erie plant, and adding a new beneficiation circuit and hydrometallurgical plant (table 8). PolyMet and Swiss trading firm Glencore International AG had a strategic partnership whereby Glencore was investing in PolyMet and would purchase or market NorthMet's products (PolyMet Mining Corp., 2012, p. 11–13).

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 3. The sole producer of cobalt metal powder, Global Tungsten & Powders Corp. of Towanda, PA, produced the cobalt as a byproduct of tungsten recovered from cemented carbide scrap. U.S. production

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

## Consumption

U.S. reported consumption of cobalt in 2011 was 13% more than that of 2010. Metallurgical industries used 18% more cobalt than they did in 2010; cobalt consumption for chemical uses was slightly higher. Reported consumption was derived by the USGS from voluntary surveys of U.S. operations. Most of the data on cobalt chemical uses 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 3 contain estimates to account for nonrespondents.

U.S. apparent consumption for 2011, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 10% lower than that of 2010 (table 1). The decrease was primarily because net imports in 2011 were lower than those of 2010. The discrepancy between the trend in reported consumption (an increase from that of 2010) and the trend in apparent consumption (a decrease from that of 2010), may have been the result of unreported stock drawdowns.

## Prices

The annual average U.S. spot price for cathode (minimum of 99.8% cobalt), as reported by Platts Metals Week, was 14% lower than that of 2010 (table 1). Although the price fluctuated during the year, the overall trend was downward. The highest price was \$21.50 to \$23.00 per pound during the second half of February, and the lowest price was \$13.75 to \$14.75 per pound in mid-December.

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 \$16.34 per pound, and the annual average of weekly prices for Russian cobalt was \$17.17 per pound.

In 2011, cobalt brands from two more producers were approved for delivery on the London Metal Exchange (LME) cobalt futures contract, bringing the total number of cobalt producers accepted by the LME to 13. Yearend LME inventory levels are listed in table 1 (London Metal Exchange Ltd., The, undated).

Financial services companies such as Credit Suisse Group and Standard Bank offered financial products based on cobalt, including hedging and speculation products and option and swap contracts (Southgate, 2010).

## 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 2011, net import reliance as a percentage of apparent consumption was 76%. Because there was no measurable U.S. primary cobalt production in 2011, this indicates that 76% of U.S. cobalt supply was from imports and stock releases of primary cobalt and 24% was from domestic or imported scrap.

In 2011, the United States imported 4% less cobalt than it did in 2010 (tables 4, 5). Ten countries supplied 88% of U.S. imports. China was the leading supplier, followed by Norway, Canada, Zambia, Russia, Finland, Australia, Belgium, Brazil, and the United Kingdom.

The United States imported 754 t, gross weight, of unwrought cobalt alloys valued at \$27.3 million. Most of these materials were from Canada (79%) and the United Kingdom (12%). The United States imported 730 t, gross weight, of cobalt waste and scrap valued at \$12.1 million. Eight countries supplied nearly 90% of this material—Japan (24%), Ireland (23%), the United Kingdom (20%), Germany (10%), France (5%), Tunisia (3%), and Austria and Netherlands (2% each). The United States also imported 247 t, gross weight, of wrought cobalt and cobalt articles valued at \$27.0 million. The leading suppliers of these materials were the United Kingdom (41%), Germany (17%), France (16%), Canada (15%), and China (6%).

U.S. exports of unwrought cobalt and cobalt contained in chemicals increased by 29% compared with those of 2010. As listed in table 6, the leading destinations for these exports were France, Canada, Ireland, China, Germany, the United Kingdom, Belgium, and Japan. The United States also exported 1,360 t, gross weight, of wrought metal and cobalt articles valued at \$81.8 million.

## World Review

Cobalt was produced as a byproduct of copper, nickel, and other metals, and as a primary product. Primary cobalt production included Moroccan mine and refinery production, 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 7. 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 2011. Expansions to those operations, operation restarts, and greenfield projects that were forecast to begin producing between 2012 and 2016 are listed in table 8.

**Australia.**—The Yabulu nickel-cobalt refinery in Townsville, Queensland (owned by Australian businessman Clive Palmer and operated by Queensland Nickel Pty Ltd.), produced 2,631 t of refined cobalt as cobalt oxide hydroxide; 23% more than the 2,141 t produced in 2010. The refinery processed lateritic ore imported from Indonesia, New Caledonia, and the Philippines, and reportedly began to process nickel-cobalt hydroxide from Vale S.A.'s New Caledonia operation in 2011 (Cobalt

Development Institute, 2012a; Darton Commodities Ltd., 2012, p. 12).

BHP Billiton's Nickel West operations in Western Australia comprised nickel sulfide mines; concentrators, which processed ores mined by BHP Billiton and those from other companies; the Kalgoorlie smelter, where nickel matte was produced; and the Kwinana nickel refinery, which produced cobalt in intermediate nickel-cobalt mixed sulfide. In 2011, an estimated 500 t of cobalt contained in mixed sulfide was shipped to Jinchuan Group Ltd. for refining (Darton Commodities Ltd., 2012, p. 12).

Glencore acquired Minara Resources Ltd., giving it 100% interest in the Murrin Murrin nickel-cobalt laterite mining and pressure-acid leaching operation near Leonora, Western Australia. Murrin Murrin produced 2,091 t of cobalt as metal powder and briquettes, 6% more than the 1,976 t produced in 2010. The increase was in spite of production shortfalls owing to maintenance and weather issues. In addition to feed from its own operations, Murrin Murrin also processed ore from third party sources (Cobalt Development Institute, 2012a; Glencore International plc, 2012, p. 53, 57).

First Quantum Minerals Ltd. brought the Ravensthorpe operation into commercial production. The company acquired the nickel-cobalt laterite mine and hydrometallurgical processing plant in early 2010 and spent about a year modifying the operation. During 2011, the plant produced intermediate nickel-cobalt hydroxide containing 5,666 t of nickel and an estimated 200 t of cobalt (First Quantum Minerals Ltd., 2012, p. 11, 25, 28).

OJSC MMC Norilsk Nickel restarted production from the Maggie Hays nickel sulfide mine and Lake Johnston mill in Western Australia. Nickel concentrates from the mill were sent to Harjavalta in Finland for processing (OJSC MMC Norilsk Nickel, 2012, p.15, 17).

Panoramic Resources Ltd. produced concentrates containing 453 t of cobalt (364 t in 2010) 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., 2011, p. 6; 2012, p. 6).

Xstrata Nickel Australasia produced 396 t of cobalt in nickel sulfide concentrates from the Cosmos and Sinclair operations in Western Australia, compared with 245 t in 2010. All of the concentrates were sent to Xstrata Nickel's Sudbury smelter in Ontario, Canada (Xstrata plc, 2012).

**Belgium.**—According to the Cobalt Development Institute (2012a), Umicore's 2011 cobalt refinery production increased to 3,187 t from 2,600 t produced in 2010. The company attributed the increase to greater availability of scrap resulting from an increased level of industrial activity. Umicore converted various cobalt materials into a wide range of chemicals and metal powders. Umicore's cobalt refining took place at plants in Olen, Belgium, and Ganzhou, China. The company's cobalt processing plants were in Arab, AL, in the United States; Bruges, Belgium; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. During the year, Umicore expanded its South Korean plant, commissioned a new plant for the production of a lithium-

nickel-manganese-cobalt material for rechargeable batteries in Kobe, Japan, and commissioned an ultra high temperature pilot plant in Hoboken, Belgium, for recycling spent rechargeable batteries (n.v. Umicore, s.a., 2012, p. 33, 36, 49).

**Botswana.**—Tati Nickel Mining Co. Pty. Ltd. (a Norilsk subsidiary) mined the Phoenix open pit and produced nickel-copper sulfide concentrates, which were toll-smelted by BCL Ltd. in Botswana. BCL also smelted concentrate from its Selebi-Phikwe operation in Botswana. Matte produced by BCL was refined by RioZim Ltd. in Zimbabwe and Xstrata Nickel in Norway.

**Brazil.**—In 2011, Votorantim increased the cobalt production capacity at its Sao Miguel Paulista, Sao Paulo State, refinery by 300 t. Feed for the refinery was 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 (Votorantim Metais SA, 2011).

