



# 2009 Minerals Yearbook

---

COBALT [ADVANCE RELEASE]

---

# COBALT

By Kim B. Shedd

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

In 2009, world production of refined cobalt increased, primarily as a result of increased production from Australia, China, and Congo (Kinshasa). The United States did not mine or refine cobalt in 2009. However, a small number of mining operations produced negligible amounts of byproduct cobalt as intermediate products. Since 1993, sales of excess cobalt from the National Defense Stockpile (NDS) have contributed to U.S. and world supplies.

According to the Cobalt Development Institute (2010a), world apparent consumption of cobalt was approximately 56,000 metric tons (t), about 8% less than that of 2008. Chinese apparent consumption increased, but consumption from other regions decreased. The U.S. spot price for cobalt generally trended upward after reaching a low of less than \$12 per pound in February. Salient U.S. and world cobalt statistics for 2009 and the previous 4 years 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 airbags for automobiles; 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 steel-belted radial tires.

## Legislation and Government Programs

During fiscal year 2009 (October 1, 2008, through September 30, 2009), the Defense National Stockpile Center (DNSC), U.S. Department of Defense, sold 187 t of cobalt metal valued at \$6.80 million under a basic ordering agreement (BOA) (table 2). This represented 14% of the 1,360-metric-ton (3-million-pound) maximum allowed for sale under the fiscal year 2009 Annual Materials Plan (AMP). The AMP for fiscal year 2010 (October 1, 2009, through September 30, 2010) reduced the maximum allowable sale of cobalt to 454 t (1 million pounds) (U.S. Department of Defense, 2010, p. 6–7, and 9).

During calendar year 2009, the DNSC sold 169 t of cobalt valued at \$6.30 million under the BOA. On December 31, the total uncommitted cobalt inventory held by the DNSC was 293 t of cobalt cathode.

The Department of Defense (DOD) was directed by Congress to review its current policy to dispose of NDS material and determine whether the NDS was properly configured to assure future availability of materials for defense needs in light of current world market conditions. A DOD working group concluded that DNSC's current disposal policy required

revision and that the NDS should be reconfigured into a Strategic Material Security Program to encompass the full range of responsibilities required to develop an integrated and comprehensive approach to strategic materials management. The working group supported DNSC's recommendation to temporarily suspend or limit the sale of 13 materials which had no viable substitutes and on which the United States was wholly or substantially import dependent or at a significant risk of supply disruption. Sales of cobalt were curtailed to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2010, p. 1–2).

## Production

With the exception of negligible amounts of byproduct cobalt produced from Stillwater Mining Co.'s platinum-group metal (PGM) operation in southeastern Montana, the United States did not mine or refine cobalt in 2009. Cobalt-bearing nickel sulfate produced from Stillwater's mining and refining operations was sold to several companies. Some of southeastern Missouri's lead ores contained minor amounts of cobalt.

In late 2009, Formation Metals Inc. (formerly Formation Capital Corp.) received approval from the U.S. Forest Service to begin construction of its Idaho cobalt project and began to actively pursue financing. Formation planned to develop an underground cobalt-copper-gold mine and mill complex in the Idaho Cobalt Belt in Lemhi County and retrofit its Big Creek hydrometallurgical complex near Kellogg, ID, to refine the concentrates. The refinery was to produce approximately 1,500 metric tons per year (t/yr) of cobalt as high-grade cathode suitable for critical superalloy applications. Formation estimated that construction would take 12 to 14 months (Formation Metals Inc., 2010, p. 3, 6).

Kennecott Minerals Co., a fully owned subsidiary of Rio Tinto (Melbourne, Australia, and London, United Kingdom), continued to work on permitting for its Eagle project in Michigan. The project comprised a small underground nickel-copper mine in the Eagle deposit in the Yellow Dog Plains area northwest of Marquette and a rehabilitated mill in Humboldt Township, which would produce concentrate for export. At the proposed rate of 16,000 t/yr of nickel, an estimated 400 t/yr of cobalt would be produced during a 7-year mine life, based on nickel and cobalt grades in the resource. By early 2010, Kennecott had received all of the State permits needed for the project (Kennecott Eagle Minerals Co., 2010; Rio Tinto, 2010, p. 39, 41).

The Minnesota Department of Natural Resources and the U.S. Army Corps of Engineers prepared a 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. The final products of the project would be copper cathode, a nickel-cobalt mixed hydroxide, and a precipitate of PGMs and gold. PolyMet planned to develop the project in stages and sell either a bulk concentrate or separate copper and nickel concentrates during the construction and commissioning of the hydrometallurgical plant (table 8). PolyMet and Swiss trading firm Glencore International AG had a strategic partnership whereby Glencore would invest in Polymet and purchase or market NorthMet's concentrates, intermediate products, and metal (PolyMet Mining Corp., 2009, p. 9, 13, 15–17, 27).

U.S. processors made cobalt chemicals and cobalt metal powders 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.

The Hall Chemical Co. was acquired by newly formed CP Chemicals LP (New Castle, DE) from Meridian Group, the investment banking and management consulting firm that had been appointed as receiver when Hall Chemical ceased operations owing to insufficient funds. The Hall Chemical Co. was founded in 1946 and produced cobalt chemicals at its Wickliffe, OH, plant. The new owners planned to restart operations by yearend (Tascarella, 2009).

Carolmet Cobalt Products (a division of n.v. Umicore, s.a.) ceased production at its Maxton plant near Laurinburg, NC. The plant, which began operations in 1980 as a producer of cobalt metal powder, had been producing cobalt salts prior to its closure (Witten, 2009; n.v. Umicore, s.a., 2010, p. 53).

## Consumption

U.S. apparent consumption for 2009, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 26% lower than that of 2008 (table 1). The decrease was primarily because net imports in 2009 were significantly lower than those of 2008.

U.S. reported consumption of cobalt in 2009 was 15% lower than that of 2008. Metallurgical industries used 18% less cobalt than they did in 2008; cobalt consumption for chemical uses was 9% lower. 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.

## Prices

The annual average U.S. spot price for cathode (minimum of 99.8% cobalt), as reported by Platts Metals Week, was less than one-half that of 2008 (table 1). After reaching a low of \$11.50 to \$14.00 per pound in late February, the price generally trended upward and was highest in early November at \$22.00 to \$23.50 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 averages of weekly prices for Zambian cobalt and Russian cobalt were each \$16.55 per pound, and less than one-half of those in 2008.

In early 2009, BHP Billiton (Melbourne, Australia, and London, United Kingdom) suspended sales of cobalt via its Cobalt Open Sales System Web site. The company planned to market its cobalt directly to customers (BHP Billiton, 2009a).

Financial services company Credit Suisse Group offered a financial product based on cobalt in a joint venture with Glencore. The product was intended to allow hedge funds and other interested parties to buy over-the-counter futures positions in cobalt settled against the Metal Bulletin price (Metal Bulletin, 2007).

The London Metal Exchange (LME) launch of a cobalt futures contract was delayed until February 2010. Under the proposed contract, cobalt would trade in 1-metric-ton lots (in 100 to 500 kilogram drums) of minimum 99.3% cobalt, and would be delivered by brand, with impurities identified, to warehouses in Baltimore, Rotterdam, and Singapore. The cobalt would be traded by open outcry ring trading, on an electronic trading platform, and by an interoffice telephone market. LME prices could be used by industry as a reference price. By mid-February 2010, cobalt from the following six producers had been approved for delivery against the LME contract: Jiangsu Cobalt Nickel Metal Co. Ltd., Jinchuan Group Ltd., Kasese Cobalt Co. Ltd., Sumitomo Metal Mining Co., Ltd., Vale Inco Ltd., and Votorantim Metais Niquel S/A (London Metal Exchange Ltd., The, 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 2009, net import reliance as a percentage of apparent consumption was 76%. Because there was no measurable U.S. primary cobalt production in 2009, 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 2009, the United States imported 28% less cobalt than it did in 2008 (tables 4, 5). Ten countries supplied more than 90% of U.S. imports. Norway was the leading supplier, followed by China, Russia, Finland, Canada, Belgium, Australia, Japan, Morocco, and the United Kingdom.

The United States imported 387 t, gross weight, of unwrought cobalt alloys valued at \$10.3 million. These materials were sourced from nine countries, with Canada supplying the majority (98%). The United States imported 650 t, gross weight, of cobalt waste and scrap valued at \$9.1 million. Eight countries supplied 95% of this material—the United Kingdom (32%), Ireland (31%), Japan (11%), France (7%), Germany (6%), India and Tunisia (3% each), and Mexico (2%). The United States also imported 154 t, gross weight, of wrought cobalt and cobalt articles valued at \$15.7 million. The leading suppliers of these materials were the United Kingdom (52%), Canada (18%), Germany (16%), and China, France, and Japan (5% each).

U.S. exports of unwrought cobalt and cobalt contained in chemicals decreased by 14% compared with those of 2008. As listed in table 6, the leading destinations for these exports were Ireland, France, Japan, Belgium, Germany, and China. The United States also exported 1,340 t, gross weight, of wrought metal and cobalt articles valued at \$78.5 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) and Zambia], which were processed primarily to recover cobalt.

Refinery capacity by country is listed in table 7. Plants that processed refined cobalt, used secondary materials (scrap) as their main source of feed, or produced a cobalt product that required further refining were not included.

The following review by country focuses on operations in production during 2009. Expansions to those operations and greenfield projects that were forecast to begin producing between 2010 and 2014 are listed in table 8.

**Australia.**—The Yabulu nickel-cobalt refinery in Townsville, Queensland, operated by Queensland Nickel Pty Ltd., produced 1,700 t of refined cobalt as cobalt oxide hydroxide; 6% more than the 1,600 t produced in 2008. Yabulu processed lateritic ore imported from Indonesia, New Caledonia, and the Philippines, and nickel-cobalt mixed hydroxide from BHP Billiton's Ravensthorpe Mine and processing operation in Western Australia. In early 2009, BHP Billiton announced that it planned to suspend operations at Ravensthorpe and stop refining the mixed hydroxide at Yabulu. BHP Billiton subsequently sold the Yabulu refinery to Australian businessman Clive Palmer and the Ravensthorpe operation to First Quantum Minerals Ltd. (BHP Billiton, 2009b; Cobalt Development Institute, 2010a; First Quantum Minerals Ltd., 2010, p. 9).

BHP Billiton's Nickel West operations in Western Australia processed two types of ore—nickel laterite and nickel sulfide. The laterite operation was the Ravensthorpe Mine and enhanced pressure acid leaching plant. The nickel sulfide operations comprised 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 that was subsequently toll-refined to cobalt cathode in Norway by Xstrata Nickel (a business unit of Xstrata plc). This tolling agreement reportedly expired during the year (Wallop, 2009).

