



2008 Minerals Yearbook

COBALT [ADVANCE RELEASE]

COBALT

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In 2008, world production of refined cobalt increased, primarily as a result of a significant increase in production from China. The United States did not mine or refine cobalt in 2008. 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 and World Bureau of Metal Statistics (2009, p. 3–4), world apparent consumption of cobalt was nearly 60,700 metric tons (t), about 1,200 t more than that of 2007. The increase was primarily in Asia, as apparent consumption in Europe declined in 2008, and apparent consumption in North America was roughly equal to that of 2007. The U.S. spot price for cobalt peaked at more than \$50 per pound in March but dropped below \$13 per pound in December.

Salient U.S. and world cobalt statistics for 2008 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 paints, varnishes, and inks; 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 2008 (October 1, 2007, through September 30, 2008), the DNSC sold 481 t of cobalt metal valued at \$35.5 million under a basic ordering agreement (BOA) (table 2). This represented 30% of the 1,590-metric-ton (3.5-million-pound) maximum allowed for sale under the fiscal year 2008 Annual Materials Plan (AMP). At the end of the fiscal year, 61 t of cobalt had been sold but not shipped from the stockpile. The AMP for fiscal year 2009 (October 1, 2008, through September 30, 2009) reduced the maximum allowable sale of cobalt to 1,360 t (3 million pounds) (U.S. Department of Defense, 2009, p. 5, 7, 9, and 58–59).

During calendar year 2008, the DNSC sold 203 t of cobalt valued at \$14.8 million under the BOA. On December 31, the total uncommitted cobalt inventory held by the DNSC was 473 t of cobalt cathode.

Production

With the exception of negligible amounts of byproduct cobalt produced from lead and platinum-group metal (PGM) operations, the United States did not mine or refine cobalt in 2008. Cobalt-bearing nickel sulfate produced from Stillwater Mining Co.'s PGM mining and refining operations in southeastern Montana was sold to several companies. Some of southeastern Missouri's lead ores contained minor amounts of cobalt.

In 2008, there were three U.S. mine projects in the permitting stage of development that planned to produce cobalt—Formation Capital Corp.'s Idaho cobalt project, Kennecott Minerals Co.'s Eagle project in Michigan, and PolyMet Mining Corp.'s NorthMet project in Minnesota.

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 refinery near Kellogg, ID, to refine the cobalt concentrates. The project was expected to produce more than 1,500 metric tons per year (t/yr) of cobalt as high-grade cathode suitable for critical superalloy applications. At yearend, Formation was in the final permitting stage and had purchased some of the mining and milling equipment for the project. Once sufficient financing and bonding were in place, Formation planned to commence construction, which was expected to take 12 to 14 months (Formation Capital Corp., 2009, p. 3–6).

Kennecott's project comprised a small underground nickel-copper mine in the Eagle deposit in the Yellow Dog Plains area northwest of Marquette, MI, and a rehabilitated mill in Humboldt Township, MI, to 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. In early 2009, Kennecott's parent company announced that development of the project would be deferred until market conditions recovered (Kennecott Eagle Minerals Co., 2008; Peppin, 2008; Rio Tinto plc, 2009, p. 10).

Polymet worked with State and Federal regulatory agencies on the preparation of the draft environmental impact statement for its NorthMet project. The project entailed open pit mining of the NorthMet polymetallic deposit in the Duluth Complex of northeastern Minnesota. A bulk concentrate produced at the nearby Erie mill and concentrator would be processed in a new hydrometallurgical plant using the company's PlatSol technology. Products would include copper cathode, a nickel-cobalt mixed hydroxide, and a precipitate of PGMs and gold. During the year, PolyMet updated its definitive feasibility study to include the sale of either a bulk concentrate or separate

copper and nickel concentrates during the construction and commissioning of the hydrometallurgical plant (table 8). The company formed a strategic partnership with Swiss trading firm Glencore International AG, whereby Glencore would invest up to \$50 million in Polymet and purchase all of the operation's concentrates, intermediate products, or metal for a minimum of 5 years (PolyMet Mining Corp., 2009, p. 11–12, 21–22).

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

Osram Sylvania Inc. (Danvers, MA) sold its tungsten processing business unit to Plansee Group of Reutte, Austria. As a result of the sale, the business unit became a new company named Global Tungsten & Powders Corp. This company's plant in Towanda, PA, produced extra-fine cobalt metal powder as a byproduct of tungsten recovered from cemented carbide scrap (Global Tungsten & Powders Corp., undated).