Mirabela Nickel continued to ramp-up production from its Santa Rita open pit nickel sulfide mine and concentrator in Bahia State, and by yearend produced 273 t of cobalt in concentrate (179 t in 2010). All concentrate produced at Santa Rita was committed through offtake agreements to Votorantim (50%) and Norilsk (50%) (Mirabela Nickel Ltd., 2012).

**Canada.**—Vale produced 2,675 t of cobalt in 2011, 151% more than the 1,066 t produced in 2010, when labor strikes at its operations in Sudbury and Voisey's Bay resulted in reduced production. Vale reported production in the form of cathode, 1,469 t, from its Port Colborne, Ontario, refinery; cobalt hydrate, 594 t, from its Thompson, Manitoba, refinery; and cobalt contained in unrefined products such as nickel concentrates, 611 t, from its New Caledonian operation and external sources. Vale's cobalt originated from nickel sulfide ores from company mines at Sudbury, Ontario; Thompson, Manitoba; Voisey's Bay in northeastern Labrador; nickel laterite ores from New Caledonia; and purchased feedstocks. Vale reported the following distribution of sources for its cobalt production: Ontario, 593 t (302 t in 2010); Manitoba, 158 t (189 t in 2010); Voisey's Bay, 1,585 t (524 t in 2010); New Caledonia, 245 t (zero in 2010); and external sources, 93 t (51 t in 2010). Concentrates from Voisey's Bay are being smelted and refined at Sudbury and Thompson until the Long-Harbour refinery is operational (table 8). Vale planned to phase out smelting and refining at Thompson by 2015 (Vale S.A., 2012, p. 34–35, 42–43).

Xstrata Nickel produced 473 t of cobalt in concentrates from mines at Sudbury (341 t in 2010) and 561 t of cobalt in concentrate from its Raglan Mine in Quebec (567 t in 2010). Nickel-copper matte containing 2,209 t of cobalt was produced at the company's Sudbury smelter (2,634 t in 2010); this was refined at Xstrata's Nikkelverk refinery in Norway. Some of the cobalt in the matte originated from ores produced at company mines in Australia and Canada and some originated from custom feed materials, which were primarily nickel concentrates and nickel-copper-cobalt secondary materials (scrap). Custom feed from mining operations included nickel sulfide ores containing approximately 40 t of cobalt from URSA Major Minerals

Inc.'s Shakespeare Mine in Ontario, nickel sulfide ore from First Nickel Inc.'s Lockerby Mine in Sudbury, nickel sulfide concentrates produced by CaNickel Mining Ltd.'s Bucko Lake nickel mine in the Thompson Nickel Belt of Manitoba and Liberty Mines Inc. in Ontario, and a copper-nickel-PGM-gold concentrate containing approximately 9 t of cobalt from North American Palladium Ltd.'s Lac des Iles Mine in Northern Ontario (North American Palladium Ltd., 2012, p. 15; URSA Major Minerals Inc., 2012, p. 5; Xstrata plc, 2012).

The Fort Saskatchewan refinery of the joint venture of Sherritt International Corp. and General Nickel Co. S.A. produced a record 3,854 t of cobalt as metal powder and briquettes in 2011, 4% more than the 3,706 t produced in 2010. Nearly 99% of the cobalt was from nickel-cobalt mixed sulfides from the joint venture's operations at Moa Bay, Cuba; the remainder was from purchased feed materials. During the year, the joint-venture partners continued to review alternative strategies for completing the phase 2 expansion of the refinery, which was suspended in 2008. 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 (Sherritt International Corp., 2012, p. 7, 13).

First Nickel restarted operations at its Lockerby Mine. Liberty Mines placed its Redstone and McWatters nickel sulfide mines near Timmins, Ontario, on care-and-maintenance status, while it addressed maintenance requirements at the Redstone Mill and issues with the tailings pond. Prior to shutdown, the mill produced concentrates containing 2 t of cobalt, which were shipped to Xstrata Nickel's smelter in Sudbury (Liberty Mines Inc., 2012, p. 1–8).

**China.**—China was the world's leading producer of refined cobalt. In 2011, China's production decreased by about 3% to approximately 35,000 t. Only a small portion of this cobalt originated from domestic mines and recycled scrap. Most was from imported ores, concentrates, and semirefined materials, the majority which was sourced from Congo (Kinshasa). CRU International Ltd. (London, United Kingdom) estimated that China imported 34,100 t of cobalt contained in ores, concentrates, and semirefined materials in 2011, down from 35,300 t in 2010. China's imports of cobalt ores and concentrates were slightly lower than those of 2010 and its imports of semirefined materials were 6% lower. The decrease in production and imports was attributed to the availability of large inventories of cobalt materials that had accumulated since 2008 (CRU International Ltd., 2012, p. 7; Xu, 2012, p. 4, 10, 26).

Numerous companies refined and (or) processed cobalt in China. The leading four refiners were Jinchuan, Zhejiang Galico Cobalt & Nickel Material Co., Ltd., Zhejiang Huayou Cobalt Nickel Materials Co., Ltd., Zhejiang Galico Cobalt & Nickel Material Co., Ltd., and Ganzhou Yi Hao Umicore Industries, listed in descending order of 2011 estimated cobalt production. Jinchuan produced cobalt as cathode and other products from its refinery at Jinchang, Gansu Province. Some of Jinchuan's cobalt production was from domestic nickel-copper-cobalt sulfide ores mined and refined at Jinchang and some was from other cobalt or nickel feeds. Jinchuan's other feeds included cobalt intermediates (chemical compounds), which were either

imported or produced in China from imported concentrates; nickel or nickel-copper concentrates from Australia, Finland, Spain, and Zambia; and nickel matte and mixed sulfides from BHP Billiton (CRU International Ltd., 2012, p. 4, 6; Darton Commodities Ltd., 2012, p. 12).

**Congo (Kinshasa).**—Congo (Kinshasa) was the world's leading producer of mined cobalt. Some of the country's cobalt mine production was from copper-cobalt ores mined by traditional methods, and some was gathered by artisanal miners hand-picking cobalt-rich ores. Some of Congo (Kinshasa)'s ores and concentrates were exported, some were processed to semirefined materials such as cobalt carbonate, cobalt hydroxide, or cobalt-bearing alloys, and some were refined to cobalt metal. China was the leading destination for Congo (Kinshasa)'s cobalt exports. As discussed in the "China" section of this report, exports of cobalt materials to China decreased in 2011 compared with those of 2010.

La Générale des Carrières et des Mines (Gécamines) produced 650 t of refined cobalt, compared with 745 t produced in 2010 (Cobalt Development Institute, 2012a).

Kamoto Copper Company SARL [KCC, Katanga Mining Ltd., Gécamines, and La Société Immobilière du Congo] produced 2,433 t of cobalt cathode (3,437 t in 2010). The company's Luilu refinery processed concentrates produced at its Kamoto concentrator from ore extracted from the Kamoto underground mine and KOV and T17 open pit mines. During the year, KCC completed the new phase 3 expansion of its operations, bringing Luilu's cobalt refining capacity to 8,000 t/yr of cobalt, and worked on the phase 4 expansion (table 8). Glencore had an offtake agreement for all of KCC's copper and cobalt output; all of the company's copper oxide concentrate produced for sale was purchased by Mopani Copper Mines in Zambia (Katanga Mining Ltd., 2012, p. 6–10).

Boss Mining Sprl [70% Eurasian Natural Resources Corp. PLC (ENRC) and 30% Gécamines] mined copper-cobalt oxide ore from the Mukondo Mountain deposit and produced 9% more cobalt in concentrate than in 2010. By yearend, Boss Mining had commissioned the copper solvent extraction portion of its new cobalt solvent extraction-electrowinning (SX-EW) plant at Luita, but had suspended the cobalt extraction portion of the plant pending a review of its economic viability (Eurasian Natural Resources Corp. PLC, 2012, p. 33, 35).