The Murrin Murrin Nickel Cobalt Joint Venture (60% Minara Resources Ltd. and 40% Glencore) produced a record 2,350 t of cobalt as metal powder and briquettes from its nickel-cobalt laterite mining and pressure-acid leaching operation near Leonora, Western Australia, 16% more than the 2,018 t produced in 2008. Minara's demonstration plant for recovering nickel and cobalt by heap-leaching stockpiled ore-reject material provided 124 t of the cobalt produced (Minara Resources Ltd., 2010, p. 18–19).

In late 2008, OJSC MMC Norilsk Nickel placed the Cawse nickel laterite mine and processing plant, the Silver Swan underground nickel sulfide mine, and the Waterloo underground nickel sulfide mine on indefinite care-and-maintenance status. In early 2009, Norilsk suspended operations at its remaining Western Australian nickel operations—the Black Swan and Lake Johnston nickel sulfide mines and mills—and placed them on care-and-maintenance status (OJSC MMC Norilsk Nickel, 2009).

Panoramic Resources Ltd. produced concentrates containing 420 t of cobalt (408 t in 2008) 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., 2009, p. 2; 2010, p. 2).

China Minmetals Non-Ferrous Metals Co., Ltd. acquired the Avebury nickel sulfide mine in Tasmania and the Century zinc mine in northern Queensland from OZ Minerals Ltd. Prior to being placed on care-and-maintenance status in late 2008, nickel concentrate from Avebury was shipped to Jinchuan under an offtake agreement. Zinc concentrates produced from the Century Mine are shipped to Nyrstar NV's Budel smelter in the Netherlands, where cobalt was recovered as filter cake (OZ Minerals Ltd., 2009).

At yearend, Fox Resources Ltd. announced that it would restart production at its Radio Hill operation near Karratha, Western Australia. Fox planned to process stockpiled nickel-copper sulfide ore using bacterial heap leaching. The Radio Hill mine and mill remained on care-and-maintenance status (Fox Resources Ltd., 2010, p. 1).

Xstrata Nickel Australasia produced 459 t of cobalt in nickel sulfide concentrates from the Cosmos and Sinclair operations in Western Australia in 2009 (120 t during the 11 months of ownership in 2008) (Xstrata plc, 2010b).

**Belgium.**—According to the Cobalt Development Institute (2010a), Umicore's 2009 cobalt refinery production decreased to 2,150 t from 3,020 t produced in 2008. Umicore converted cobalt metal, residues, and other cobalt-bearing materials into a wide range of cobalt specialty products, including metal powders, hydroxides, oxides, salts, and compounds. Umicore's cobalt refining took place at plants in Olen, Belgium, and Ganzhou, China. The company's cobalt processing plants were in Arab, AL, and Laurinburg, NC, in the United States; Bruges, Belgium; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. In 2009,

Umicore expanded the production capability of its plants in Cheonan and Jiangmen to include nickel-manganese-cobalt cathode materials for lithium-ion batteries, and announced a plan to build an industrial scale recycling facility for spent rechargeable batteries in Hoboken, Belgium (n.v. Umicore, s.a., 2009; 2010, p. 14).

**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 (OJSC MMC Norilsk Nickel, 2010, p. 20).

**Brazil.**—Votorantim Metais Níquel S.A. produced cobalt cathode at its refinery in Sao Miguel Paulista, Sao Paulo State, from lateritic nickel-cobalt ore mined from Niquelandia, Goias State. The company also produced nickel matte, primarily from sulfide ores mined and smelted at Fortaleza de Minas, Minas Gerais State. During the fourth quarter of 2009, Votorantim received nickel sulfide concentrate from Mirabela Nickel Ltd.

Mirabela Nickel began production from its Santa Rita open pit nickel sulfide mine and concentrator in Bahia State, and by yearend produced 14 t of cobalt in concentrate. All concentrate produced from Santa Rita was committed via offtake agreements with Votorantim (50%) and Norilsk (50%) through 2014 (Mirabela Nickel Ltd., 2010).

**Canada.**—Vale Inco Ltd. produced 1,575 t of cobalt in 2009, 44% less than the 2,828 t produced in 2008. The decrease in production was the result of labor strikes at its operations in Sudbury from July through yearend and Voisey's Bay from August through yearend. Vale reported production in the form of cathode, 639 t, from its Port Colborne, Ontario, refinery; cobalt hydrate, 554 t, from its Thompson, Manitoba, refinery; and cobalt contained in unrefined products such as nickel concentrates, 491 t. Vale's cobalt originated from nickel sulfide ores from company mines at Sudbury, Ontario; Thompson, Manitoba; and Voisey's Bay in northeastern Labrador; and purchased feedstocks, including nickel sulfide ore from FNX Mining Co. Inc.'s Sudbury operations. Vale reported the following distribution of sources for its cobalt production: Ontario, 359 t (804 t in 2008); Manitoba, 181 t (168 t in 2008); Voisey's Bay, 971 t (1,695 t in 2008); and external sources, 64 t (161 t in 2008) (Vale S.A., 2010, p. 32–33, 43–44).

Xstrata Nickel produced 277 t of cobalt in concentrates from mines at Sudbury (538 t in 2008), 73 t of cobalt in concentrate from its Montcalm Mine northwest of Timmins, Ontario (338 t in 2008), and 586 t of cobalt in concentrate from its Raglan Mine in Quebec (512 t in 2008). Mine production from Sudbury was lower than that of 2008 because of the closure of several high-cost, end-of-life mines but included production from the newly started Nickel Rim South Mine. Production from Montcalm was suspended after the first quarter because of structural damage to the mine. Nickel-copper matte containing 2,476 t of cobalt was produced at the company's Sudbury smelter (2,648 t in 2008); this was refined at Xstrata's Nikkelverk refinery in Norway. Some of the cobalt in the matte originated from ores produced at company mines 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 from URSA Major Minerals Inc.'s Shakespeare Mine in Ontario and First Nickel Inc.'s Lockerby Mine in Sudbury, and nickel sulfide concentrates produced by Crowflight Minerals Inc.'s Bucko Lake nickel mine in the Thompson Nickel Belt of Manitoba and Liberty Mines Inc. in Ontario. Secondary custom feed materials included battery-manufacturing scrap, high-grade slags, metal residues, smelter byproducts, spent batteries and catalysts, superalloy and other alloy scrap, and other secondary materials (Tollinsky, 2008; Xstrata Nickel, 2008, p. 9–11, 21; URSA Major Minerals Inc., 2009; Xstrata plc, 2010b).

The Fort Saskatchewan refinery of the joint venture of Sherritt International Corp. and General Nickel Co. S.A. produced a record 3,721 t of cobalt as metal powder and briquettes in 2009, 9% more than the 3,428 t produced in 2008. Approximately 93% 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. Limited activity related to the phase 2 expansion of the refinery took place during the year (table 8). 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., 2010, p. 8, 10).

FNX mined ore from sulfide deposits in Sudbury. In 2009, the company shifted its focus from nickel to copper, and the payable cobalt production decreased to 4 t from 75 t in 2008. First Nickel's Lockerby Mine was on care-and-maintenance status all year. The company's sales of payable cobalt in concentrates decreased to 4 t from 33 t in 2008. In the summer of 2009, Liberty Mines resumed production from its Redstone Mine southeast of Timmins, Ontario, and development of the nearby McWatters Mine. Nickel sulfide ore from the mines was processed at the company's Redstone Mill; Liberty had agreements to sell the resulting concentrate to Xstrata Nickel in Sudbury and Jilin Jien Nickel Industry Company Ltd. in China (First Nickel Inc., 2010, p. 3–4, 18; FNX Mining Company Inc., 2010, p. 8, 10; Liberty Mines Inc., 2010a, p. 27, 2010b, p. 1–2).

**China.**—China's production of refined cobalt was nearly 24,000 t, which made it the world's leading producer. In 2009, only a small portion of China's cobalt production originated from domestic mines. Most of the production was from imported ores, concentrates, and intermediate materials; the remainder was from stocks and scrap. Most of the imported raw materials were from Congo (Kinshasa). One analyst estimated that China imported 24,900 t of cobalt contained in ores, concentrates, and semirefined materials in 2009, up from 21,400 t in 2008. China's imports of cobalt ores and concentrates and semirefined materials both increased in 2009 compared with those of 2008 (CRU International Ltd., 2010, p. 7; Xu, 2010, p. 5).

The number of companies refining and/or processing cobalt in China has been estimated to be as many as 120. The leading four refiners were Jinchuan, 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 2009 estimated cobalt production. Jinchuan produced cobalt as cathode and other products from its refinery at Jinchang, Gansu Province. By 2009, the refinery's cobalt

production capacity had been increased to 10,000 t/yr. 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-copper concentrates from Australia, Spain, and Zambia; nickel concentrates from Australia; and nickel matte from BHP Billiton (Li, 2007; Metal Bulletin Daily, 2009a; Yang, 2009; CRU International Ltd., 2010, p. 4, 6).

In 2009, the Chinese Government reversed its ban on toll processing cobalt materials. The reversal allowed companies to import cobalt concentrates and intermediates produced by hydrometallurgical methods for the production of cobalt metal, metal powder, and salts for export. It was intended to support Chinese producers by enabling them to rely less on the domestic market for the sale of their products (Beijing Antaike Information Development Co., Ltd., 2009).

**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 tens of thousands of artisanal miners hand-picking cobalt-rich ores. The hand-picked ores were either exported, primarily to China and India, or processed at numerous plants within Congo (Kinshasa) to semirefined materials such as cobalt carbonate or cobalt-bearing alloys. As discussed in the "China" section of this report, exports of cobalt materials to China increased in 2009 compared with those of 2008. In addition, the Government of Katanga Province, where copper and cobalt were mined, removed a ban on exports of cobalt concentrates to neighboring Zambia (Metal Bulletin, 2009a).

The Government of Congo (Kinshasa) nearly completed its review of mining contracts signed between private companies and the Government or Government-owned companies. The review, which began in 2007, was intended to evaluate whether each contract gave a fair share of its revenues to the country and to determine whether it should be maintained, renegotiated, or terminated. At yearend, contracts on two copper-cobalt projects—the Kolwezi Tailings project, which was being developed by First Quantum Ltd., and the Tenke Fungurume project, which was developed by Freeport-McMoRan Copper & Gold Inc. (FCX)—had not yet been finalized (First Quantum Minerals Ltd., 2010, p. 35–37; Freeport-McMoRan Copper & Gold Inc., 2010a, p. 22, 91).