Carolmet Cobalt Products (a division of n.v. Umicore, s.a.) produced cobalt salts at its Maxton plant near Laurinburg, NC. The plant has not produced extra-fine cobalt metal powder since late 2006 (n.v. Umicore, s.a., 2006, p. 4–5; Witten, 2009).

Consumption

U.S. apparent consumption for 2008, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 5% higher than that of 2007 (table 1). The increase was primarily because net imports in 2008 were significantly higher than those of 2007. Underreported stock buildups could result in an apparent consumption that was higher than true consumption.

U.S. reported consumption of cobalt in 2008 was 5% lower than that of 2007. Metallurgical industries consumed approximately the same amount of cobalt in 2008 as they did in 2007; cobalt consumption for chemical uses was significantly 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 28% higher than that of 2007 (table 1). The price was highest in mid-March at \$52.00 to \$54.00 per pound, decreased to \$24.75 to \$25.75 per pound in mid-August, rebounded to \$37.00 to \$38.80 per pound in late September, dropped to an annual low

of \$12.50 to \$14.00 per pound in early December, and then increased to \$17.00 to \$19.00 per pound at yearend.

Trends in Platts' prices for Zambian cobalt (minimum 99.6% cobalt) and Russian cobalt (minimum 99.3% cobalt) were similar to those for U.S. spot cathode. The annual average of weekly prices for Zambian cobalt was \$37.76 per pound, and the annual average of weekly prices for Russian cobalt was \$36.79. Sales prices for 99.8% cobalt cathode reported by BHP Billiton ranged from \$13.00 to \$52.25 per pound.

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. The investors could take physical delivery of the cobalt if they chose, but would not be required to do so (Metal Bulletin, 2007).

The London Metal Exchange announced a plan to launch a cobalt futures contract during the second half of 2009. Under the proposed contract, cobalt would trade in 1-metric-ton lots (four 250 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. Prices determined in the ring could be used by industry as a reference price (The London Metal Exchange Ltd., undated a, b).

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 2008, net import reliance as a percentage of apparent consumption was 81%. Because there was no measurable U.S. primary cobalt production in 2008, this indicates that 81% of U.S. cobalt supply was from imports and stock releases of primary cobalt and 19% was from domestic or imported scrap.

In 2008, the United States imported 4% more cobalt than it did in 2007 (tables 4, 5). Ten countries supplied more than 90% of U.S. imports. China was the leading supplier, followed by Finland, Norway, Russia, Canada, Australia, Belgium, Zambia, Morocco, and the United Kingdom.

The United States imported 115 t, gross weight, of unwrought cobalt alloys valued at \$6.3 million. Three countries supplied most of these materials—the United Kingdom (74%), Morocco (17%), and Finland (6%). The United States imported 1,110 t, gross weight, of cobalt waste and scrap valued at \$22.7 million. Seven countries supplied most of this material—the United Kingdom (38%), Ireland (16%), Germany (13%), Japan (8%), Canada (6%), and France and Tunisia (4% each). The United States also imported 345 t, gross weight, of wrought cobalt and cobalt articles valued at \$30.4 million. The leading suppliers of these materials were the United Kingdom (52%), Germany

(11%), Canada, Japan, and Kazakhstan (7% each), France (6%), and India (5%).

U.S. exports of unwrought cobalt and cobalt contained in chemicals decreased by 8% compared with those of 2007. As listed in table 6, the leading destinations for these exports were Ireland, France, Belgium, Japan, and Canada. The United States also exported 1,370 t, gross weight, of wrought metal and cobalt articles valued at \$104 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), which were processed primarily to recover cobalt.

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

The following review by country focuses on operations in production during 2008. Expansions to those operations and greenfield projects that were forecast to begin producing between 2009 and 2013 are listed in table 8. During the year and into early 2009, development of many of these projects was postponed because of the downturn in the global economy that began in the second half of 2008.

Australia.—BHP Billiton produced 1,600 t of refined cobalt as cobalt oxide hydroxide, an 11% decrease from 1,800 t produced in 2007. The company's Yabulu nickel-cobalt refinery in Townsville, Queensland, processed lateritic ore imported from Indonesia, New Caledonia, and the Philippines, and nickel-cobalt mixed hydroxide from its Ravensthorpe operation in Western Australia. In early 2009, BHP Billiton announced that it planned to suspend operations at Ravensthorpe and stop processing the mixed hydroxide at Yabulu (BHP Billiton, 2008, p. 11; 2009, p. 11).

BHP Billiton's Nickel West operations in Western Australia processed two types of ore—nickel sulfide and nickel laterite. 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). Nickel West's laterite operation was the Ravensthorpe Mine and enhanced pressure acid leaching plant.