Compagnie Minière du Sud Katanga [CMSK, a joint venture between L'Entreprise Générale Malta Forrest S.P.R.L.(EGMF) and Gécamines] produced copper-cobalt concentrate from the Luiswishi Mine and Kipushi concentrator. During the year, EGMF's plan to build a refinery to produce copper cathode and cobalt carbonate was interrupted when Gécamines disputed EGMF's share in CMSK (Metal Bulletin, 2011).

The Big Hill smelter at Lubumbashi [operated as a joint venture between Gécamines, OM Group, Inc. (OMG), and S.A. Groupe George Forrest] processed stockpiled slag to produce alliage blanc, an alloy of cobalt and copper, which was refined at OMG's Kokkola refinery.

Freeport-McMoRan Copper & Gold Inc. (FCX) produced 11,182 t of cobalt in hydroxide from its Tenke Fungurume operation, compared with 9,225 t in 2010. Tenke Fungurume, between the towns of Kolwezi and Likasi, comprised open pit

mining of copper-cobalt oxide ore, processing milled ore by agitation leaching, and SX–EW to produce copper cathode and cobalt hydroxide, which was sold under contract and on the spot market. In 2011, the milling facilities performed above rated capacity levels, and FCX approved a phase 2 expansion of the project (table 8) (Freeport-McMoRan Copper & Gold Inc., 2012, p. 17, 24; Lundin Mining Corp., 2012a, p. 27; 2012b).

Mutanda Mining SPRL (Glencore International AG, Groupe Bazano, and Rowny Assets Ltd.) completed phase I of its copper-cobalt hydrometallurgical plant, which had the capacity to produce 8,000 t/yr of cobalt in hydroxide, and worked on phase 2 and 3 expansions (table 8). In 2011, Mutanda mined copper-cobalt oxide ore from open pits near Kolwezi and produced 7,900 t of cobalt in concentrate and hydroxide, 11% less than the 8,900 t produced in 2010 (Glencore International plc, undated; 2012, p. 53, 55).

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 SX–EW plant at Usoko in Lubumbashi. The plant produced 2,155 t of cobalt contained in carbonate, 21% less than the 2,744 t produced in 2010 (Metal Bulletin, 2012).

Metorex Ltd.'s Ruashi operation north of Lubumbashi comprised mining copper-cobalt oxides ores from open pits and then milling and processing the ore in the Ruashi phase 2 SX–EW refinery. In 2011, production of cobalt in carbonate and hydroxide increased to 3,678 t from 3,580 t in 2010. Gécamines had a 25% interest in the Ruashi operation. By early 2012, Jinchuan had completed a takeover of Metorex (Metorex Ltd., 2012, p. 3, 22–24, 55).

Société Minière du Katanga sprl (Somika) mined and beneficiated copper-cobalt ore, and refined the concentrate at its hydrometallurgical copper refinery in Lubumbashi. The refinery had the capacity to produce 2,160 t/yr of cobalt hydroxide (Société Minière du Katanga sprl, undated).

**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 mixed sulfides, which were sent to the joint venture's Fort Saskatchewan refinery in Canada. In 2011, the mixed sulfides contained a record 38,641 t of nickel and cobalt, slightly more than the 37,745 t produced in 2010. The increase in production was attributed to continuous improvement in efficiency at the Moa plant. During the year, the joint-venture partners continued to review alternative strategies for the completion of the phase 2 expansion of the plant, which was suspended in 2008 (Sherritt International Corp., 2012, p. 12–13).

Grupo Empresarial Cubaníquel S.A.'s Ernesto Che Guevara and Rene Ramos Latour Mining and Metallurgical Combines also mined and processed nickel-cobalt laterites in Holguin Province. Nickel and cobalt of Cuban origin cannot be imported into the United States because of a United States embargo on imports from Cuba.

**Finland.**—OMG's production of refined cobalt, as metal powders, briquettes, oxides, and compounds, was 11% higher than that of 2010. The company's Kokkola Chemicals Oy refinery processed raw materials sourced primarily from Congo (Kinshasa), Finland, and Russia. Most of the feed was alliage

blanc from the Big Hill smelter in Congo (Kinshasa), crude cobalt hydroxide from Norilsk's Monchegorsk nickel refinery in Russia, and cobalt sulfate solution from Norilsk's Harjavalta nickel refinery in Finland. OMG also refined materials from other sources (OM Group, Inc., 2012, p. 5, 14).

Talvivaara Mining Co. Plc continued to ramp-up and optimize production from its polymetallic sulfide mine and bioheap-leaching operation in Sotkamo in central Finland. During the year, technical issues and a shortage of spare parts kept Talvivaara from meeting its original production targets. In 2011, Talvivaara sold nickel-cobalt sulfide containing approximately 400 t of cobalt to Norilsk for processing at Harjavalta (Talvivaara Mining Co. Plc, 2012, p. 18, 61–62, 82).

Belvedere Resources Ltd. produced an estimated 85 t of cobalt in nickel-copper concentrates from the Hitura Mine. The concentrates were sold to Jinchuan (Belvedere Resources Ltd., 2012, p. 2, 7).

**France.**—The Eramet Group's production of cobalt chloride from its refinery at Sandouville was 17% more than that produced in 2010. Feed for the refinery was nickel matte imported from Eramet subsidiary Le Nickel SLN's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2012a).

**India.**—According to an estimate by the Cobalt Development Institute (2012a), India's cobalt production increased by 9% from that of 2010. Nicomet Industries Ltd. and Rubamin Ltd. were India's leading cobalt producers.

**Indonesia.**—PT Vale Indonesia Tbk [formerly PT International Nickel Indonesia Tbk (PT Inco)] produced cobalt-bearing nickel matte from lateritic ores at its integrated mining and smelting operation near Sorowako on Sulawesi Island. Vale Indonesia sold its matte production to Vale (80%) and Sumitomo Metal Mining Co., Ltd. (20%) under long-term contracts.

PT Antam Tbk exported lateritic nickel-cobalt ore to Queensland Nickel's Yabulu refinery for processing (CRU International Ltd., 2012, p. 4).

**Japan.**—Sumitomo's production of electrolytic cobalt at its Niihama nickel refinery increased by 4% from that of 2010. The refinery processed nickel-cobalt mixed sulfide feed from the Coral Bay Nickel Corp. plant in the Philippines and nickel matte from PT Inco in Indonesia and BHP Billiton's Nickel West operations. Sumitomo planned to increase Niihama's production capacity to accommodate the nickel-cobalt mixed sulfide feed that would be generated from its Taganito project in the Philippines (table 8) (Cobalt Development Institute, 2012a; CRU International Ltd., 2012, p. 4).

**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 at CTT's Guemassa hydrometallurgical refinery north of Marrakech. In 2011, CTT's refined cobalt production increased as a result of an increase in ore grade and recovery rate (Groupe Managem, 2012, p. 44, 61).

**New Caledonia.**—Vale ramped 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, high pressure acid leaching processing plant, and refinery. In 2011,

Vale produced 245 t of cobalt in an intermediate nickel-cobalt hydroxide cake, which was sold to other companies for refining. Vale expected to ramp-up production during a 4-year period to reach the nominal production capacity of 60,000 t/yr of nickel contained in nickel oxide and 4,600 t/yr of cobalt contained in cobalt carbonate (Vale S.A., 2012, p. 36, 43).

Lateritic nickel-cobalt ore was exported to Queensland Nickel's Yabulu refinery for processing. Nickel matte from Le Nickel SLN's Doniambu smelter was sent to Eramet's refinery in Sandouville, France, where nickel products and cobalt chloride were produced.

**Norway.**—Xstrata Nickel's production of cobalt cathode at its Nikkelverk refinery was 4% less than that of 2010. The cobalt originated from Xstrata Nickel mines in Australia and Canada, recycled materials, and custom feeds, which included matte from Botswana processed under a long-term agreement with BCL. Glencore was the sole distributor of Xstrata's cobalt (CRU International Ltd., 2012, p. 4; Xstrata plc, 2012).

**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 nickel-cobalt mixed sulfide from its high-pressure acid-leaching operation at the Rio Tuba nickel laterite mine on Palawan Island. The mixed sulfide was refined by Sumitomo in Japan.