The Government of Congo (Kinshasa) signed an amended multibillion dollar cooperation agreement with a group of Chinese enterprises led by China Railway Group and Sinohydro Corp. Under the agreement, the Chinese consortium would invest in the construction and/or upgrading of infrastructure in exchange for access to deposits containing a potential 10.6 million metric tons of copper and 620,000 metric tons of cobalt. In 2009, Sicomin Sarl, the joint venture between the Chinese consortium (68%) and State-owned producer La Générale des Carrières et des Mines (Gécamines) (32%), reportedly completed a feasibility study on developing the deposits (table 8) (Reuters Ltd., 2009a).

S.A. Groupe George Forrest signed various agreements with Korea Water Resources Corp., Alfonso Rowemberg Korea Ltd., and Korea Resources Corp. Under the agreements, the companies were to rehabilitate existing energy infrastructure, to build new dams, water systems, and hydroelectric installations, and to examine opportunities for investments, acquisitions, or joint business in the mining industry. Congo (Kinshasa) reportedly was to provide access to mineral resources including 430,000 t/yr of copper, 21,500 t/yr of cobalt, and 2,000 t/yr of uranium (George Forrest International S.A., 2009; Park, 2009).

Gécamines produced 415 t of refined cobalt, compared with an estimated 300 t produced in 2008 (Cobalt Development Institute, 2010a).

Katanga Mining Ltd.'s production of cobalt cathode increased to 2,534 t from 749 t in 2008 as the company ramped up operations at its Luilu refinery. The refinery processed concentrates produced from ore extracted from Katanga's Kamoto underground mine and T17 open pit. By yearend, Katanga had begun commercial production from the second phase of its program to rehabilitate its operations and announced a revised accelerated development plan for phase 3, which included restarting production from the large Kamoto-East Olivera Virgule (KOV) open pit mine and increasing capacity at the Luilu refinery (table 8). Glencore had an offtake agreement for all of Katanga's copper and cobalt output (Katanga Mining Ltd., 2010, p. 2–3, 7, 20, 34–35).

Central African Mining & Exploration Company plc (CAMEC) restarted cobalt mining at Mukondo Mountain and copper refining at its Luita solvent extraction–electrowinning (SX–EW) plant. Production from Luita during the 12-month period ending March 31, 2009, included 4,631 t of cobalt in carbonate, a 61% increase from the 12-month period ending March 31, 2008. Following the fiscal yearend, Luita's monthly production of cobalt in carbonate reached 710 t. CAMEC made improvements to its Kakanda concentrator, raising the capacity to approximately 6,000 t/yr of cobalt contained in concentrates, and continued to build the Luita plant on a modular basis, reporting that it was to have a design capacity of 3,200 t/yr of cobalt cathode. CAMEC entered into a long-term agreement to sell an estimated 6,000 to 8,000 t/yr of cobalt in concentrate from Mukondo Mountain to Zhejiang Galico in China. Late in the year, however, CAMEC was acquired by Eurasian Natural Resources Corp. PLC (Central African Mining & Exploration Company plc, 2009a; 2009b, p. 9, 11, 17–18; Eurasian Natural Resources Corp. PLC, 2010, p. 2).

Gécamines and L'Enterprise Générale Malta Forrest S.P.R.L. temporarily suspended production of copper-cobalt concentrate from the Luiswishi Mine and Kipushi concentrator in late 2008 in response to low demand and prices. As a result, 2009 production from the mine was only 437 t of cobalt in concentrate (Harrison, 2008; La Générale des Carrières et des Mines, undated).

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 a cobalt-copper alloy, which was sold to OMG's Kokkola refinery. Production of cobalt contained in alloy during recent years was

as follows: 5,593 t in 2007; 5,545 t in 2008; and 4,590 t in 2009 (George Forrest International S.A., 2010).

FCX completed construction of the initial phase of the Tenke Fungurume project and began producing copper cathode. The project, between the towns of Kolwezi and Likasi, comprised open pit mining of sediment-hosted copper-cobalt ore, recovering the metals by agitation leaching, and SX-EW to produce copper cathode and cobalt hydroxide. The first phase of the project was designed to produce more than 8,000 t/yr of contained cobalt. Although the cobalt plant was commissioned in September, FCX was still addressing startup and quality issues at yearend; the company's 2009 sales included approximately 1,360 t of cobalt. Late in the year, FCX began a feasibility study on the second phase of the project, which included optimizing the current plant and potentially expanding its capacity by approximately 50%. Lundin Mining Corp. and Gécamines had minority interests in Tenke Fungurume (Freeport-McMoRan Copper & Gold Inc., 2010a, p. 2, 21–22, 91; 2010b, p. 36).

ROQ Mining Sprl mined copper-cobalt ores from the Goma 1 and Goma 2 open pit deposits southwest of Kolwezi. In 2009, the company expected to produce about 1,000 t of cobalt in concentrate, which would be processed offsite to cobalt hydroxide or aliage blanc prior to export (Levy, 2009, p. 9–11).

Chemaf SPRL mined copper-cobalt oxide ores from the Etoile open pit mine and produced approximately 3,000 t of cobalt contained in carbonate at its nearby Lubumbashi plant (Metal Bulletin, 2010).

Metorex Ltd.'s Ruashi operation north of Lubumbashi comprised mining copper-cobalt oxides ores from open pits and milling and processing the ore in the newly commissioned Ruashi phase 2 SX-EW refinery. In 2009, the plant produced 2,198 t of cobalt in carbonate, which was sold to Jinchuan under an offtake agreement. Gécamines had a 25% interest in the Ruashi operation (Metorex Ltd., 2009a, p. 12–13; 2009b; 2010).

**Cuba.**—The 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 2009, the mixed sulfides contained a record 37,328 t of nickel and cobalt, 6% more than the 35,119 t produced in 2008. The increase in production was mainly attributed to operating the Moa plant for a full year following an expansion that was completed during 2008. Most activity related to further expansion of the plant remained under suspension during the year (table 8) (Sherritt International Corp., 2010, p. 8, 10).

The Ernesto Che Guevara and Rene Ramos Latour Mining and Metallurgical Combines also mined nickel-cobalt laterites and produced mixed nickel-cobalt sulfides 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 7% lower than that of 2008. The company's Kokkola Chemicals Oy refinery processed raw materials sourced primarily from Congo (Kinshasa), Finland, and Russia. Most of the feed

was cobalt-copper alloy from the Big Hill smelter in Congo (Kinshasa) and crude cobalt hydroxide and crude cobalt sulfate from Norilsk's nickel operations in Russia. OMG also refined cobalt solution from Norilsk's Harjavalta nickel refinery in Finland and materials from other sources, such as ores and concentrates, sulfides, metallic feeds, and secondary materials (scrap) (OM Group, Inc., 2010, p. 5, 29).

Talvivaara Mining Co. Plc worked to ramp up and to optimize production from its polymetallic sulfide mine and bioheap-leaching operation in Sotkamo in central Finland. During the year, the company produced commercial quantities of nickel; production of commercial quantities of cobalt and copper was expected to begin in 2011. Talvivaara announced that it planned to increase the operation's production capacity (table 8). The nickel-cobalt sulfide product from Talvivaara was committed to Norilsk for processing at Harjavalta under a 10-year offtake agreement (Talvivaara Mining Co. Plc, 2010, p. 23, 86).

Belvedere Resources Ltd.'s Hitura and Sarkiniemi nickel-copper sulfide mines remained on care-and-maintenance status throughout the year. Finn Nickel Ltd. (Belvedere's nickel production subsidiary) filed for bankruptcy at midyear, after which Belvedere sold some of Finn Nickel's assets—the Luikonlahti Mill and the Hautalampi and Valkeisenranta nickel properties—to Vulcan Resources Ltd. (Belvedere Resources Ltd., 2009, p. 1, 3).

**France.**—The Eramet Group's production of cobalt chloride from its refinery at Sandouville was 18% more than that produced in 2008. Feed for the refinery was nickel matte imported from Eramet subsidiary Le Nickel SLN's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2010a).

**India.**—According to an estimate by the Cobalt Development Institute (2010a), India's cobalt production increased by 17% from that of 2008. Nicomet Industries Ltd. and Rubamin Ltd. were India's leading cobalt producers.

**Indonesia.**—PT International Nickel Indonesia Tbk (PT Inco) produced nickel matte from lateritic ores at its integrated mining and smelting operation near Sorowako on Sulawesi Island. Cobalt contained in matte deliveries decreased to 891 t from 981 t in 2008. PT Inco sold its entire matte production to Vale Inco (80%) and Sumitomo Metal Mining Co., Ltd. (20%) under long-term contracts (PT International Nickel Indonesia Tbk, 2010, p. 111, 113).

PT Antam Tbk exported lateritic nickel-cobalt ore to Queensland Nickel's Yabulu refinery for processing (CRU International Ltd., 2010, p. 4).

**Japan.**—Sumitomo's production of electrolytic cobalt at its Niihama nickel refinery increased by 24% from that of 2008. 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 (CRU International Ltd., 2010, p. 4; Cobalt Development Institute, 2010a).

Japan Oil, Gas and Metals National Corp. (JOGMEC) reportedly held tenders to purchase 130 t of cobalt metal for its national rare-metals stockpile; results of the tenders were not released (Ryan's Notes, 2009).

**Korea, Republic of.**—The Korean Government reportedly planned to secure a strategic stockpile of various metals, including 84 t of cobalt (Metal-Pages, 2009b).

**Morocco.**—Cie. de Tifnout Tighanimine (CTT) produced cobalt hydroxide at its processing plant at Bouazzer, and cobalt cathode and oxide at its Guemassa hydrometallurgical refinery north of Marrakech. CTT's cobalt production was from domestic cobalt-arsenic deposits and heterogenite imported from Congo (Kinshasa).

**New Caledonia.**—Lateritic nickel-cobalt ore was exported to Queensland Nickel's Yabulu refinery for processing. Nickel matte from Le Nickel SLN's Doniambo 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 6% less than that of 2008. 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, and copper-cobalt white alloy purchased from Glencore. The decrease in refined cobalt production was similar in amount to the decrease in cobalt contained in matte produced from Xstrata Nickel's Sudbury operations, which was attributed to lower volumes of cobalt-rich third-party feed. Glencore is the sole distributor of Xstrata's cobalt (Xstrata plc, 2010a, p. 19, 29, 80–81, 203; 2010b).

**Philippines.**—Coral Bay Nickel (a joint venture between Sumitomo, Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp.) began production from a second high-pressure acid-leaching plant at the Rio Tuba nickel laterite mine on Palawan Island. The combined capacity of the two plants was an estimated 1,500 t/yr of cobalt in nickel-cobalt mixed sulfide. All the mixed sulfide produced by Coral Bay Nickel was refined by Sumitomo in Japan (Metal Bulletin Daily, 2009b).

Toledo Mining Corp. plc exported lateritic nickel-cobalt ore from its Berong Mine to Queensland Nickel's Yabulu refinery for processing (CRU International Ltd., 2010, p. 4).