The Murrin Murrin Nickel Cobalt Joint Venture (60% Minara Resources Ltd. and 40% Glencore) produced 2,018 t of cobalt as metal powder and briquettes from its nickel-cobalt laterite mining and pressure-acid leaching operation near Leonora, Western Australia. This was 7% more than the 1,884 t produced in 2007. Production in 2008 was impacted by electrical control system failures, an interruption in gas supply, and a planned maintenance shutdown. Minara's demonstration plant for recovering nickel and cobalt by heap-leaching stockpiled

ore-reject material achieved design capacity and provided a second feed source to the Murrin Murrin refinery at a rate of 1,782 t of nickel and 112 t of cobalt (Minara Resources Ltd., 2009, p. 5–6, and 19).

During the fourth quarter, OJSC MMC Norilsk Nickel placed the following Western Australian nickel operations on indefinite care-and-maintenance status: the Cawse nickel laterite mine and processing plant, the Silver Swan underground nickel sulfide mine, and the Waterloo underground nickel sulfide mine. Prior to the suspension, intermediate nickel-cobalt carbonate produced by Cawse was processed at Norilsk's Harjavalta, Finland, refinery; concentrates from Silver Swan were converted to matte at Boliden AB's smelter in Harjavalta, which subsequently was sent to Norilsk's Harjavalta refinery; and ores from Waterloo were beneficiated at BHP Billiton's Nickel West operations. Although at yearend Norilsk's other Western Australian operations—the Black Swan and Lake Johnston nickel sulfide mines and mills—were still in operation, they were placed on care-and-maintenance status in early 2009 (OJSC MMC Norilsk Nickel, 2009a, p. 69; 2009b; [undated]).

Sally Malay Mining Ltd. changed its name to Panoramic Resources Ltd. and the name of its underground nickel-copper sulfide mine operation in Western Australia to Savannah. The company produced concentrates containing 408 t of cobalt from Savannah (413 t in 2007), which were shipped to Jinchuan Group Ltd.'s operations in China under a life-of-mine sales agreement. Panoramic and its joint-venture partner Thundelarra Exploration Ltd. began open pit mining at the nearby Copernicus nickel-copper sulfide deposit. Late in the year the joint venture decided to suspend operations at Copernicus and place the mine on care-and-maintenance status in response to low nickel prices (Panoramic Resources Ltd., 2008, 2009).

Zinifex Ltd. acquired Allegiance Mining NL and then merged with Oxiana Ltd. to become OZ Minerals Ltd. The Avebury nickel sulfide mine in Tasmania was commissioned and began shipping nickel concentrate to Jinchuan under an offtake agreement. At yearend, the mine was placed on care-and-maintenance status in response to low nickel prices. OZ Minerals shipped zinc concentrates produced at its Century Mine in northern Queensland to Nyrstar NV's Budel smelter in the Netherlands, where cobalt was recovered as filter cake (OZ Minerals Ltd., 2009, p. 4; Nyrstar NV, undated).

Fox Resources Ltd. temporarily suspended operations at its underground Radio Hill nickel-copper sulfide mine near Karratha, Western Australia, by the end of July, and placed the mine and mill on care-and-maintenance status. Bulk nickel-copper concentrates from Radio Hill were sold to Jinchuan (Fox Resources Ltd., 2009).

Xstrata Nickel acquired Jubilee Mines NL and renamed the operation Xstrata Nickel Australasia (XNA). XNA produced 120 t of cobalt in nickel sulfide concentrates from the Cosmos and Sinclair operations in Western Australia during the 11 months ending December 31, 2008 (Xstrata plc, 2009a, p. 66; 2009b).

Belgium.—According to the Cobalt Development Institute (2009a), Umicore's 2008 cobalt refinery production increased to 3,020 t from 2,825 t produced in 2007. 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. This production took place at plants in Olen, Belgium, and Ganzhou, China. In addition, Umicore produced specialty cobalt products at processing plants in Arab, AL, and Laurinburg, NC, in the United States; Bruges, Belgium; Guarulhos, Brazil; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. During the year, Umicore announced plans to expand the capacities of its cobalt powder production facility in Fort Saskatchewan and its lithium-ion battery material facilities in Cheonan and Jiangmen (n.v. Umicore, s.a., 2008, p. 4).

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, 2009a, p. 33, 71).

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 from sulfide ores mined and smelted at Fortaleza de Minas, Minas Gerais State. In 2008, Votorantim signed a 5-year purchase agreement with Mirabela Nickel Ltd., for one-half of the nickel concentrate to be produced from the Santa Rita nickel sulfide mine in Bahia State; the balance of Santa Rita's production during the first 5 years was committed to Norilsk under a separate agreement (Mirabela Nickel Ltd., 2008, p. 9).