**Russia.**—Norilsk conducted nickel-copper sulfide mining, ore beneficiation, concentrate smelting, and metal refining on the Taimyr and Kola Peninsulas. Cobalt from ores mined on the Taimyr Peninsula was refined to metal, in the form of ingot, at the company's nickel plant at Norilsk. According to the Cobalt Development Institute (2012a), the company produced 2,337 t of refined cobalt, 5% less than the 2,460 t produced in 2010. At Norilsk's nickel refinery at Monchegorsk on the Kola Peninsula, high-grade matte produced from both regions was refined. The intermediate cobalt hydroxide produced from the matte was sent to OJSC MMC Norilsk Nickel's operations in Finland under a 5-year supply agreement that began in 2007. Under this agreement, Norilsk was to supply OJSC MMC with up to 2,500 t/yr cobalt metal, up to 2,500 t/yr of cobalt contained in cobalt hydroxide, and up to 1,500 t/yr of cobalt contained in cobalt sulfate solution. In 2011, Norilsk announced plans to produce cobalt cathode at its Monchegorsk refinery (table 8) and Nadezhda Metallurgical Plant (OJSC MMC Norilsk Nickel, 2011a, p. 23; 2011b; 2012, p. 180).

**South Africa.**—The Nkomati nickel sulfide mine (a joint venture of African Rainbow Minerals Ltd. and Norilsk) produced 513 t of cobalt in nickel concentrate in 2011 (667 t in 2010). The concentrate was processed at Norilsk's Harjavata refinery in Finland. The Nkomati mine was undergoing an expansion, which was forecast to produce 1,000 t/yr of cobalt in concentrates once at full steady state production in 2014 (African Rainbow Minerals Ltd., 2012a, p. 20–21; b, p. 63–64; undated; OJSC MMC Norilsk Nickel, 2012, p. 39).

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-metal refinery near Rustenburg, Northwest Province. In 2011, Rustenburg completed an expansion of the refinery's

nickel capacity, which was expected to result in an estimated increase in cobalt capacity to 825 t/yr. 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-metal refineries and produced semirefined nickel sulfate containing cobalt.

**Spain.**—Lundin Mining Corp. restarted mining nickel sulfide ore from its Aguablanca open pit in Badajoz Province in August; the processing plant was expected to restart operations in 2012 (Lundin Mining Corp., 2012a, p. 21).

**Uganda.**—Kasese Cobalt Co. Ltd. produced cobalt cathode from stockpiled pyrite concentrates using a bacterial leaching-SX-EW process at its cobalt refinery in southwestern Uganda. At current production rates, the stockpile was expected to be exhausted in late 2013 (MFC Industrial Ltd., 2012).

**Zambia.**—Mopani Copper Mines produced approximately 900 t of cobalt metal at its Nkana cobalt refinery, compared with 1,092 t in 2010. The decrease was attributed to lower cobalt grades in the concentrates processed, a realignment of the Nkana concentrator to maximize copper production, and the cobalt roaster being placed on care-and-maintenance status. Approximately 67% of the cobalt produced originated from company sources, mainly the Nkana underground copper-cobalt mine; the remaining 33% originated from third party sources (Glencore International plc, 2012, p. 53, 56).

Chambishi Metals plc (90% ENRC and 10% ZCCM Investments Holdings Plc) produced 4,856 t of cobalt metal at its Chambishi refinery, 23% more than the 3,934 t produced in 2010. The refinery processed copper-cobalt sulfide concentrate from ENRC's operations in Congo (Kinshasa) and cobalt-containing materials from other companies (Eurasian Natural Resources Corp. PLC, 2011, p. 16; Cobalt Development Institute, 2012a).

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. KCM was adding a second cobalt recovery furnace to the smelter (table 8) (Vedanta Resources plc, 2012).

China Nonferrous Metal Mining Group Co. Ltd. (CNMC) mined and processed copper-cobalt ore in the Zambian Copperbelt through four majority-owned subsidiaries—NFC Africa Mining Plc. (NFC), CNMC Luanshya Copper Mines Plc. (CLM), Chambishi Copper Smelter Ltd. (CCS), and Sino-Metal Leach Zambia Ltd. CCS smelted copper concentrates from NFC, CLM, and other miners. CNMC planned to recover cobalt from the CCS's smelter slag (table 8) and worked toward producing a cobalt concentrate from CLM's Baluba beneficiation plant (China Nonferrous Metal Mining Group Co. Ltd., 2012, p. 2–3, 150, 172).

Equinox Minerals Ltd. and its Lumwana copper mine were acquired by Barrick Gold Corp. Concentrates from Lumwana were sold to CNMC's CCS and KCM's Nchanga smelter for processing (Equinox Minerals Ltd., 2009; China Nonferrous Metal Mining Group Co. Ltd., 2012, p. 45).

Metorex sold its Sable Zinc copper electrowinning plant near Kabwe to a subsidiary of Glencore. During the first six months of 2011, the plant produced 4 t of cobalt in carbonate. The low cobalt production levels in recent years were attributed to the low cobalt grades of the Zambian copper concentrates processed by the plant (Metorex Ltd., 2011, p. 7, 15).

Production from Albidon Ltd.'s Munali nickel mine in southern Zambia was less than planned, primarily owing to a geotechnical anomaly that resulted in higher than expected levels of ore dilution. Albidon temporarily suspended operations in November and placed the mine on care-and-maintenance status. Majority shareholder Jinchuan was to provide funding while Albidon sought a strategic investor (Albidon Ltd., 2012).

**Zimbabwe.**—Aquarius Platinum Ltd. produced 86 t of cobalt from its Mimosa platinum mine (79 t in 2010). The concentrates were refined by Impala in South Africa (Aquarius Platinum Ltd., 2011, p. 13; 2012, p. 14). The Bindura Nickel Corp. (BNC) Shangani and Trojan nickel sulfide mines, smelter, and refinery remained on care-and-maintenance status while the company sought funding to restart operations. BNC refurbished part of the Trojan Mine and processing plant in preparation for restart and signed an offtake agreement with Glencore for the operation's nickel concentrates (Mwana Africa PLC, 2011, p. 4).

## Outlook

Trends in cobalt demand closely follow those of global industrial production. Increasing consumption to make rechargeable batteries and aircraft engines is forecast to result in yearly increases in cobalt consumption of between 6% and 8% from 2012 to 2016. During the first half of 2012, the world production of refined cobalt was estimated to be 8% lower than that of the first half of 2011. China showed the largest decrease in production, and this was attributed to a reduction in global demand for cobalt. In the next few years, global increases in supply from existing producers and new projects are forecast to outpace increases in consumption. If an oversupply of cobalt were to continue, cobalt prices would be expected to remain suppressed for the short to medium term (Cobalt Development Institute, 2012b; Kotseras, 2012, p. 5, 9–10, 17, 22, 24).

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

(Metric tons, cobalt content, unless otherwise specified)

	2007	2008	2009	2010	2011	
<b>United States:</b>						
<b>Consumption:</b>						
Reported	9,320	8,820	7,470	8,030	9,100	
Apparent	9,630	10,100	7,580	10,300	9,230	
Imports for consumption	10,300	10,700	7,680	11,100	10,600	
Exports	3,100	2,850	2,440	2,640	3,390	
<b>Stocks, December 31:</b>						
Industry <sup>2</sup>	620	582	525	630	784	
London Metal Exchange (LME), U.S. warehouse	XX	XX	XX	23	43	
U.S. Government <sup>3</sup>	676	473	293	301	301	
<b>Price, metal</b>						
U.S. Spot <sup>4</sup>	dollars per pound	30.55	39.01	17.86	20.85	17.99
LME, cash <sup>5</sup>	do.	XX	XX	XX	XX	16.01
<b>World:</b>						
<b>Production:</b>						
Mine	73,700 <sup>r</sup>	79,100 <sup>r</sup>	78,800 <sup>r</sup>	106,000 <sup>r</sup>	109,000 <sup>e</sup>	
Refinery	53,500 <sup>r</sup>	57,500 <sup>r</sup>	62,100 <sup>r</sup>	79,400 <sup>r</sup>	82,200	
Stocks, December 31, LME <sup>6</sup>	XX	XX	XX	278	304	

<sup>e</sup>Estimated. <sup>r</sup>Revised. do. Ditto. XX Not applicable.