**Russia.**—Norilsk, Russia's leading producer of cobalt, conducted nickel-copper sulfide mining and refining on the Taimyr and Kola Peninsulas. Cobalt from ores mined on the Taimyr Peninsula was refined to metal at the company's nickel plant at Norilsk. According to the Cobalt Development Institute (2010a), Norilsk produced 2,352 t of refined cobalt, 6% less than the 2,502 t produced in 2008. Cobalt from ores mined on the Kola Peninsula was extracted as an intermediate product at the company's nickel plant in Monchegorsk and sent to OMG's operations in Finland under a 5-year supply agreement that began in 2007. Under this agreement, Norilsk was to supply OMG with up to 2,500 t/yr cobalt metal, up to 2,500 t/yr of cobalt contained in cobalt hydroxide concentrate, and up to 1,500 t/yr of cobalt contained in cobalt sulfate solution. Norilsk continued to study the feasibility of producing electrolytic cobalt at Monchegorsk (OJSC MMC Norilsk Nickel, 2010, p. 61).

**South Africa.**—Cobalt was produced as a byproduct from some of South Africa's PGM mines and from the Nkomati nickel sulfide mine. Nkomati (a joint venture of African Rainbow Minerals Ltd. and Norilsk) produced 333 t of cobalt in 2009, compared with 296 t in 2008. During the year, the

joint-venture partners completed the first phase of an expansion project (table 8) (African Rainbow Minerals Ltd., 2009, p. 35; 2010, p. 60–61).

Two companies produced refined cobalt as a byproduct of platinum refining. Rustenburg Base Metals Refiners (Proprietary) Ltd. (a subsidiary of Anglo American plc) produced cobalt sulfate at its refinery near Rustenburg, Northwest Province. The company was increasing the nickel capacity of its base-metals refinery to 33,000 t/yr from 21,500 t/yr; an equivalent increase in cobalt capacity was expected (table 8). 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.

**Spain.**—Lundin Mining Corp.'s Aguablanca open pit nickel sulfide mine and processing plant in Badajoz Province produced nickel-copper concentrate containing an estimated 200 t of cobalt, which it sold to Glencore under a long-term sales agreement (Lundin Mining Corp., 2010).

**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 2013. The company reportedly was negotiating to acquire tailings from the nearby Kilembe Mine, so that the refinery could continue operating (Metal Bulletin, 2009b).

**Zambia.**—Mopani Copper Mines Plc produced approximately 1,300 t of cobalt metal at its Nkana cobalt refinery, 7% less than the 1,400 t produced in 2008. Most of the cobalt originated from the company's Nkana underground copper-cobalt mine (First Quantum Minerals Ltd., 2010, p. 4).

Chambishi Metals plc produced 235 t of cobalt metal at its Chambishi refinery, a significant decrease from the 2,591 t produced in 2008. Production from the refinery was suspended in late 2008 in response to low cobalt and copper prices. The operation remained on care-and-maintenance status until early November, when it reportedly began toll-refining material imported from the Tenke Fungurume project in Congo (Kinshasa). Chambishi Metals planned to process feed from multiple sources in Congo (Kinshasa) and Zambia and would not resume processing slag from the stockpile at Nkana until the price of cobalt increased to \$22 per pound (Platts Metals Week, 2009; Reuters Ltd., 2009b; Cobalt Development Institute, 2010a).

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga and Konkola operations. The company's main source of cobalt was its Nchanga open pit. Cobalt in concentrate was processed to an alloy with a design specification of 63% copper, 23.6% iron, and 6.3% cobalt at the company's Nchanga copper smelter. KCM planned to expand the cobalt capacity of the smelter (table 8) (Metal Bulletin, 2009c; Vedanta Resources plc, 2009, p. 17).

China Nonferrous Metal Mining (Group) Co. Ltd. (CNMC) purchased the Baluba copper-cobalt mine and the Muliashi copper-cobalt project from Luanshya Copper Mines plc (a unit of Enya Holdings BV of Amsterdam, Netherlands). At yearend, NFC Africa Mining plc (85% CNMC and 15%

ZCCM Investments Holdings Plc.) restarted production at the Baluba Mine. The mine, which had been placed on care-and-maintenance status in late 2008 in response to low copper prices, reportedly had the capacity to produce 4,000 t/yr of cobalt (Metal-Pages, 2009a).

Metorex produced 39 t of cobalt in cobalt carbonate at its Sable copper electrowinning plant near Kabwe, compared with 388 t produced in 2008. The decrease in production was because Metorex discontinued its Ruashi phase I operation in Congo (Kinshasa) in December 2008 and ceased shipments of copper-cobalt concentrates to Sable. The Sable plant continued to process copper-cobalt concentrates from third party suppliers (Metorex Ltd., 2009a, p. 5, 13; 2009b; 2010).

In early 2009, Albidon Ltd. ceased production at its Munali nickel mine in southern Zambia, placed the concentrator on care-and-maintenance status, and went into voluntary administration. Jinchuan, Albidon's major shareholder, restructured and recapitalized the company, and by yearend underground mining operations had resumed at Munali. Nickel-copper-cobalt-PGM sulfide concentrate from Munali is committed to Jinchuan under a life-of-mine offtake agreement (Albidon Ltd., 2010).

Chambishi Copper Smelter Ltd. (a joint venture between China Nonferrous Metal Mining Group Co. Ltd. (CNMC) and Yunnan Copper Industry Group Co. Ltd.) began production at its newly constructed smelter at CNMC's Chambishi Mine. The smelter had the capacity to produce 150,000 t/yr of copper and 2,800 t/yr of cobalt. Equinox Minerals Ltd. had a 5-year offtake agreement with Chambishi Copper Smelter to process copper concentrates from its newly opened Lumwana Mine. Equinox also sent Lumwana concentrates to KCM's Nchanga smelter for processing (Interfax China Ltd., 2008; Equinox Minerals Ltd., 2010, p. 14).

**Zimbabwe.**—In late 2008, Bindura Nickel Corp. placed its Shangani and Trojan nickel sulfide mines on care-and-maintenance status in response to the decrease in nickel prices and difficult economic conditions in Zimbabwe. The company operated the nickel smelter and refinery until all concentrate stocks were depleted in March 2009, and investigated options for restarting operations. Cobalt hydroxide is one of the products from the company's refinery (Mwana Africa PLC, 2009, p. 5). Aquarius Platinum Ltd. produced 74 t of cobalt from its Mimosa platinum mine (64 t in 2008). The concentrates were refined by Impala in South Africa (Aquarius Platinum Ltd., 2009, p. 15; 2010, p. 12).

## Outlook

The global economic downturn that began in late 2008 resulted in reduced demand for cobalt in 2008 and 2009, affecting all major end-use sectors. As global economic conditions showed signs of recovery in 2009 and into 2010, demand for cobalt improved (Collignon, 2010, p. 8–11).

During the first half of 2010, the world availability of refined cobalt (as measured by production and U.S. Government shipments) was 49% higher than that of the first half of 2009. China showed the largest increase in production; production from Congo (Kinshasa), Japan, and Zambia also increased significantly. 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 takes place, it could lead to a downward trend in prices (Cobalt Development Institute, 2010b).

The LME's cobalt contract was launched in February 2010. As the year progressed, the number of producers' cobalt brands approved for listing on the exchange increased and the LME added Antwerp, Belgium, as a fourth delivery point. The LME cash price for cobalt generally followed the same trend as Metal Bulletin's spot price for 99.3% cobalt. Some companies began to use the LME price as a reference for their purchases or sales.

## References Cited

- African Rainbow Minerals Ltd., 2009, Annual report 2009: Sandton, South Africa, African Rainbow Minerals Ltd., October 7, 220 p.
- African Rainbow Minerals Ltd., 2010, Interim results for the six months ended 31 December 2009: Sandton, South Africa, African Rainbow Minerals Ltd., February 22, 80 p.
- Albidon Ltd., 2010, Quarterly activities report for the period ended 31 December 2009: West Perth, Australia, Albidon Ltd., February 3, 11 p.
- Aquarius Platinum Ltd., 2009, Second quarter 2009 production results (to 31 December 2008): Hamilton, Bermuda, Aquarius Platinum Ltd., January 28, 31 p.
- Aquarius Platinum Ltd., 2010, Second quarter 2010—Production results to 31 December 2009: Hamilton, Bermuda, Aquarius Platinum Ltd., January 28, 28 p.
- Beijing Antaika Information Development Co., Ltd., 2009, Overview of China's foreign trade policy on cobalt: China Metal Market—Precious & Minor Metals Monthly, no. 107, February, p. 1–2.
- Belvedere Resources Ltd., 2009, Management's discussion & analysis for the quarter ended September 30, 2009: Vancouver, British Columbia, Canada, Belvedere Resources Ltd., November 27, 13 p.
- BHP Billiton, 2009a, Cobalt Open Sales System: Melbourne, Australia, BHP Billiton Internet sale platform. (Accessed January 22, 2009, at <http://cobalt.bhpbilliton.com/default.asp>.)
- BHP Billiton, 2009b, Sale of Yabulu nickel refinery, Queensland, Australia: Melbourne, Australia, BHP Billiton news release, July 3, 1 p.
- Central African Mining & Exploration Company plc, 2009a, Long-term cobalt sales agreement with Zhejiang Galico: London, United Kingdom, Central African Mining & Exploration Company plc press release, July 6, 3 p.
- Central African Mining & Exploration Company plc, 2009b, Report and financial statements—Year ended 31 March: London, United Kingdom, Central African Mining & Exploration Company plc, September 24, 130 p.
- Cobalt Development Institute, 2010a, 2009 production statistics: Cobalt News, no. 2, April, p. 3–4.
- Cobalt Development Institute, 2010b, 2010 first half production statistics: Cobalt News, no. 4, October, p. 3–4.
- Collignon, Maartje, 2010, The outlook for cobalt: The Cobalt Conference, Cobalt Development Institute, Cape Town, South Africa, September 28–29, 2010, Presentation, 29 p.
- CRU International Ltd., 2010, CRU monitor—Nickel cobalt intermediates: London, United Kingdom, CRU International Ltd., August, 14 p.
- Equinox Minerals Ltd., 2010, Annual report 2009: Toronto, Ontario, Canada, Equinox Minerals Ltd., March 10, 84 p.
- Eurasian Natural Resources Corp. PLC, 2010, Production report for the fourth quarter ended 31 December 2009: London, United Kingdom, Eurasian Natural Resources Corp. PLC press release, February 3, 14 p.
- First Nickel Inc., 2010, Management's discussion and analysis for the year ended December 31, 2009: Toronto, Ontario, Canada, First Nickel Inc., March 24, 35 p.
- First Quantum Minerals Ltd., 2010, Annual information form—As at December 31, 2009: Vancouver, British Columbia, Canada, First Quantum Minerals Ltd., March 31, 85 p.
- FNX Mining Company Inc., 2010, Annual information form for the year ended December 31, 2009: Toronto, Ontario, Canada, FNX Mining Company Inc., March 30, 40 p.
- Formation Metals Inc., 2010, Management's discussion and analysis for the third quarter ending November 30, 2009: Vancouver, British Columbia, Canada, Formation Metals Inc., January 14, 20 p.