Canada.—Vale Inco Ltd. produced 2,828 t of cobalt in 2008, 12% more than the 2,524 t produced in 2007. The company reported production in the form of cathode, 1,472 t, from its Port Colborne, Ontario, refinery; cobalt hydrate, 728 t, from its Thompson, Manitoba, refinery; and cobalt contained in unrefined products such as nickel concentrates, 773 t. The cobalt originated from nickel sulfide ores from company mines at Sudbury, Ontario; Thompson; 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, 804 t (727 t in 2007); Manitoba, 168 t (179 t in 2007); Voisey's Bay, 1,695 t (1,239 t in 2007); and external sources, 161 t (379 t in 2007) (Companhia Vale do Rio Doce, 2009, p. 44).

Xstrata Nickel produced 538 t of cobalt in concentrates from mines at Sudbury (620 t in 2007), 338 t of cobalt in concentrate from its Montcalm Mine northwest of Timmins, Ontario (404 t in 2007), and 512 t of cobalt in concentrate from its Raglan Mine in Quebec (523 t in 2007). Nickel-copper matte containing 2,648 t of cobalt was produced at the company's Sudbury smelter (2,498 t in 2007); 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 mined in Sudbury by First Nickel Inc., nickel sulfide concentrates produced by Liberty Mines Inc. in Ontario, and PGM concentrates from North American Palladium Ltd.'s Lac des Iles Mine in northern 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. Some of the secondary materials were processed in Xstrata's newly commissioned calciner prior to smelting (Tollinsky, 2008; Xstrata Nickel, 2008, p. 9–11, 21; Xstrata plc, 2009b).

The Fort Saskatchewan refinery of the joint venture of Sherritt International Corp. and General Nickel Co. S.A. produced 3,428 t of cobalt as metal powder and briquettes in 2008, 4% less than the 3,573 t produced in 2007. Approximately 88% 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. Sherritt was incrementally expanding the refinery to accommodate an anticipated increase in mixed sulfide production from Moa Bay, and had increased the capacity to 3,700 t/yr of cobalt by midyear (table 8). In the fourth quarter, spending on the second and third phases of the expansion was suspended in response to market conditions. 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., 2008, p. 14; 2009a, p. 8–9, and 11).

FNX mined ore containing 75 t of cobalt (71 t in 2007) from nickel sulfide deposits in Sudbury. Liberty Mines extracted nickel sulfide ore from its Redstone Mine southeast of Timmins, Ontario, and began preproduction at the nearby McWatters Mine. Concentrates produced at the company's Redstone Mill were shipped to Xstrata Nickel in Sudbury and Jilin Jien Nickel Industry Company Ltd. in China. First Nickel mined nickel sulfide ores from its Lockerby Mine in Sudbury. URSA Major Minerals Inc. began preproduction at its Shakespeare nickel mine and mill west of Sudbury. During the fourth quarter, production at all of these operations was suspended in response to low metal prices (First Nickel Inc., 2008; Liberty Mines Inc., 2008, p. 1–4; FNX Mining Company Inc., 2009, p. 21–23, and 39; URSA Major Minerals Inc., 2009).

China.—China's production of refined cobalt was estimated to be approximately 18,000 t to 20,000 t, which made it the world's leading producer. In 2008, 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 21,429 t of cobalt contained in ores, concentrates, and semirefined materials in 2008, up from 13,945 t in 2007. China's imports of cobalt ores and concentrates and semirefined materials both increased in 2008 compared with those of 2007 (Baker, 2008, p. 6–9; Xu, 2008, p. 3–5; Taarland, 2009, p. 22–23; Xu and Yang, 2009, p. 28).

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 2007 estimated cobalt production. Jinchuan produced cobalt as cathode and other

products from its refinery at Jinchang, Gansu Province. Some of Jinchuan's cobalt production was from domestic nickel-copper-cobalt sulfide ores mined and refined at Jinchang and some was from other nickel or cobalt feeds. Jinchuan refined cobalt intermediates such as carbonates produced in China from imported cobalt concentrates; nickel-copper concentrates from Australia, GobiMin Inc.'s mines in the Hami region of northwestern China, Finland, Zambia, and elsewhere; nickel concentrates from Australia; and nickel matte from BHP Billiton and other companies (Li, 2007; Asian Metal Ltd., 2008; CRU International Ltd., 2008, p. 4).