<sup>1</sup>Data are rounded to no more than three significant digits, except prices.

<sup>2</sup>Stocks held by cobalt processors and consumers.

<sup>3</sup>Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center). Data are uncommitted material only.

<sup>4</sup>Annual average U.S. spot price for minimum 99.8% cobalt cathode reported by Platts Metals Week.

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

<sup>6</sup>Stocks held in Asia, Europe, and the United States.

TABLE 2  
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE  
SALES AND SHIPMENTS<sup>1</sup>

(Metric tons, cobalt content)

	2010	2011
<b>Sales:</b>		
Fiscal year <sup>2</sup>	6	--
Calendar year	--	--
<b>Shipments:<sup>3</sup></b>		
Fiscal year <sup>2</sup>	3	--
Calendar year	-8	--

-- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Twelve-month period ending September 30 of year stated.

<sup>3</sup>Calculated from yearend inventory levels. Yearend data are uncommitted material only. Negative numbers are the result of inventory adjustments.

Source: Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).

TABLE 3  
U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT<sup>1,2</sup>

(Metric tons, cobalt content)

	2010	2011
Consumption by end use:		
Steels	550	548
Superalloys	3,740	4,650
Alloys, excludes steels and superalloys:		
Magnetic alloys	357	313
Other alloys <sup>3</sup>	364	438
Cemented carbides <sup>4</sup>	696	773
Chemical and ceramic uses	2,260	2,310
Miscellaneous and unspecified	63	63
Total	8,030	9,100
Consumption by form:		
Chemical compounds, organic and inorganic <sup>5</sup>	2,180	2,220
Metal	3,860	4,670
Purchased scrap	2,000	2,210
Total	8,030	9,100
Stocks, December 31: <sup>6</sup>		
Chemical compounds, organic and inorganic <sup>5</sup>	173	202
Metal	W	W
Purchased scrap	W	W
Total	630	784

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

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

<sup>2</sup>Includes estimates.

<sup>3</sup>Includes nonferrous alloys, welding materials, and wear-resistant alloys.

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

<sup>5</sup>Includes oxides.

<sup>6</sup>Stocks held by cobalt processors and consumers.

TABLE 4  
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM<sup>1</sup>

	2010			2011		
	Gross weight (metric tons)	Cobalt content <sup>2</sup> (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content <sup>2</sup> (metric tons)	Value (thousands)
Metal <sup>3</sup>	8,750	8,750	\$350,000	8,020	8,020	\$296,000
Oxides and hydroxides	2,010	1,450	60,700	2,590	1,870	61,200
Other forms:						
Acetates	301	72	2,720	305	73	2,570
Carbonates	686	315	14,400	649	298	12,400
Chlorides	311	78	2,580	102	26	965
Sulfates	1,440	388	9,200	1,140	307	9,360
Total	13,500	11,100	439,000	12,800	10,600	383,000

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

<sup>2</sup>Estimated from gross weights.

<sup>3</sup>Unwrought cobalt, excluding alloys and waste and scrap.

Source: U.S. Census Bureau.

TABLE 5  
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY<sup>1</sup>

Country of origin	Metal <sup>2</sup>			Oxides and hydroxides				Other forms <sup>3</sup>			Total	
	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)
2010:												
Australia	711	711	\$28,000	--	--	--	--	--	--	711	711	\$28,000
Belgium	198	198	7,310	543	391	\$19,400	43	11	\$364	784	601	27,100
Brazil	166	166	6,930	--	--	--	20	6	245	186	172	7,180
Canada	141	141	6,700	415	299	9,160	--	--	--	556	440	15,900
China	2,330	2,330	93,400	355	255	9,850	728	209	3,640	3,410	2,790	107,000
Congo (Kinshasa)	465	465	14,300	--	--	--	--	--	--	465	465	14,300
Finland	276	276	14,600	242	174	7,820	1,150	403	16,500	1,660	854	38,900
France	23	23	1,490	--	--	--	74	18	393	97	42	1,880
Germany	15	15	857	7	5	649	(6)	(6)	3	22	20	1,510
India	61	61	2,560	--	--	--	382	103	3,350	443	164	5,910
Japan	272	272	13,000	4	3	147	--	--	--	276	274	13,200
Morocco	235	235	9,160	--	--	--	--	--	--	235	235	9,160
Norway	1,240	1,240	51,500	--	--	--	--	--	--	1,240	1,240	51,500
Russia	1,520	1,520	56,100	--	--	--	--	--	--	1,520	1,520	56,100
South Africa	321	321	13,400	2	1	55	--	--	--	323	322	13,400
Sweden	18	18	748	--	--	--	--	--	--	18	18	748
Taiwan	3	3	85	--	--	--	58	16	576	61	19	660
Uganda	148	148	6,210	--	--	--	--	--	--	148	148	6,210
United Kingdom	17	17	826	446	321	13,600	260	79	3,630	724	418	18,100
Zambia	576	576	22,100	--	--	--	--	--	--	576	576	22,100
Other	10	10	360	--	--	--	27	8	227	38	19	587
Total	8,750	8,750	350,000	2,010	1,450	60,700	2,740	854	28,900	13,500	11,100	439,000
2011:												
Australia	792	792	27,900	--	--	--	--	--	--	792	792	27,900
Belgium	131	131	5,480	426	307	13,500	--	--	--	557	438	19,000
Brazil	387	387	12,800	--	--	--	63	19	770	449	405	13,600
Canada	231	231	10,000	1,210	870	20,100	--	--	--	1,440	1,100	30,100
China	1,820	1,820	65,800	308	222	8,460	231	69	2,060	2,360	2,110	76,300
Congo (Kinshasa)	268	268	9,060	21	15	633	--	--	--	289	283	9,690
Finland	265	265	13,200	325	234	9,290	1,170	418	15,600	1,760	917	38,200
France	11	11	699	(6)	(6)	3	18	4	86	29	15	788
Germany	3	3	168	8	6	658	4	1	22	15	10	848
India	159	159	5,580	--	--	--	516	139	4,440	675	298	10,000
Japan	216	216	8,610	8	6	335	--	--	--	224	221	8,950
Morocco	200	200	6,940	--	--	--	--	--	--	200	200	6,940
Norway	1,140	1,140	42,300	--	--	--	--	--	--	1,140	1,140	42,300
Russia	1,020	1,020	38,500	--	--	--	(6)	(6)	8	1,020	1,020	38,500
South Africa	173	173	6,150	--	--	--	--	--	--	173	173	6,150
Sweden	8	8	336	--	--	--	--	--	--	8	8	336
Uganda	81	81	2,640	--	--	--	--	--	--	81	81	2,640
United Kingdom	66	66	2,590	288	207	8,180	184	51	2,130	537	325	12,900

See footnotes at end of table.

TABLE 5—Continued  
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY<sup>1</sup>

Country of origin	Metal <sup>2</sup>		Oxides and hydroxides				Other forms <sup>3</sup>		Total	
	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)
Zambia	1,040	1,040	--	--	--	--	--	1,040	1,040	\$36,900
Other	10	10	(6)	(6)	\$5	5	2	14	12	596
Total	8,020	8,020	2,590	1,870	61,200	2,190	704	12,800	10,600	383,000

-- Zero.

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

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

<sup>3</sup>Includes cobalt acetates, cobalt carbonates, cobalt chlorides, and cobalt sulfates.

<sup>4</sup>Estimated from gross weights.

<sup>5</sup>Customs value.