Fox Resources Ltd., 2010, Quarterly activities report for the period ended 31 December 2009: East Perth, Australia, Fox Resources Ltd., January 21, 13 p.

Freeport-McMoRan Copper & Gold Inc., 2010a, Form 10-K—2009: Securities and Exchange Commission, 184 p.

Freeport-McMoRan Copper & Gold Inc., 2010b, Form 10-Q—For the quarterly period ended March 31, 2010: Securities and Exchange Commission, 52 p.

George Forrest International S.A., 2009, New investments: Lubumbashi, Congo (Kinshasa), George Forrest International S.A. press release, March 3, 2 p.

George Forrest International S.A., 2010, Side walls relining: Lubumbashi, Congo (Kinshasa), George Forrest International S.A. press release, February 11, 1 p.

Harrison, Alex, 2008, DRC cobalt producer CMSK to stop operations on low prices: London, United Kingdom, Metal Bulletin, no. 9078, December 22, p. 12.

Interfax China Ltd., 2008, CNMC's Zambian subsidiary ransacked by striking workers: China Mining & Metals Weekly, v. 7, issue 9, March 1–7, p. 21.

Katanga Mining Ltd., 2010, Management's discussion and analysis December 31, 2009: London, United Kingdom, Katanga Mining Ltd., 47 p.

Kennecott Eagle Minerals Co., 2010, Kennecott Eagle Minerals Company welcomes Humboldt Mill permits: Ishpeming, MI, Kennecott Eagle Minerals Co. news release, February 9, 2 p.

La Générale des Carrières et des Mines, [undated], Production: Kinshasa, Congo (Kinshasa), La Générale des Carrières et des Mines. (Accessed June 3, 2010, at <http://www.gecamines.cd/production.php>.)

Levy, Isaac, 2009, ROQ Mining, its operations in the Katanga Province of the DRC and current events related to cobalt production in the region: The Cobalt Conference, Cobalt Development Institute, Lisbon, Portugal, May 13–14, 2009, Presentation, 16 p.

Li, Xiaodong, 2007, The status and perspective of China cobalt processing industry: The Cobalt Conference, Cobalt Development Institute, Shanghai, China, May 9–10, 2007, Presentation, 8 p.

Liberty Mines Inc., 2010a, Consolidated financial statements—Liberty Mines Inc.—Years ended December 31, 2009 and 2008: Edmonton, Alberta, Canada, Liberty Mines Inc., March 18, 29 p.

Liberty Mines Inc., 2010b, Management's discussion and analysis for the twelve months ended December 31, 2009: Edmonton, Alberta, Canada, Liberty Mines Inc., March 18, 17 p.

London Metal Exchange Ltd., The, 2010, LME minor metals—Molybdenum & cobalt futures: London, United Kingdom, The London Metal Exchange Ltd. (Accessed March 1, 2010, at [http://www.lme.com/downloads/LME\\_Minor\\_Metals\\_brochure\\_web\\_160210.pdf](http://www.lme.com/downloads/LME_Minor_Metals_brochure_web_160210.pdf).)

Lundin Mining Corp., 2010, Quarterly operations update—Aguablanca—Fourth quarter December 31, 2009. (Accessed March 19, 2010, at <http://www.lundinmining.com/s/QOU.asp?ReportID=388442>.)

Metal Bulletin, 2007, Comment—Cobalt's new conduit: Metal Bulletin, no. 9011, September 3, p. 5.

Metal Bulletin, 2009a, DRC lifts ban on concentrate exports to neighboring Zambia: Metal Bulletin, no. 9086, February 23, p. 5.

Metal Bulletin, 2009b, Kasese will not sell cobalt metal in 2010: Metal Bulletin, no. 9126, November 30, p. 11.

Metal Bulletin, 2009c, Konkola set to produce 30,000 tpy of cobalt-copper alloy: Metal Bulletin, no. 9100, June 1, p. 9.

Metal Bulletin, 2010, Chemaf will boost Cu, Co output: Metal Bulletin, no. 9154, June 21, p. 6.

Metal Bulletin Daily, 2009a, Lower Jinchuan buying leaves Metorex and Chemaf with more Co concs to sell: Metal Bulletin Daily, no. 9099.5, May 22, p. 1.

Metal Bulletin Daily, 2009b, SMM's second Coral Bay nickel plant hits capacity: Metal Bulletin Daily, no. 9101.1, June 1, p. 3.

Metal-Pages, 2009a, Luanshya Copper Mines restarts production at Baluba: Metal-Pages, December 16. (Accessed June 14, 2010, via <http://www.metal-pages.com/news/>.)

Metal-Pages, 2009b, South Korea boosts metals stockpiling plan in 2009: Metal-Pages, June 26. (Accessed June 29, 2009, via <http://www.metal-pages.com/news/>.)

Metorex Ltd., 2009a, Annual report 2009: Johannesburg, South Africa, Metorex Ltd., 119 p.

Metorex Ltd., 2009b, Quarterly operational and general update: Johannesburg, South Africa, Metorex Ltd., October 14, 3 p.

Metorex Ltd., 2010, Consolidated unaudited interim results for the period ended 31 December 2009: Johannesburg, South Africa, Metorex Ltd., March 2, 12 p.

Minara Resources Ltd., 2010, 2009 annual report: Perth, Australia, Minara Resources Ltd., 92 p.

Mirabela Nickel Ltd., 2010, Quarterly activity report for the period ended 31 December 2009: Perth, Australia, Mirabela Nickel Ltd., January 29, 9 p.

Mwana Africa PLC, 2009, Annual report 2009: London, United Kingdom, Mwana Africa PLC, 80 p.

n.v. Umicore, s.a., 2009, Umicore invests in recycling of rechargeable batteries: Brussels, Belgium, n.v. Umicore, s.a. press release, November 16, 2 p.

n.v. Umicore, s.a., 2010, 2009 report to shareholders and society: Brussels, Belgium, n.v. Umicore, s.a., 147 p.

OJSC MMC Norilsk Nickel, 2009, Norilsk Nickel International will suspend its Black Swan and Lake Johnston nickel operations: Moscow, Russia, OJSC MMC Norilsk Nickel news release, February 16, 1 p.

OJSC MMC Norilsk Nickel, 2010, Annual report 2009: Moscow, Russia, OJSC MMC Norilsk Nickel, 255 p.

OM Group, Inc., 2010, Form 10-K—2009: Securities and Exchange Commission, 106 p.

OZ Minerals Ltd., 2009, Quarterly report for the three months ending 30 June 2009: Southbank, Australia, OZ Minerals Ltd., July 21, 7 p.

Panoramic Resources Ltd., 2009, Quarterly report for the period ending 30 June 2009: Perth, Australia, Panoramic Resources Ltd., July 27, 12 p.

Panoramic Resources Ltd., 2010, Quarterly report for the period ending 31 December 2009: Perth, Australia, Panoramic Resources Ltd., January 29, 13 p.

Park, Sungwoo, 2009, South Korea will join \$750 million Congolese deal: Bloomberg News, March 4. (Accessed June 18, 2010, at [http://africanewsanalysis.blogspot.com/2009\\_03\\_01\\_archive.html](http://africanewsanalysis.blogspot.com/2009_03_01_archive.html).)

Platts Metals Week, 2009, Chambishi not producing own metal: Platts Metals Week, v. 80, no. 48, November 30, p. 9.

PolyMet Mining Corp., 2009, PolyMet Mining—Advancing toward production—Copper, nickel & precious metals in the U.S.: Vancouver, British Columbia, Canada, PolyMet Mining Corp. investor presentation, December, 39 p.

PT International Nickel Indonesia Tbk, 2010, 2009 annual report: Jakarta, Indonesia, PT International Nickel Indonesia Tbk, 256 p.

Reuters Ltd., 2009a, Chinese companies sign \$6 billion Congo deal: New York, NY, Reuters Ltd. news release, October 8. (Accessed June 14, 2010, at <http://www.reuters.com/article/idUSL8309410>.)

Reuters Ltd., 2009b, Cobalt price delays full output at Zambia plant: Lusaka, Zambia, Reuters Ltd. news release, November 25. (Accessed November 27, 2009, at <http://www.reuters.com/article/idUSGEE5A00G020091125>.)

Rio Tinto, 2010, 2009 annual report: London, United Kingdom, Rio Tinto plc, 237 p.

Ryan's Notes, 2009, Japan Oil, Gas and Metals Corp.: Ryan's Notes, v. 15, no. 31, August 3, p. 6.

Sherritt International Corp., 2010, 2009 annual information form: Toronto, Ontario, Canada, Sherritt International Corp., 103 p.

Talvivaara Mining Co. Plc, 2010, Annual report 2009: Espoo, Finland, Talvivaara Mining Company Plc, 134 p.

Tascarella, Patty, 2009, Chemical producer gets new life from New Castle company: Pittsburgh, PA, Pittsburgh Business Times, September 18. (Accessed October 22, 2009, at <http://pittsburgh.bizjournals.com/pittsburgh/stories/2009/09/21/story3.html>.)

Tollinsky, Norm, 2008, Xstrata boosts recycling capacity: Sudbury Mining Solutions Journal, v. 5, no. 2, June 1, p. 1, 36.

URSA Major Minerals Inc., 2009, URSA Major Minerals to send 10,000 tonnes of Shakespeare nickel copper ore for processing, Sudbury, Ontario: Toronto, Ontario, Canada, URSA Major Minerals Inc. press release, April 2, 1 p.

U.S. Department of Defense, 2010, Strategic and critical materials operations report to the Congress—Operations under the Strategic and Critical Materials Stock Piling Act during the period October 2008 through September 2009: Washington, DC, U.S. Department of Defense, 70 p.

Vale S.A., 2010, Form 20-F for the fiscal year ended December 31, 2009: Securities and Exchange Commission, 153 p.

Vedanta Resources plc, 2009, Annual report 2009: London, United Kingdom, Vedanta Resources plc, May 6, 128 p.

Wallop, Clementine, 2009, BHP withdraws from Co spot market as Nikkelverk deal ends: Metal Bulletin, no. 9113, August 31, p. 7.

Witten, Scott, 2009, Umicore to close Maxton salt plant: The Laurinburg Exchange, May 20. (Accessed May 21, 2009, via <http://www.laurinburgexchange.com>.)