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. The government of the Province where copper and cobalt were produced maintained a ban on the export of unprocessed cobalt ores, and temporarily banned all exports of cobalt concentrates before allowing selected companies to resume concentrate exports. As discussed in the "China" section of this report, exports of cobalt materials to China increased significantly in 2008 compared with those of 2007 (Thomson Reuters Corp., 2008; Taarland, 2009, p. 23).

The Government of Congo (Kinshasa) continued its review of more than 60 mining contracts signed between private companies and the Government or Government-owned companies. The review 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, some contract agreements had not yet been finalized (Thomson Reuters Corp., 2009).

The Government of Congo (Kinshasa) signed a 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 the following infrastructure: airports, health centers and hospitals, housing, hydroelectric dams and electricity distribution networks, roads and railways, and schools and universities. In exchange, the Chinese consortium would gain access to deposits containing a potential 10.62 million metric tons of copper and 620 thousand metric tons of cobalt. These deposits would be developed by Sicomin Sarl, a joint venture between the Chinese consortium (68%) and State-owned producer La Générale des Carrières et des Mines (Gécamines) (32%) (Ministry of Infrastructure, Public Works, and Reconstruction, 2008).

Gécamines produced an estimated 300 t of refined cobalt, less than one-half of the 606 t in 2007 (Cobalt Development Institute, 2009a).

Katanga Mining Ltd. completed a merger acquisition of Nikanor PLC. The resulting company reunited adjacent properties near Kolwezi which were previously part of the same mine complex—Katanga Mining's Kamoto/Dima mining complex (which included the large underground Kamoto

copper-cobalt mine, various open pit oxide resources, the Kamoto concentrator, and the Luilu copper and cobalt refinery) and Nikanor's assets [which included the large Kamoto-East Olivera Virgule (KOV) open pit mine, smaller Tilwezembe and Kananga open pit mines, and Kolwezi concentrator]. Ore mined from the Kamoto Mine and T17 open pit were processed at the Kamoto concentrator, and the resulting concentrates were refined at the newly refurbished Luilu refinery. In May, Katanga began cobalt metal production at Luilu, and made 749 t of cobalt cathode by yearend. Plans for increasing capacity at Luilu are listed in table 8. Ore mined from Tiwezembe was processed at the Kolwezi concentrator, which produced 36,764 t of concentrate with quarterly average cobalt grades ranging from 3.78% to 7.03%. Late in the year, Katanga suspended mining at Tilwezembe and production of cobalt concentrate at Kolwezi in response to the decline in cobalt and copper prices. Glencore had offtake agreements for Katanga's copper and cobalt output (Katanga Mining Ltd., 2009, p. 2, 12, 21, 28, 36).

Central African Mining & Exploration Company plc (CAMEC) finalized a joint-venture agreement with Prairie International Ltd. to develop and operate copper-cobalt mines at Mukondo Mountain and other concession areas in Congo (Kinshasa), and to control the Kakanda concentrator and the Luita heap-leaching and solvent extraction-electrowinning (SX-EW) operation. The joint venture was to own 70% of the following companies, with Gécamines holding the remaining 30%: Boss Mining SPRL, Savannah Mining SPRL, and Mukondo Mining SPRL. Early in the year, CAMEC restarted mining at Mukondo Mountain. By July, production from the Kakanda concentrator had reached 480 metric tons per month of cobalt in concentrates, and CAMEC forecast that 2008 production would be 5,000 t of cobalt in concentrates. The company continued to build the Luita SX-EW plant on a modular basis. By May, monthly production from Luita had reached 583 t of cobalt in carbonate. Plans for future expansions are listed in table 8. In November, CAMEC temporarily halted its copper-cobalt mining operations in response to a steep decline in cobalt demand from China and a further decrease in the copper price (Central African Mining & Exploration Company plc, 2008a–d).

Gécamines and L'Enterprise Générale Malta Forrest S.P.R.L. reportedly produced 3,500 t of cobalt in copper-cobalt concentrates from the Luiswishi Mine and Kipushi concentrator, as compared with 4,000 t in 2007. The concentrates were exported to Asia, Europe, and South Africa. Operations at the mine were temporarily suspended at yearend in response to low demand and prices (Harrison, 2008; George Forrest International S.A., undated).

Anvil Mining Ltd. produced copper-cobalt oxide concentrates from its Mutoshi stage I tailings retreatment operation near Kolwezi. This operation, which processed material from the Kulumaziba River tailings deposit, was formerly referred to as Kulu. Some of the concentrates were processed in Congo (Kinshasa) and some were exported. The operation was placed on care-and-maintenance status by yearend (Anvil Mining Ltd., 2009, p. 8, 11).

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.