<sup>6</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6  
U.S. EXPORTS OF COBALT IN 2011, BY COUNTRY<sup>1,2</sup>

Country of destination	Metal <sup>3</sup>		Oxides and hydroxides		Acetates		Chlorides		Total	
	Gross weight (metric tons)	Value <sup>4</sup> (thousands)	Gross weight (metric tons)	Value <sup>4</sup> (thousands)	Gross weight (metric tons)	Value <sup>4</sup> (thousands)	Gross weight (metric tons)	Value <sup>4</sup> (thousands)	Cobalt content <sup>5</sup> (metric tons)	Value <sup>4</sup> (thousands)
Argentina	49	\$1,690	--	--	--	--	--	--	49	\$1,690
Australia	9	302	2	\$72	--	--	--	--	10	373
Austria	21	886	--	--	--	--	--	--	21	886
Belgium	117	2,470	36	774	143	\$1,540	--	--	177	4,790
Brazil	8	267	--	--	--	--	2	\$32	9	299
Canada	608	9,920	(6)	12	173	1,980	5	66	650	12,000
China	123	1,580	239	748	5	54	(6)	4	296	2,380
Colombia	9	126	(6)	13	--	--	--	--	9	139
France	701	22,400	--	--	--	--	--	--	701	22,400
Germany	220	12,200	(6)	12	--	--	--	--	221	12,200
India	52	2,420	--	--	--	--	--	--	52	2,420
Ireland	540	15,200	--	--	--	--	--	--	540	15,200
Japan	134	7,450	5	249	5	225	--	--	138	7,920
Korea, Republic of	37	2,490	--	--	--	--	--	--	37	2,490
Mexico	6	231	35	405	62	646	--	--	46	1,280
Netherlands	78	3,090	(6)	10	--	--	--	--	78	3,100
Norfolk Island	13	403	--	--	--	--	--	--	13	403
Singapore	11	820	--	--	--	--	--	--	11	820
South Africa	9	395	1	30	--	--	--	--	10	425
Sweden	18	259	--	--	--	--	--	--	18	259
Taiwan	12	603	--	--	2	22	--	--	12	625
Thailand	12	622	--	--	1	11	--	--	12	633
Tunisia	18	601	--	--	--	--	--	--	18	601
United Kingdom	207	6,970	4	44	--	--	--	--	211	7,010
Other	45	2,890	10	333	5	10	--	--	53	3,230
Total	3,060	96,300	332	2,700	396	4,490	7	102	3,390	104,000

-- Zero.

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

<sup>2</sup>In addition to the materials listed, the United States exports cobalt ores and concentrates and wrought cobalt and cobalt articles.

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

<sup>4</sup>Free alongside ship value.

<sup>5</sup>Estimated from gross weights.

<sup>6</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7  
 WORLD ANNUAL COBALT REFINERY  
 CAPACITY, DECEMBER 31, 2011<sup>1,2</sup>

(Metric tons, cobalt content)

Country	Capacity
Australia	6,700
Belgium	1,500
Brazil <sup>c</sup>	1,700
Canada <sup>c</sup>	6,420
China <sup>c</sup>	50,000
Congo (Kinshasa) <sup>c</sup>	12,000
Finland <sup>c</sup>	11,000
France	500
India <sup>c</sup>	2,060
Japan	2,000
Morocco	2,000
Norway	5,200
Russia <sup>c</sup>	6,000
South Africa <sup>c</sup>	1,000
Uganda	720
Zambia	8,800
Total	118,000

<sup>c</sup>Estimated.

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

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

TABLE 8  
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2016<sup>1,2</sup>

Projected year of first production	Country	Project and company <sup>3</sup>	Project type <sup>4</sup>	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2012 <sup>5</sup>	Australia	Mount Gunson MG 14 deposit Gunson Resources Ltd.	new mine and beneficiation plant	copper	copper-cobalt-silver sulfide ore	215	Cobalt-copper concentrate.
2012 <sup>e</sup>	Botswana	Dumps Tailings Retreatment Bamangwato Concessions Ltd. (BCL) and Global Initiatives Pty. Ltd.	new processing plant	nickel	nickel-copper-cobalt sulfide tailings and smelter slag	NA	NA.
2012	Brazil	Sao Miguel Paulista refinery Votorantim Metais Niquel SA	expansion of existing refinery	do.	nickel-cobalt matte	3,000 <sup>6</sup>	Cobalt cathode.
2012	Canada	Nunavik Nickel Jien Canada Mining Ltd. and Goldbrook Ventures Inc.	new mine and beneficiation plant	do.	nickel-copper-cobalt platinum-group metals sulfide ore	425 <sup>7</sup>	Nickel concentrate.
2012	Congo (Kinshasa)	Fours de Production des Alliages La Minière de Kalukundi [Groupe Managem and Congo Stars Mining Sarl (Costamin)]	new smelter	copper	copper-cobalt concentrates	480	Copper-cobalt alloy.
2012	Do.	Kabolela South Boss Mining Sprl [Eurasian Natural Resources Corp. PLC and La Générale des Carrières et des Mines (Gécamines)]	new mine	do.	copper-cobalt sulfide ore	NA	Copper-cobalt concentrate.
2012	Do.	Luisha South DMS plant– stockpile African Metals Corp.	new beneficiation plant	do.	stockpiled copper- cobalt oxide ore	215	Do.
2012	Do.	Luisha South DMS plant– hard rock African Metals Corp.	new mine and relocated beneficiation plant	do.	copper-cobalt oxide and sulfide ores	NA	Do.
2012	Do.	Mutanda, phase 2 Mutanda Mining SPRL (Glencore International AG, Groupe Bazano, and Rowny Assets Ltd.)	expansion of existing operation	do.	copper-cobalt oxide ore	18,000 <sup>6</sup>	Cobalt hydroxide.
2012	Finland	Kevitsa First Quantum Minerals Ltd.	new mine and beneficiation plant	nickel	nickel-copper-cobalt platinum-group metals-gold sulfide ore	400 <sup>e,7</sup>	Nickel-cobalt- platinum-group metals concentrate.
2012	Do.	Outokumpu stage 1 Altona Mining Ltd. (Vulcan Resources Ltd. and Universal Resources Ltd.)	new mine and refurbished beneficiation plant	copper	copper-zinc-cobalt- nickel-gold sulfide ore	940 <sup>7</sup>	Cobalt-nickel concentrate. <sup>8</sup>
2012	Do.	Talvivaara Talvivaara Mining Co. Plc.	expansion of existing operation	nickel	nickel-zinc-copper- cobalt sulfide ore	1,800 <sup>6</sup>	Nickel-cobalt sulfide.
2012	Madagascar	Ambatovy Joint Venture Sherritt International Corp., Sumitomo Corp., Korea Resources Corp., and SNC-Lavalin Group Inc.	new mine, HPAL processing plant, and refinery	do.	nickel-cobalt laterite ore	5,600	Cobalt metal powder and briquettes.

See footnotes at end of table.



TABLE 8—Continued  
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2016<sup>1,2</sup>

Projected year of first production	Country	Project and company <sup>3</sup>	Project type <sup>4</sup>	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2012	Papua New Guinea	Ramu Metallurgical Corporation of China Ltd., Jinchuan Group Ltd., Jilin Jien Nickel Industry Co., Ltd., Jiuquan Iron & Steel Group Co., Ltd., Highlands Pacific Ltd., and Mineral Resources Development Co.	new mine, beneficiation plant, and HPAL processing plant	nickel	nickel-cobalt laterite ore	3,300	Nickel-cobalt hydroxide.
2012	South Africa	Jubilee Smelting and Refining (Middleburg) smelter Jubilee Platinum plc and Thos Begbie Holdings Pty. Ltd.	adapt existing smelter to include ConRoast process	platinum-group metals-nickel	platinum-group concentrates and sludge	NA	Nickel-copper-cobalt-iron-platinum-group metals alloy.
2012	Zambia	Chambishi Metals Eurasian Natural Resources Corp. PLC	new SX-EW cobalt plant	copper	NA	3,000	Cobalt cathode.
2012	Do.	New Nchanga smelter Konkola Copper Mines Plc	expansion of production from existing smelter	do.	copper-cobalt concentrates	5,000 <sup>6</sup>	Alliage rouge.
2013	Australia	Barnes Hill Proto Resources & Investments Ltd. and Metals Finance Ltd.	new mine and ATML processing plant	nickel	nickel-cobalt laterite ore	400 <sup>e</sup>	Nickel-cobalt intermediate.
2013	Do.	Rocklands Group Copper CuDeco Ltd.	new mine and beneficiation plant	copper	copper-cobalt-gold oxide and sulfide ore	NA	Cobaltic-pyrite concentrate.
2013	Canada	Raglan Mine Xstrata Nickel	expansion of existing mine	nickel	nickel-copper-cobalt platinum-group metals sulfide ore	NA <sup>6</sup>	Nickel concentrate.
2013	Do.	Voisey's Bay Long-Harbour commercial nickel processing plant Vale S.A.	new refinery	do.	nickel-copper-cobalt sulfide concentrate	2,500	Cobalt cathode.
2013–14	Congo (Kinshasa)	Kakanda North Boss Mining Sprl [Eurasian Natural Resources Corp. PLC and La Générale des Carrières et des Mines (Gécamines)]	new mine and beneficiation plant	copper	copper-cobalt oxide and sulfide ore	NA	Copper-cobalt concentrate.
2013	Do.	Kolwezi tailings Eurasian Natural Resources Corp. PLC, Gertler Family Trust, La Générale des Carrières et des Mines (Gécamines), and Government of Congo (Kinshasa) <sup>9</sup>	new refinery	do.	copper-cobalt tailings	10,000	Cobalt hydroxide.
2013	Do.	Mutanda, phase 3 Mutanda Mining SPRL (Glencore International AG, Groupe Bazano, and Rowny Assets Ltd.)	expansion of existing operation	do.	copper-cobalt oxide ore	23,000 <sup>6</sup>	Do.
2013	Do.	NA Boss Mining Sprl [Eurasian Natural Resources Corp. PLC and La Générale des Carrières et des Mines (Gécamines)]	do.	do.	do.	NA	Copper-cobalt concentrate.