Xstrata Nickel, 2008, [untitled]: 12th International Battery Materials Recycling Seminar & Exhibit, Fort Lauderdale, FL, March 17–19, 2008, Presentation, 24 p.

Xstrata plc, 2010a, Annual report 2009: Zug, Switzerland, Xstrata plc, March 2, 228 p.

Xstrata plc, 2010b, Production report for 12 months ended 31 December 2009: Zug, Switzerland, Xstrata plc press release, February 1, 11 p.

Xu, Aidong, 2010, China cobalt market review: The Cobalt Conference, Cobalt Development Institute, Cape Town, South Africa, September 28–29, 2010, Presentation, 25 p.

Yang, Chongzhen, 2009, Cobalt in China—A producer's perspective: Ryan's Notes Conference, Ryan's Notes, Scottsdale, AZ, October 25–27, Presentation, 13 p.

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

Cobalt. Ch. in *Metal Prices in the United States Through 1998*, 1999.

Cobalt. Ch. in *Mineral Commodity Summaries*, annual.

Cobalt. Ch. in *United States Mineral Resources*, Professional Paper 820, 1973.

Cobalt. *International Strategic Minerals Inventory Summary Report*, Circular 930–F, 1987.

Cobalt. *Mineral Industry Surveys*, monthly.

Cobalt Recycling in the United States in 1998. Ch. in *Flow Studies for Recycling Metal Commodities in the United States*, Circular 1196–A–M, 2004.

*Historical Statistics for Mineral and Material Commodities in the United States*. Data Series 140.

### Other

Cobalt. Ch. in *Mineral Facts and Problems*, U.S. Bureau of Mines Bulletin 675, 1985.

Cobalt Development Institute.

Company reports and media releases.

DATAWEB. U.S. International Trade Commission.

Defense National Stockpile Center, Defense Logistics Agency.

Federal Register, daily.

Materials Flow of Cobalt in the United States, The. U.S. Bureau of Mines Information Circular 9350, 1993.

Metal Bulletin, weekly.

Platts Metals Week, weekly.

Precious & Minor Metals. Beijing Antaike Information Development Co., Ltd., monthly.

Roskill Information Services Ltd.

Ryan's Notes, weekly.

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

(Metric tons, cobalt content, unless otherwise specified)

	2005	2006	2007	2008	2009
<b>United States:</b>					
<b>Consumption:</b>					
Reported	9,150	9,280	9,320	8,810	7,460
Apparent	11,800	11,000	9,630	10,100	7,520
Imports for consumption	11,100	11,600	10,300	10,700	7,680
Exports	2,440	2,850	3,100	2,850	2,440
<b>Stocks, December 31:</b>					
Industry <sup>2</sup>	705	737	620	582	587
U.S. Government <sup>3</sup>	1,550	1,290	676	473	293
Price, metal <sup>4</sup> dollars per pound	15.96	17.22	30.55	39.01	17.86
<b>World, production:</b>					
Mine	65,200 <sup>r</sup>	68,900 <sup>r</sup>	71,500 <sup>r</sup>	76,300 <sup>r</sup>	72,300 <sup>e</sup>
Refinery	54,100	53,800	53,300	57,200 <sup>r</sup>	59,800

<sup>e</sup>Estimated. <sup>r</sup>Revised.

<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 National Stockpile Center. Data for 2005–06 include material committed for sale pending shipment; data for 2007–09 are uncommitted material only.

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

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

(Metric tons, cobalt content)

	2008	2009
<b>Sales:</b>		
Fiscal year <sup>2</sup>	481	187
Calendar year	203	169
<b>Shipments:<sup>3</sup></b>		
Fiscal year <sup>2</sup>	493	192
Calendar year	203	180

<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.

Source: Defense National Stockpile Center.

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

(Metric tons, cobalt content)

	2008	2009
<b>Consumption by end use:</b>		
Steels	604	510
Superalloys	4,320	3,680
<b>Alloys, excludes steels and superalloys:</b>		
Magnetic alloys	368	295
Other alloys <sup>3</sup>	226	221
Cemented carbides <sup>4</sup>	827	503
Chemical and ceramic uses	2,410	2,190
Miscellaneous and unspecified	63	63
<b>Total</b>	<b>8,810</b>	<b>7,460</b>
<b>Consumption by form:</b>		
Chemical compounds, organic and inorganic <sup>5</sup>	2,250	2,130
Metal	4,640	3,540
Purchased scrap	1,930	1,790
<b>Total</b>	<b>8,810</b>	<b>7,460</b>
<b>Stocks, December 31:<sup>6</sup></b>		
Chemical compounds, organic and inorganic <sup>5</sup>	203	171
Metal	307	347
Purchased scrap	72	68
<b>Total</b>	<b>582</b>	<b>587</b>

<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>

	2008			2009		
	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>	8,430	8,430	\$618,000	5,870	5,870	\$198,000
Oxides and hydroxides	1,110	800	63,400	1,460	1,050	37,500
Other forms:						
Acetates	439	105	3,140	168	40	1,220
Carbonates	1,100	508	31,800	972	447	18,000
Chlorides	177	44	1,280	231	58	2,220
Sulfates	2,990	806	13,700	760	205	5,900
Grand total	14,200	10,700	732,000	9,470	7,680	262,000

<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)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)
2008:															
Argentina	--	--	--	--	--	--	134	34	\$538	134	34	\$538	134	34	\$538
Australia	757	757	\$60,200	--	--	--	--	--	--	757	757	--	757	757	60,200
Belgium	353	353	21,800	518	373	\$28,100	69	22	1,350	939	748	1,350	939	748	51,300
Brazil	110	110	8,540	--	--	--	219	61	1,270	329	171	1,270	329	171	9,810
Canada	1,360	1,360	89,100	21	15	1,100	--	--	--	1,380	1,370	--	1,380	1,370	90,100
China	1,240	1,240	86,900	252	181	13,800	226	78	5,090	1,710	1,490	5,090	1,710	1,490	106,000
Congo (Kinshasa)	28	28	1,140	--	--	--	--	--	--	28	28	--	28	28	1,140
Finland	441	441	34,300	178	128	11,000	2,760	879	27,400	3,380	1,450	27,400	3,380	1,450	72,600
France	27	27	2,830	(6)	(6)	7	1	(6)	6	28	28	6	28	28	2,840
Germany	13	13	1,040	12	9	1,230	--	--	--	25	21	--	25	21	2,270
India	21	21	1,220	--	--	--	719	194	2,760	740	215	2,760	740	215	3,980
Japan	143	143	12,300	2	1	106	--	--	--	145	144	--	145	144	12,400
Korea, Republic of	12	12	295	--	--	--	9	4	256	21	16	--	21	16	552
Morocco	444	444	33,100	--	--	--	--	--	--	444	444	--	444	444	33,100
Norway	1,400	1,400	115,000	--	--	--	--	--	--	1,400	1,400	--	1,400	1,400	115,000
Russia	1,390	1,390	93,900	--	--	--	--	--	--	1,390	1,390	--	1,390	1,390	93,900
South Africa	178	178	17,000	1	1	60	--	--	--	179	178	--	179	178	17,000
Uganda	20	20	1,980	--	--	--	--	--	--	20	20	--	20	20	1,980
United Kingdom	32	32	1,780	119	86	7,480	541	184	10,900	692	302	10,900	692	302	20,200
Zambia	456	456	35,200	--	--	--	--	--	--	456	456	--	456	456	35,200
Other	8	8	480	8	6	416	28	8	361	44	22	361	44	22	1,260
Total	8,430	8,430	618,000	1,110	800	63,400	4,710	1,460	49,900	14,200	10,700	49,900	14,200	10,700	732,000
2009:															
Australia	380	380	11,600	--	--	--	--	--	--	380	380	--	380	380	11,600
Belgium	99	99	4,560	531	382	16,100	69	24	850	699	505	850	699	505	21,500
Brazil	172	172	5,280	--	--	--	7	2	60	179	173	60	179	173	5,340
Canada	246	246	7,820	471	339	8,140	2	(6)	5	719	586	5	719	586	16,000
China	1,360	1,360	47,800	128	92	3,590	433	150	5,570	1,920	1,600	5,570	1,920	1,600	57,000
Congo (Kinshasa)	101	101	3,170	--	--	--	--	--	--	101	101	--	101	101	3,170
Finland	175	175	7,340	151	108	4,020	1,180	438	16,200	1,510	721	16,200	1,510	721	27,600
France	18	18	968	--	--	--	1	(6)	23	19	18	23	19	18	992
Germany	14	14	1,010	4	3	336	--	--	--	18	16	--	18	16	1,340
Hong Kong	--	--	--	14	10	335	--	--	--	14	10	--	14	10	335
India	2	2	47	--	--	--	206	56	1,620	208	58	1,620	208	58	1,670

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)	Value <sup>5</sup> (thousands)	Gross weight (metric tons)	Cobalt content <sup>4</sup> (metric tons)	Value <sup>5</sup> (thousands)
2009—Continued:											
Japan	273	273	3	2	\$176	45	12	\$374	321	287	\$11,300
Morocco	247	247	--	--	--	--	--	--	247	247	7,550
Norway	1,650	1,650	--	--	--	--	--	--	1,650	1,650	52,300
Russia	851	851	--	--	--	--	--	--	851	851	28,500
South Africa	26	26	1	1	29	--	--	--	27	26	876
Taiwan	5	5	--	--	--	40	9	91	44	14	190
Uganda	30	30	--	--	--	--	--	--	30	30	968
United Kingdom	42	42	149	108	4,580	140	54	2,360	331	204	8,440
Zambia	183	183	--	--	--	--	--	--	183	183	5,080
Other	7	7	9	6	226	8	4	173	24	17	730
Total	5,870	5,870	1,460	1,050	37,500	2,130	751	27,300	9,470	7,680	262,000