Minière de Musoshi et Kinsenda S.A.R.L. (a joint venture of Copper Resources Corp., Sodimico, and Metorex Ltd.) processed copper-cobalt ore from its Kimono dumps and produced alliage blanc (an alloy of cobalt, copper, and iron) at its electric arc furnace at Musoshi. At midyear, production was approximately 12 to 15 metric tons per month of cobalt contained in alloy (Copper Resources Corp., 2008).

Chemaf SPRL mined copper-cobalt oxide ores from the Etoile open pit mine and produced cobalt carbonate at its nearby Lubumbashi plant (Shalina Resources Ltd., 2008).

Numerous additional processing plants in Katanga Province, many of which were owned by Chinese companies, produced cobalt carbonate or cobalt alloys from cobalt concentrates. By late 2008, 45 of 75 cobalt and copper plants reportedly ceased operation in response to reduced demand and metal prices (Bavier, 2008).

Metorex's Ruashi operation north of Lubumbashi comprised open pit mining and beneficiation of the ore to produce copper-cobalt concentrate, which was sent to the company's Sable Zinc refinery in Zambia for processing. During the year, Metorex commissioned a plant to process Ruashi concentrates onsite. This plant, known as Ruashi phase 2, began producing copper cathode and was expected to begin producing cobalt hydroxide in early 2009 (table 8) (Metorex Ltd., 2008a, p. 1, 10, and 21–22; 2008b).

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 2008, the mixed sulfides contained a record 35,119 t of nickel and cobalt, 4% more than the 33,661 t produced in 2007. The increase in production was mainly attributed to the completion of the first phase of an expansion project, which resulted in increasing the plant's mixed sulfide capacity by approximately 4,000 t/yr to total 37,000 t/yr (approximately 33,500 t/yr of nickel plus 3,500 t/yr of cobalt). In the fourth quarter, spending on the second and third phases of the expansion was suspended as a result of market conditions (table 8) (Sherritt International Corp., 2009a, p. 8–9, and 11; 2009b, p. 6).

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 5% higher than that of 2007. The company's Kokkola Chemicals Oy refinery processed raw materials sourced primarily from Congo (Kinshasa), Finland, and Russia. These included cobalt-copper alloy from the Big Hill smelter in Congo (Kinshasa), cobalt solution from Norilsk's Harjavalta nickel refinery in Finland, crude cobalt hydroxide and crude cobalt sulfate from Norilsk's nickel operations in Russia, and materials from other sources, such as ores and concentrates, sulfides, metallic feeds, and

secondary materials (scrap) (OM Group, Inc., 2009a, p. 6, 27, and 81).

Belvedere Resources Ltd. mined ore from its Hitura and Sarkiniemi nickel-copper sulfide mines. The company's Hitura mill produced nickel concentrate containing 105 t of cobalt, which was sent to Jinchuan for refining. At yearend, the mines were placed on care-and-maintenance status in response to low nickel prices (Belvedere Resources Ltd., 2009, p. 1, 16).

Talvivaara Mining Co. Plc began production from its new mine and bioheap-leaching operation in Sotkamo, central Finland. Nickel sulfide ore containing zinc, copper, and cobalt was mined by open pit methods, crushed and agglomerated, stacked into heaps, and then subjected to bacterial leaching to release the metals into solution. The solution was then processed to recover the metals as intermediate sulfide precipitates. Talvivaara agreed to sell its entire output of nickel-cobalt sulfide to Norilsk for processing at Harjavalta under a 10-year offtake agreement. At full capacity, the operation was expected to produce 1,200 t/yr of cobalt. Talvivaara was reevaluating its production plan and considering an increase in the operation's capacity (Talvivaara Mining Co. Plc, 2009, p. 16, 24).

France.—The Eramet Group's production of cobalt chloride from its refinery at Sandouville was slightly more than that produced in 2007. Feed for the refinery was nickel matte imported from Eramet subsidiary Le Nickel SLN's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2009a).

India.—According to an estimate by the Cobalt Development Institute (2009a), India's cobalt production decreased by 12% from that of 2007. The decrease was attributed to a shortage of raw materials, which have been mainly imported from Congo (Kinshasa) in recent years. Nicomet Industries Ltd. and Rubamin Ltd. were India's leading cobalt producers. Rubamin planned to begin producing alliage blanc from its newly constructed smelter in Likasi, Congo (Kinshasa) at midyear. The alliage blanc would be exported to its plant near Vadodara, Gujarat State, for refining (Metal Bulletin, 2008b).

Indonesia.—PT International Nickel Indonesia Tbk (PT Inco) produced nickel matte from lateritic ores at its integrated mining and smelting operation near Sorowako on the island of Sulawesi. Cobalt contained in matte deliveries during the past 3 years was as follows: 981 t in 2008, 1,198 t in 2007, and 1,153 t in 2006. 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, 2008, p. 97; 2009, p. 113–114).