See footnotes at end of table.

TABLE 8—Continued  
 COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2016<sup>1,2</sup>

Projected year of first production	Country	Project and company <sup>3</sup>	Project type <sup>4</sup>	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2013	Congo (Kinshasa)	Pumpi (Project Cobalto-Cuprifere) La Miniere de Kalukundi [Groupe Managem and Congo Stars Mining SARL (Costamin)]	new mine	copper	copper-cobalt ore	NA	Copper-cobalt concentrate.
2013	Do.	Tenke Fungurume, phase 2 Freeport-McMoRan Copper & Gold Inc., Lundin Mining Corp., and La Générale des Carrières et des Mines (Gécamines)	expansion of existing operation	do.	copper-cobalt oxide ore	15,000 <sup>6</sup>	Cobalt hydroxide.
2013	Do.	Usoko refinery, EW plant for cobalt Chemaf SPRL	addition to existing refinery	do.	copper-cobalt ore	NA <sup>10</sup>	Cobalt cathode.
2013	Japan	Niihama expansion Sumitomo Metal Mining Co., Ltd.	expansion of existing refinery	nickel	nickel-cobalt sulfide and nickel matte	4,500 <sup>6</sup>	Do.
2013	Mexico	El Boleo Baja Mining Corp., Korea Resources Corp., L.S. Nikko Copper Inc., Hyundai Hysco Co. Ltd., SK Networks Co. Ltd., and Iljin Copper Foil Co. Ltd.	new mine and refinery	copper	copper-cobalt-zinc-manganese oxide and sulfide ores	2,400	Do. <sup>11</sup>
2013–14	Philippines	Mindoro Nickel, stage 1 Intex Resources ASA	new mine, beneficiation plant, ATML and HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	1,200	Cobalt sulfate.
2013	Do.	Taganito Sumitomo Metal Mining Co., Ltd., Nickel Asia Corp., and Mitsui & Co., Ltd.	new HPAL processing plant	do.	do.	2,600	Nickel-cobalt sulfide.
2013	United States (Idaho)	Idaho Cobalt Formation Metals Inc.	new mine and refinery	cobalt	stratiform cobalt-copper-gold ore	1,525 <sup>7</sup>	Cobalt cathode.
2013	United States (Michigan)	Eagle Kennecott Eagle Minerals Co.	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	nickel-copper sulfide ore	400 <sup>e</sup>	Copper-nickel concentrate.
2014	Afghanistan	Aynak MCC-JCL Aynak Minerals Co., Ltd. [Metallurgical Corporation of China Ltd., Jiangxi Copper Co., Ltd., and Fujian Zijin Mining Group Co. Ltd.]	new mine	copper	copper-cobalt ore	NA	NA.
2014 <sup>e</sup>	Canada	Makwa Mustang Minerals Corp.	new mine and relocated beneficiation plant	nickel	nickel-copper-platinum-group metals sulfide ore	150 <sup>e</sup>	Nickel concentrate.
2014	Do.	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished beneficiation plant, and refinery	gold	gold-cobalt-bismuth-copper ore	1,550 <sup>7</sup>	Cobalt cathode.

See footnotes at end of table.

TABLE 8—Continued  
 COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2016<sup>1,2</sup>

Projected year of first production	Country	Project and company <sup>3</sup>	Project type <sup>4</sup>	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2014	Congo (Kinshasa)	Kipoi, stage 2 Congo Minerals sprl [subsidiary of Tiger Resources Ltd. and La Générale des Carrières et des Mines (Gécamines)]	addition of heap-leaching and SX-EW to existing operation	copper	copper-cobalt oxide ore	1,100 <sup>e</sup>	NA.
2014 <sup>e</sup>	Do.	NA. La Sino-Congolaise des Mines Sarl (Sicomines) joint venture <sup>12</sup>	new mine, beneficiation plant, and smelter	do.	copper-cobalt ore	19,000	Alliage blanc.
2014	Do.	Usoko refinery Chemaf SPRL	expansion of existing refinery	do.	do.	6,000 <sup>6</sup>	Cobalt cathode and cobalt hydroxide.
2014	Philippines	Acoje, stage 1a European Nickel PLC and DMCI Mining Corp.	new mine and atmospheric tank leaching operation	nickel	nickel-cobalt laterite ore	530 <sup>e,7</sup>	Cobalt carbonate.
2014	Russia	Monchegorsk OJSC MMC Norilsk Nickel	new refinery	do.	cobalt hydroxide	3,000	Cobalt cathode.
2014	Tanzania	Kabanga Barrick Gold Corp. and Xstrata Nickel	new mine and beneficiation plant	do.	nickel sulfide ore	NA	Nickel concentrate.
2014 <sup>e</sup>	United States (Minnesota)	NorthMet PolyMet Mining Corp.	new mine, beneficiation plant, and refinery	copper	copper-nickel-platinum-group metals sulfide ore	360	Separate nickel and copper concentrates initially, followed by nickel-cobalt hydroxide.
2014	Zambia	Chambishi Copper Smelter Chambishi Copper Smelter Co., Ltd. (China Nonferrous Mining Corp. Ltd. and Yunnan Copper Industry Group Co. Ltd.) and Hunan Shijiyintianxinye Technology Co., Ltd.	add new bioleaching plant to existing smelter	do.	Copper-cobalt converter slag	500–700	Cobalt cathode.
2014 <sup>13</sup>	Do.	Ichimpe Zhonghui Mining Group Ltd.	new mine	do.	copper-cobalt ore	2,000	NA.
2015 <sup>e</sup>	Australia	Gladstone Nickel, stage 1 Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	6,000	Cobalt metal.
2015	Do.	Mt. Thirsty Barra Resources Ltd. and Fission Energy Ltd.	new mine and atmospheric leaching plant	do.	manganese-nickel-cobalt oxide ore	2,700	Nickel-cobalt sulfide.
2015	Cameroon	Nkamouna Geovic Mining Corp. and Société National d'Investissement du Cameroun	new mine and processing plant	cobalt	nickel-cobalt laterite ore	6,100 <sup>7</sup>	Cobalt-nickel sulfide.
2015	Canada	Minago Victory Nickel Inc.	new mine and beneficiation plant	nickel	nickel-copper-cobalt platinum-group metals-precious metals sulfide ore	230 <sup>e,7</sup>	Nickel concentrate.

See footnotes at end of table.