-- 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 2009, 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	11	\$431	4	\$128	--	--	--	--	14	\$559
Australia	3	146	(6)	7	9	\$34	--	--	6	186
Austria	12	400	--	--	--	--	--	--	12	400
Belgium	146	3,830	53	1,280	100	1,930	--	--	208	7,050
Brazil	1	55	3	103	308	1,690	--	--	77	1,840
Canada	51	2,310	50	1,140	30	317	1	\$12	95	3,780
China	152	4,230	(6)	9	18	191	--	--	157	4,430
France	502	16,100	--	--	--	--	1	26	502	16,100
Germany	179	9,180	(6)	8	--	--	2	37	180	9,230
Hong Kong	3	226	(6)	3	28	12	--	--	9	241
India	9	501	--	--	--	--	--	--	9	501
Ireland	598	19,300	(6)	4	--	--	--	--	598	19,300
Italy	9	510	--	--	--	--	--	--	9	510
Japan	228	13,100	16	526	(6)	6	--	--	239	13,600
Korea, Republic of	33	1,230	(6)	3	11	244	5	72	37	1,550
Malaysia	7	116	--	--	--	--	--	--	7	116
Mexico	4	242	76	2,120	123	3,150	(6)	7	89	5,520
Oman	--	--	--	--	20	630	--	--	5	630
Singapore	13	841	2	5	--	--	--	--	14	845
Switzerland	6	285	--	--	--	--	--	--	6	285
Taiwan	18	360	(6)	4	1	10	--	--	18	374
Tunisia	20	810	--	--	--	--	--	--	20	810
United Kingdom	91	1,970	8	69	--	--	--	--	97	2,040
Venezuela	9	295	2	71	--	--	--	--	11	366
Other	12	834	10	71	--	--	1	9	20	914
Total	2,120	77,300	225	5,550	648	8,210	10	163	2,440	91,200

-- 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, 2009<sup>1,2</sup>

(Metric tons, cobalt content)

Country	Capacity
Australia <sup>e</sup>	6,200
Belgium	1,500
Brazil	1,420
Canada <sup>e</sup>	6,200
China <sup>e</sup>	35,600
Congo (Kinshasa) <sup>e</sup>	10,000
Finland	10,000
France	500
India <sup>e</sup>	2,060
Japan <sup>e</sup>	1,800
Morocco <sup>e</sup>	1,750
Norway	5,200
Russia <sup>e</sup>	6,000
South Africa <sup>e</sup>	800
Uganda	720
Zambia	8,200
Total	98,000

<sup>e</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 2014<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
2009 <sup>5</sup>	Australia	Heap-leach expansion Minara Resources Ltd. and Glencore International AG	expansion of demonstration plant	nickel	stockpiled nickel- cobalt laterite ore reject material	750 <sup>e,6</sup>	Nickel-cobalt solution.
2009 <sup>5</sup>	Canada	Fort Saskatchewan expansion Sherritt International Corp.	expansion of existing refinery	do.	nickel-cobalt sulfide	4,600 <sup>e,6</sup>	Cobalt metal powder and briquettes.
2009 <sup>5</sup>	Cuba	Moa Joint Venture Expansion, phase 2 Moa Nickel S.A. (Sherritt International Corp. and General Nickel Co. S.A.)	expansion of existing plant	do.	nickel-cobalt laterite ore	4,300 <sup>e,6</sup>	Nickel-cobalt sulfide.
2009 <sup>5,7</sup>	Vietnam	Ban Phuc Asian Mineral Resources Ltd. and Son La Mechanical Engineering Joint Stock Company	new mine and beneficiation plant	do.	nickel sulfide ore	170	Nickel concentrate.
2010 <sup>f</sup>	Australia	Browns Oxide HNC (Australia) Resources Pty. Ltd.	new mine and relocated and refurbished refinery	copper	copper-cobalt-nickel oxide ore	1,000	Cobalt-nickel carbonate.
2010	do.	Radio Hill Fox Resources Ltd.	new heap-leaching operation	nickel	nickel-copper sulfide ore	NA	Nickel-cobalt carbonate or hydroxide.
2010	China	Nickel-cobalt refinery Jiangxi Rare Earth and Rare Metals Tungsten Group Co. Ltd. and Ipilan joint venture	new refinery	do.	nickel-cobalt hydroxide	600	NA.
2010	do.	Plant expansion Zhejiang Huayou Cobalt Co.	addition of cobalt tetroxide facility	cobalt	cobalt concentrates	8,000 <sup>r,6</sup>	Cobalt salts.
2010 <sup>5</sup>	Congo (Kinshasa)	Kalukundi H & J Swanepoel Famille Trust sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and refinery	copper	copper-cobalt oxide ore	4,200 <sup>r</sup>	Cobalt cathode.
2010	do.	Kipoi, stage I Congo Minerals sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and beneficiation plant	do.	do.	NA	Stockpiled cobalt ore or cobalt concentrate for sale.
2010	do.	Likasi plant Rubamin Ltd.	expansion of existing smelter	do.	copper-cobalt ore	2,000 <sup>6</sup>	Alliage blanc.
2010 <sup>f</sup>	do.	Luita SX-EW line Eurasian Natural Resources Corp. PLC	addition to existing plant	cobalt	cobalt in solution	3,200 <sup>8</sup>	Cobalt cathode.
2010 <sup>f</sup>	New Caledonia	Vale Inco Nouvelle-Calédonie <sup>9</sup> Vale Inco, Sumic Nickel Netherlands b.v. (Sumitomo Metal Mining Co., Ltd. and Mitsui & Co., Ltd.), and Société de Participation Minière du Sud Calédonien S.A.S.	new mine and HPAL processing plant	nickel	nickel-cobalt laterite ore	4,600 to 5,500	Cobalt carbonate.

See footnotes at end of table.

TABLE 8—Continued  
 COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014<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
2010	Papua New Guinea	Ramu China Metallurgical Construction Group Corp., Jinchuan Group Ltd., Jilin Jien Nickel Industry Co. Ltd., Jiuquan Iron & Steel Group Co. Ltd., Highlands Pacific Ltd., Mineral Resources Development Co.	new mine, beneficiation plant, and HPAL processing plant	nickel	nickel-cobalt laterite ore	3,300	Nickel-cobalt hydroxide.
2010	South Africa	Nkomati Large Scale Expansion African Rainbow Minerals Ltd. and OJSC MMC Norilsk Nickel	expansion of existing mine and beneficiation plant	do.	nickel-copper-cobalt-platinum-group metals sulfide and chromite ores	550 <sup>e,6</sup>	Nickel concentrate.
2011	Australia	Barnes Hill Proto Resources & Investments Ltd. and Metals Finance Ltd.	new mine and ATML processing plant	do.	nickel-cobalt laterite ore	400 <sup>e</sup>	Nickel-cobalt intermediate.
2011 <sup>5</sup>	do.	Mutooroo Havilah Resources NL	new mine, beneficiation plant, and refinery <sup>10</sup>	copper	copper-cobalt sulfide ore	1,200	Cobalt hydroxide. <sup>10</sup>
2011 <sup>5</sup>	do.	Niwest GME Resources Ltd.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	1,400	Nickel-cobalt sulfide.
2011 <sup>f</sup>	Canada	Lockerby Depth First Nickel Inc.	expansion of existing mine	do.	nickel-copper-cobalt sulfide ore	80 <sup>6</sup>	Nickel-copper-cobalt sulfide ore.
2011 <sup>e</sup>	do.	Makwa Mustang Minerals Corp.	new mine and beneficiation plant	do.	nickel-copper-platinum-group metals sulfide ore	150 <sup>e</sup>	Nickel concentrate.
2011 <sup>5</sup>	do.	Raglan Mine Xstrata Nickel	expansion of existing mine, stage I	do.	nickel-copper-cobalt-platinum-group metals sulfide ore	NA	Do.
2011 <sup>r,11</sup>	Congo (Kinshasa)	Kolwezi tailings First Quantum Minerals Ltd., La Générale des Carrières et des Mines (Gécamines), Industrial Development Corp., International Finance Corp., and Government of Congo (Kinshasa)	new refinery	copper	copper-cobalt tailings	5,800	Cobalt hydroxide.
2011 <sup>f</sup>	do.	Luilu Metallurgical Plant, accelerated development plan, new phase 3 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	refurbishment and expansion of existing beneficiation plant and refinery	do.	copper-cobalt oxide and sulfide concentrates	8,000 <sup>r,6</sup>	Cobalt cathode.
2011	Madagascar	Ambatovy Joint Venture Sherritt International Corp., Sumitomo Corp., Korea Resources Corp., SNC-Lavalin Group Inc.	new mine, HPAL processing plant, and refinery	nickel	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 2014<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
2011	Philippines	Coral Bay enhancement Coral Bay Nickel Corp. (Sumitomo Metal Mining Co., Ltd., Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp.)	increase capacity of existing operation	nickel	nickel-cobalt laterite ore	1,600 <sup>e,6</sup>	Nickel-cobalt sulfide.
2011 <sup>f</sup>	South Africa	Base Metals Refinery Anglo Platinum Ltd.	expansion of existing refinery	do.	nickel-cobalt-platinum-group metals converter matte	825 <sup>e,6</sup>	Cobalt sulfate.
2011 <sup>f</sup>	United States (Idaho)	Idaho Cobalt Formation Metals Inc. (formerly Formation Capital Corp.)	new mine and refinery	cobalt	stratiform cobalt-copper-gold ore	1,625	Cobalt cathode.
2011	United States (Minnesota)	NorthMet PolyMet Mining Corp.	do.	copper	copper-nickel-platinum-group metals sulfide ore	360	Bulk or separate nickel and copper concentrates initially, followed by nickel-cobalt hydroxide.
2011 <sup>f</sup>	Zambia	Muliashi China Nonferrous Metal Mining (Group) Co., Ltd.	new mine and processing plant	do.	copper-cobalt oxide ores	1,500	Cobalt hydroxide.
2011	do.	New Nchanga smelter Konkola Copper Mines Plc	expansion of production from existing smelter	do.	copper-cobalt concentrates	3,000 <sup>6</sup>	Alliage rouge.
2012	Australia	Cloncurry Copper Exco Resources Ltd.	new mine and beneficiation plant	do.	copper-gold-cobalt sulfide ore	NA	Copper concentrate.
2012 <sup>5</sup>	do.	Gladstone Nickel, stage I Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	6,000 <sup>r</sup>	Cobalt metal.
2012	do.	Mount Gunson MG 14 deposit Gunson Resources Ltd.	new mine and beneficiation plant	copper	copper-cobalt-silver sulfide ore	215	Copper-cobalt concentrate.
2012 <sup>f</sup>	do.	Rocklands Group Copper CuDeco Ltd.	do.	do.	copper-cobalt-gold oxide and sulfide ore	NA	Cobaltic-pyrite concentrate.
2012	Canada	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished beneficiation plant, and refinery	gold	gold-cobalt-bismuth-copper ore	1,800 <sup>12</sup>	Cobalt cathode.
2012 <sup>f</sup>	Congo (Kinshasa)	SX-EW plant for cobalt Chemaf SPRL	addition to existing refinery	copper	copper-cobalt ore	6,000 <sup>6</sup>	Do.
2012 <sup>f</sup>	Finland	Kevitsa First Quantum Minerals Ltd.	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum-group metals-gold sulfide ore	400 <sup>r,e,12</sup>	Nickel-cobalt-platinum-group metals concentrate.
2012 <sup>f</sup>	do.	Outokumpu copper (formerly Kylylahti) Vulcan Resources Ltd.	new mine and refurbished beneficiation plant	copper	copper-zinc-cobalt-nickel-gold sulfide ore	1,200 <sup>r,e,12</sup>	Nickel-cobalt concentrate.