Lateritic nickel-cobalt ore was exported to BHP Billiton's Yabulu refinery for processing.

Japan.—Sumitomo's production of electrolytic cobalt at its Niihama nickel refinery was nearly equal to that of 2007. 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, BHP Billiton's Nickel West operations, and elsewhere (CRU International Ltd., 2008, p. 4; Cobalt Development Institute, 2009a).

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. The company forecast that it would produce 685 t of cobalt oxide in 2009. CTT's cobalt production was from domestic cobalt-arsenic deposits and heterogenite imported from Congo (Kinshasa) (Groupe ONA, 2007, 2008).

New Caledonia.—Lateritic nickel-cobalt ore was exported to BHP Billiton'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 2007. 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 Ltd. The decrease in cathode production was attributed to the lower cobalt content of the feeds processed. Glencore International AG is the sole distributor of Xstrata's cobalt (Xstrata plc, 2009a, p. 20, 66; 2009b).

Philippines.—Coral Bay Nickel Corp. (a joint venture between Sumitomo, Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp.) produced nickel-cobalt mixed sulfides from laterite ore at its high-pressure acid-leaching plant at the Rio Tuba Mine on Palawan Island. In 2008, construction neared completion on a project to double the plant's capacity (table 8). All the mixed sulfide produced by Coral Bay Nickel was refined by Sumitomo in Japan (Platts Metals Week, 2008c).

Lateritic nickel-cobalt ore from the Philippines was exported to BHP Billiton's Yabulu refinery for processing.

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; cobalt from ores mined on the Kola Peninsula was extracted as an intermediate product at the company's nickel plant in Monchegorsk. The company reportedly was considering a plan to build cobalt refining facilities on the Kola Peninsula (Interfax Ltd., 2008).

According to the Cobalt Development Institute (2009a), Norilsk produced 2,502 t of refined cobalt, 30% less than the 3,587 t produced in 2007. The production decreased because Norilsk did not send any cobalt intermediates to OJSC Ufaleynickel in the Ural Mountains for toll refining in 2008. Instead, the intermediates were sent to OMG's operations in Finland under a 5-year supply agreement that began in 2007. Norilsk was to supply OMG with the following materials: 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 (OJSC MMC Norilsk Nickel, 2009a, p. 270).

South Africa.—Cobalt was mined 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 296 t of cobalt in 2008, compared with 207 t in 2007. During the year, the joint-venture partners worked on an expansion project (table 8) (African Rainbow Minerals Ltd., 2008, p. 31; 2009, p. 63).

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). The expansion was delayed in response to global economic conditions, however. Base metals produced in excess of refinery capacity were to be stockpiled and toll-refined. 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 (Anglo Platinum Ltd., 2009, p. 76).

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., 2009).

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 looking for another source of feedstock, so that the refinery could continue operating (Metal Bulletin, 2009).

Zambia.—Mopani Copper Mines Plc produced approximately 1,400 t of cobalt metal at its Nkana cobalt refinery, 18% less than the 1,700 t produced in 2007. Most of the cobalt originated from the company's Nkana underground copper-cobalt mine (First Quantum Minerals Ltd., 2009, p. 4).

Chambishi Metals plc produced 2,591 t of cobalt metal at its Chambishi refinery, slightly less than the 2,635 t produced in 2007. Furnace problems during April and May caused the loss of approximately 100 t of cobalt output from the refinery. Production was suspended again in December in response to low cobalt and copper prices. The refinery's main feed materials were slag from a stockpile at Nkana and concentrates from Luanshya Copper Mines Plc's Baluba copper-cobalt mine, where operations were also suspended in December (Metal Bulletin, 2008a; Platts Metals Week, 2008a; Bariyo, 2009; Cobalt Development Institute, 2009a).

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga and Konkola operations. The company announced plans to resume cobalt production from the Nchanga open pit in April. The cobalt was to be converted to alliage rouge at KCM's newly constructed Nchanga copper smelter, which began operating in October, but was shut down at yearend following a furnace fire (table 8) (Platts Metals Week, 2008b).

Metorex produced 388 t of cobalt in cobalt carbonate at its Sable copper electrowinning plant near Kabwe, similar to the 391 t produced in 2007. The Sable plant processed copper-cobalt concentrates from the company's Ruashi operation in Congo (Kinshasa) and third party suppliers. Future copper and cobalt production from Sable would be entirely from third party feedstocks once the Ruashi operation begins processing all of its concentrates in Congo (Kinshasa) (Metorex Ltd., 2008a, p. 24–25; 2009, p. 12).