TABLE 8—Continued  
 COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2016<sup>1,2</sup>

Projected year of first production	Country	Project and company <sup>3</sup>	Project type <sup>4</sup>	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2015	Congo (Kinshasa)	WOL-SX-EW refinery, new phase 4 Katanga Mining Ltd., La Générale des Carrières et des Mines (Gécamines), and La Société Immobilière du Congo	expand new beneficiation plant and SX-EW refinery	copper	copper-cobalt oxide and sulfide ore	22,000	Cobalt hydroxide.
2015	Zambia	Synclinorium Mopani Copper Mines Plc	expand existing mine	do.	copper-cobalt ore	NA	Copper-cobalt ore.
2016 <sup>c</sup>	Australia	Niwest GME Resources Ltd.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	1,400	Nickel-cobalt sulfide.
2016 <sup>c</sup>	Do.	Wingellina Nickel Metals X Ltd.	new mine and HPAL processing plant	do.	do.	3,000 <sup>7</sup>	Nickel-cobalt hydroxide.
2016 <sup>c</sup>	Philippines	Acoje, stage 1b European Nickel PLC and DMCI Mining Corp.	expand existing operation	do.	do.	645 <sup>c,7</sup>	Cobalt carbonate.

<sup>c</sup>Estimated. Do., do. Ditto. NA Not available.

<sup>1</sup>Estimated data are rounded to no more than three significant digits.

<sup>2</sup>Projects in feasibility or later stages of development in 2011. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2016, but not enough information was available to include them.

<sup>3</sup>DMS dense media separation. EW electrowinning. WOL-SX-EW whole ore leach—solvent extraction—electrowinning.

<sup>4</sup>ATML Atmospheric leach. HPAL High pressure acid leach. SX-EW solvent extraction—electrowinning.

<sup>5</sup>Startup date provided before project postponement was announced; no information is available on the length of delay.

<sup>6</sup>Total capacity following expansion.

<sup>7</sup>Average production.

<sup>8</sup>Cobalt-nickel concentrate will be stockpiled until a marketable product is developed.

<sup>9</sup>Ownership resulting from agreement signed with First Quantum Minerals Ltd. in January 2012.

<sup>10</sup>Addition will not increase total plant capacity.

<sup>11</sup>Cobalt production would begin after copper production reaches a steady rate.

<sup>12</sup>The Sicomines joint venture comprises the following Chinese and Congolese companies: China Railway Group Ltd., China Sinohydro Corp., China Metallurgical Group Corp., Zhejiang Huayou Cobalt Co., Ltd., and La Générale des Carrières et des Mines (Gécamines).

<sup>13</sup>Project may be delayed pending approval of environmental impact assessment and mine plan.

TABLE 9  
COBALT: WORLD MINE PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons, cobalt content)

Country <sup>3</sup>	2007	2008	2009	2010	2011 <sup>c</sup>
Australia <sup>e,4</sup>	4,730	4,780	4,340	3,850	3,850
Botswana <sup>5</sup>	242	337	270	274 <sup>r</sup>	149 <sup>6</sup>
Brazil	2,725 <sup>r</sup>	2,631 <sup>r</sup>	2,075 <sup>r</sup>	3,139 <sup>r</sup>	3,500
Canada <sup>7</sup>	8,692	8,953	3,919	4,636 <sup>r</sup>	7,071 <sup>p,6</sup>
China <sup>e</sup>	6,100	6,630	6,000	6,500	6,800
Congo (Kinshasa) <sup>e,8</sup>	25,400	32,300	40,000 <sup>r</sup>	60,000 <sup>r</sup>	60,000
Cuba <sup>9</sup>	4,540	3,175	3,600 <sup>r,c</sup>	3,700 <sup>r,c</sup>	4,000
Finland <sup>e</sup>	115	105 <sup>6</sup>	27	140	535
Indonesia <sup>10</sup>	1,600	1,300	1,200	1,600	1,600
Madagascar <sup>e</sup>	--	--	--	165 <sup>r</sup>	500
Morocco <sup>e,11</sup>	1,800	1,700	2,200	3,110 <sup>r,6</sup>	2,159 <sup>6</sup>
New Caledonia <sup>12</sup>	2,250 <sup>r</sup>	2,110 <sup>r</sup>	2,000 <sup>r</sup>	2,850 <sup>r</sup>	3,240
Philippines <sup>e</sup>	1,000	1,200	1,500	2,200	2,200
Russia <sup>e,11</sup>	6,300	6,200	6,100	6,200	6,300
South Africa <sup>e</sup>	600	590	610	1,800	1,600
Zambia <sup>e,13</sup>	7,500	7,000	4,900	6,200 <sup>r</sup>	5,400
Zimbabwe <sup>14</sup>	100 <sup>e</sup>	85 <sup>e</sup>	74	79	86 <sup>6</sup>
Total	73,700 <sup>r</sup>	79,100 <sup>r</sup>	78,800 <sup>r</sup>	106,000 <sup>r</sup>	109,000

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

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

<sup>2</sup>Table includes data available through May 2, 2012. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from cobalt, copper, nickel, platinum, or zinc operations.

<sup>3</sup>In 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 produces copper ore containing 1,500 to 5,000 metric tons per year of cobalt, which is not currently 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.

<sup>4</sup>Cobalt content of lateritic nickel ore and nickel concentrate originating from Australia. Quantities of cobalt contained in intermediate or refined metallurgical products produced from Australian and imported ores, in metric tons, were estimated to be as follows: 2007—5,500; 2008—5,100; 2009—5,500; 2010—5,700; and 2011—6,300.

<sup>5</sup>Reported cobalt content of pelletized nickel-copper matte.

<sup>6</sup>Reported figure.

<sup>7</sup>Assay content of cobalt in concentrates produced.

<sup>8</sup>Cobalt content of concentrates, tailings, and slags.

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

<sup>10</sup>Cobalt content of nickel matte plus estimated cobalt in lateritic ore processed in Australia.

<sup>11</sup>Cobalt content of concentrates.

<sup>12</sup>Cobalt contained in the following materials: cobalt chloride produced in France from New Caledonian matte, cobalt hydroxide produced in New Caledonia, and lateritic nickel ore exported to Australia.

<sup>13</sup>Cobalt content of concentrates and slags.

<sup>14</sup>Cobalt 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 10  
COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons, cobalt content)

Country	2007	2008	2009	2010	2011
Australia, metal powder and oxide hydroxide <sup>c</sup>	3,680	3,620	4,050	4,120	4,720
Belgium, metal powder, oxide, hydroxide <sup>3</sup>	2,825	3,020	2,150	2,600	3,187
Brazil, metal	1,311 <sup>r</sup>	1,215 <sup>r</sup>	1,012	1,369	1,613
Canada, metal, metal powder, oxide	5,620	5,637	4,918	4,711 <sup>r</sup>	6,038 <sup>p</sup>
China, metal, metal powder, oxide, salts <sup>c,4</sup>	13,200	18,200	25,500 <sup>r</sup>	35,900 <sup>r</sup>	35,000
Congo (Kinshasa), metal <sup>5</sup>	606	1,049	2,950	4,182	3,083
Finland, metal powder and salts <sup>6</sup>	9,173	9,645	8,962	9,413	10,441
France, chloride	305	311	368	302	354
India, metal and salts	980	858	1,001	1,187	1,299
Japan, metal	1,084	1,071	1,332	1,935	2,007
Morocco, metal and oxide	1,591	1,711	1,600	1,545	1,788
Norway, metal	3,939	3,719	3,510	3,208	3,067
Russia, unspecified <sup>7</sup>	3,800 <sup>c</sup>	2,502 <sup>r</sup>	2,352 <sup>r</sup>	2,460	2,337
South Africa, metal powder and sulfate	307	244	238	833	840
Uganda, metal	698	663	673	624	661
Zambia, metal	4,335	4,049	1,506	5,026	5,756
Total	53,500 <sup>r</sup>	57,500 <sup>r</sup>	62,100 <sup>r</sup>	79,400 <sup>r</sup>	82,200

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

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

<sup>2</sup>Table includes data available through May 2, 2012. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

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

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

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

<sup>6</sup>Production for 2007–08 reported by the Geological Survey of Finland; production for 2009–10 reported by OM Group Inc.; production for 2011 reported by the Cobalt Development Institute.

<sup>7</sup>Production reportedly includes metal, oxide, and salts; other forms may also have been produced.