See footnotes at end of table.

TABLE 8—Continued  
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014<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>	Finland	Talvivaara Talvivaara Mining Co. Ltd.	expansion of existing operation	nickel	nickel-zinc-copper-cobalt sulfide ore	1,800 <sup>6</sup>	Nickel-cobalt sulfide.
2012 <sup>f</sup>	Turkey	Caldag European Nickel PLC and Jiangxi Rare Earth and Rare Metals Tungsten Group Co. Ltd.	mine and heap-leaching operation	do.	nickel-cobalt laterite ore	1,000 <sup>r</sup>	Nickel-cobalt hydroxide.
2013 <sup>5</sup>	Australia	Wingellina Nickel Metals X Ltd.	new mine and HPAL processing plant	do.	do.	3,500 <sup>r,12</sup>	Do.
2013 <sup>f</sup>	Cameroon	Nkamouna Geovic Ltd. and Société National d'Investissement du Cameroun	new mine and processing plant	cobalt	do.	4,400 <sup>12</sup>	Cobalt-nickel intermediate.
2013 <sup>r,c</sup>	Canada	Nunavik Nickel Canadian Royalties Inc.	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum-group metals sulfide ore	425 <sup>12</sup>	Nickel concentrate.
2013	do.	Voisey's Bay Long-Harbour commercial nickel processing plant Vale Inco	new refinery	do.	nickel-copper-cobalt sulfide concentrate	2,500	Cobalt cathode.
2013 <sup>f</sup>	Congo (Kinshasa)	Luita Eurasian Natural Resources Corp. PLC	expansion of existing plant	copper	copper-cobalt ore	12,000 <sup>6</sup>	Cobalt carbonate.
2013	do.	WOL/SX/EW refinery, new phase 4 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	new beneficiation plant and SX-EW refinery	do.	copper-cobalt oxide and sulfide ore	12,000	Cobalt hydroxide.
2013 <sup>r,c</sup>	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	do.	copper-cobalt-zinc-manganese oxide and sulfide ores	2,400 <sup>r</sup>	Cobalt cathode.
2013	Philippines	Mindoro Nickel Intex Resources ASA	new mine, ATML and HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	3,300 <sup>r</sup>	Cobalt sulfate.
2013 <sup>f</sup>	do.	Taganito Sumitomo Metal Mining Co., Ltd. and Taganito Mining Corp. (Nickel Asia Corp. subsidiary)	new HPAL processing plant	do.	do.	2,600 <sup>r</sup>	Nickel-cobalt sulfide.
2013 <sup>f</sup>	United States (Michigan)	Eagle Kennecott Eagle Minerals Co.	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	nickel-copper sulfide ore	400 <sup>c</sup>	Copper-nickel concentrate.

See footnotes at end of table.

TABLE 8—Continued  
 COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014<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	Canada	Minago Victory Nickel Inc.	new mine and beneficiation plant	nickel	nickel-copper- cobalt-platinum- group metals- precious metals sulfide ore	230 <sup>e,12</sup>	Nickel concentrate.
2014	Congo (Kinshasa)	Kipoi, stage 2 Congo Minerals sprl and La Générale des Carrières et des Mines (Gécamines),	addition of leaching and SX-EW to existing operation	copper	copper-cobalt oxide ore	800	NA
2014 <sup>r,e</sup>	do.	NA La Sino-Congolaise des Mines Sarl (Sicomines) joint venture <sup>13</sup>	new mine(s)	do.	copper-cobalt ore	19,000	NA
2014	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, mixed oxide/sulfide, and sulfide ores	16,000 <sup>6</sup>	Cobalt hydroxide.
2014 <sup>f</sup>	Indonesia	Weda Bay Eramet S.A., Mitsubishi Corp., and PT Antam Tbk	new mine and ATML processing plant	nickel	nickel-cobalt laterite ore	5,000 <sup>r</sup>	Cobalt sulfide.
2014 <sup>f</sup>	Philippines	Acoje Rusina Mining NL, European Nickel PLC, and DMCI Mining Corp.	new mine and heap- leaching operation	do.	do.	930 <sup>12</sup>	Nickel-cobalt hydroxide.

<sup>e</sup>Estimated. <sup>r</sup>Revised. 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 2009. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2014, but not enough information was available to include them.

<sup>3</sup>SX-EW solvent extraction—electrowinning.

<sup>4</sup>ATML Atmospheric leach. HPAL High pressure acid leach. WOL Whole ore leach.

<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>Project remained on care-and-maintenance status as of June 15, 2010.

<sup>8</sup>SX-EW line will not increase total plant capacity.

<sup>9</sup>On December 19, 2008, Goro was renamed Vale Inco Nouvelle-Calédonie.

<sup>10</sup>Project scope under evaluation, may process ore or cobalt sulfide tailings offshore.

<sup>11</sup>Construction suspended in September 2009 following cancellation of exploitation permit; First Quantum has commenced international arbitration on the matter.

<sup>12</sup>Average production.

<sup>13</sup>The Sicomines joint venture comprises the following Chinese and Congolese companies, listed in order of share ownership: China Railway Construction Corp. Ltd., La Générale des Carrières et des Mines (Gécamines), China Metallurgical Group Corp., Sinohydro Corp., and La Société Immobilière du Congo (Congo Simco).

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

(Metric tons, cobalt content)

Country <sup>3</sup>	2005	2006	2007	2008	2009 <sup>e</sup>
Australia <sup>4</sup>	4,590 <sup>r</sup>	5,130 <sup>r</sup>	4,730 <sup>r</sup>	4,780 <sup>r</sup>	4,630 <sup>5</sup>
Botswana <sup>6</sup>	326	303	242	337	335
Brazil <sup>e</sup>	1,400	1,100	1,311 <sup>r,5</sup>	1,215 <sup>r,5</sup>	1,200
Canada <sup>7</sup>	5,767	7,115	8,692	8,953 <sup>r</sup>	4,072 <sup>p,5</sup>
China <sup>e</sup>	2,100	1,840	6,100	6,630 <sup>r</sup>	6,000
Congo (Kinshasa) <sup>e,8</sup>	24,500	27,100	25,400 <sup>r</sup>	32,300 <sup>r</sup>	35,500
Cuba <sup>9</sup>	4,798	5,602	4,540	3,175	3,500
Finland <sup>e</sup>	100	100	115	105 <sup>5</sup>	27
Indonesia <sup>10</sup>	1,600	1,600	1,600	1,300	1,200
Morocco <sup>e,11</sup>	1,600	1,500	1,600	1,700	1,600
New Caledonia <sup>12</sup>	1,769	1,629	1,620	869 <sup>r</sup>	1,000
Philippines <sup>e</sup>	300	900	1,000	1,200 <sup>r</sup>	1,500
Russia <sup>e,11</sup>	6,300	6,300	6,300	6,200	6,100
South Africa <sup>e</sup>	620	600	600	590	610
Zambia <sup>e,13</sup>	9,300	8,000	7,500	6,900	5,000
Zimbabwe <sup>e,14</sup>	100	110	100	85	74 <sup>5</sup>
Total	65,200 <sup>r</sup>	68,900 <sup>r</sup>	71,500 <sup>r</sup>	76,300 <sup>r</sup>	72,300

<sup>e</sup>Estimated. <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 June 11, 2010. 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, Poland, Spain, and Turkey are known to produce ores that contain cobalt, but information is inadequate to make reliable estimates of production. 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 produced from lateritic and sulfide ores by the Western Australian nickel industry as reported by the State government. Quantities of cobalt contained in intermediate or refined metallurgical products produced from Australian and imported ores, in metric tons, was estimated to be as follows: 2005—4,900; 2006–07—5,500; 2008—5,100; and 2009—5,500.

<sup>5</sup>Reported figure.

<sup>6</sup>Reported cobalt content of pelletized nickel-copper matte.

<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 nickel-cobalt content of sulfide and 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 content of limonitic nickel laterite ores mined. Quantities of cobalt contained in intermediate or refined metallurgical products (cobalt chloride and cobalt oxide hydroxide) produced from New Caledonian ores exported to Australia and France, in metric tons, was estimated to be as follows: 2005–06—1,200; 2007—1,400; 2008—1,200; and 2009—1,500.

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

<sup>14</sup>Estimated cobalt content of intermediate products produced in Zimbabwe from nickel and platinum ores mined in Zimbabwe.

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

(Metric tons, cobalt content)

Country <sup>3</sup>	2005	2006	2007	2008	2009
Australia, metal powder and oxide hydroxide <sup>e</sup>	3,150	3,700	3,680	3,620	4,050
Belgium, metal powder, oxide, hydroxide <sup>4</sup>	3,298	2,840	2,825	3,020	2,150
Brazil, metal	1,136	902	1,148	994	1,012
Canada, metal, metal powder, oxide	5,090	5,198	5,620	5,637 <sup>r</sup>	4,918 <sup>p</sup>
China, metal, metal powder, oxide, salts <sup>e,5</sup>	12,700	12,700	13,200	18,200	23,100
Congo (Kinshasa), metal <sup>6</sup>	600	550	606	1,049 <sup>r</sup>	2,950
Finland, metal powder and salts <sup>7</sup>	8,171	8,582	9,173	9,645	8,962
France, chloride	280	256	305	311	368
India, metal and salts	1,220	1,184	980	858	1,001
Japan, metal	471	920	1,084	1,071	1,332
Morocco, metal and oxide	1,613	1,405	1,591	1,711	1,600
Norway, metal	5,021	4,927	3,939	3,719	3,510
Russia, unspecified <sup>e,8</sup>	5,000	5,000	3,800	2,500	2,352
South Africa, metal powder and sulfate	268	267	307	244	238
Uganda, metal	638	674	698	663	673
Zambia, metal	5,422	4,665	4,335	3,991	1,535
Total	54,100	53,800	53,300	57,200 <sup>r</sup>	59,800

<sup>e</sup>Estimated. <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 June 11, 2010. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

<sup>3</sup>In addition to the countries listed, Germany and Poland may produce some cobalt, but information is inadequate to make reliable estimates of production.

<sup>4</sup>Production reported by n.v. Umicore s.a.; includes production from China and South Africa that is not otherwise included in this table.

<sup>5</sup>Production from domestic and imported ores and concentrates; excludes production by n.v. Umicore s.a. that is included under Belgium.

<sup>6</sup>Excludes production of cobalt in white alloy, matte, and slag that would require further refining.

<sup>7</sup>Production for 2005–08 reported by the Geological Survey of Finland; production for 2009 reported by OM Group Inc.

<sup>8</sup>Production reportedly includes metal, oxide, and salts; other forms may also have been produced.