Albidon Ltd. began production from its Munali nickel mine and concentrator in southern Zambia and sold its first nickel-copper-cobalt-PGM sulfide concentrate to Jinchuan under a life-of-mine offtake agreement. Albidon forecast that more than 480 t/yr of cobalt in concentrate would be produced following the ramp-up period, but in early 2009 placed the operation on care-and-maintenance status in response to low nickel prices (Albidon Ltd., 2008a, p. 11; 2008b, 2009).

Zimbabwe.—Late in the year, 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 continued economic uncertainty in Zimbabwe. The company planned to operate the nickel smelter and refinery until all concentrate stocks were depleted but was investigating the potential for restarting production using third party feedstock. Cobalt hydroxide is one of the products from the company's refinery (Mwana Africa PLC, 2008, p. 1). Aquarius Platinum Ltd. produced 64 t of cobalt from its Mimosa platinum mine, the same amount as it produced in 2007. The concentrates were refined by Impala in South Africa (Aquarius Platinum Ltd., 2008, p. 19; 2009, p. 15).

Outlook

The global economic downturn that began in late 2008 resulted in reduced demand for and supply of cobalt. During the first quarter of 2009, as a result of destocking and reduced consumption by end users, overall demand for cobalt was reported to be down approximately 20% to 25% as compared with that of the first quarter of 2008. Demand during the second quarter of 2009 improved slightly, and was reported to be 15% to 20% lower than demand during the same quarter in 2008 (OM Group, Inc., 2009b, p. 4; 2009c, p. 4).

During the first half of 2009, the world availability of refined cobalt (as measured by production and U.S. Government shipments) was 13% lower than that of the first half of 2008. The decrease was primarily because of a decline in production from China and the closure of Zambia's Chambishi refinery in late 2008. During the second half of 2009, a labor strike at Vale Inco's operations in Canada resulted in reduced production of refined cobalt from that country. Beginning in late 2008, production of cobalt-bearing concentrates and intermediates was affected by cutbacks at numerous nickel operations and at some copper-cobalt operations in Congo (Kinshasa). Financing, construction, and startup of some proposed brownfield and greenfield projects that were expected to add to future world cobalt supply were delayed by various factors, including global economic conditions and low cobalt, copper, and nickel prices (Cobalt Development Institute, 2009b).

References Cited

- African Rainbow Minerals Ltd., 2008, Annual report 2008: Sandton, South Africa, African Rainbow Minerals Ltd., 226 p.
- African Rainbow Minerals Ltd., 2009, Interim results for the six months ended 31 December 2008: Sandton, South Africa, African Rainbow Minerals Ltd., 84 p.
- Albidon Ltd., 2008a, Annual report 2008: West Perth, Australia, Albidon Ltd., 88 p.
- Albidon Ltd., 2008b, Munali Nickel project update: West Perth, Australia, Albidon Ltd. announcement, October 13, 3 p.
- Albidon Ltd., 2009, Business update: West Perth, Australia, Albidon Ltd. announcement, March 3, 4 p.
- Anglo Platinum Ltd., 2009, 2008 annual report: Johannesburg, South Africa, Anglo Platinum Ltd., 252 p.
- Anvil Mining Ltd., 2009, Annual information form for financial year ended December 31, 2008: Osborne Park, Australia, Anvil Mining Ltd., 67 p.
- Aquarius Platinum Ltd., 2008, Second quarter 2008 production results: Hamilton, Bermuda, Aquarius Platinum Ltd., January 24, 24 p.
- Aquarius Platinum Ltd., 2009, Second quarter 2009 production results (to 31 December 2008): Hamilton, Bermuda, Aquarius Platinum Ltd., January 28, 31 p.
- Asian Metal Ltd., 2008, 2007 annual report on Chinese cobalt market: Beijing, China, Asian Metal Ltd. (Accessed September 9, 2008, at http://www.asianmetal.com/report/en/2007Co_en.pdf.)
- Baker, Calum, 2008, Strategic issues for cobalt: The Cobalt Conference, Cobalt Development Institute, Toronto, Ontario, Canada, May 14–15, 2008, Presentation, 23 p.
- Bariyo, Nicholas, 2009, Luanshya Copper Mines pays benefits to laid off miners: Dow Jones & Co., Inc., January 22. (Accessed March 18, 2009, at <http://zambianchronicle.com/2009/01/22/luanshya-copper-mines-pays-benefits-to-laid-off-miners>.)
- Bavier, Joe, 2008, Congo slashes copper, cobalt goals as demand drops: Kinshasa, Congo (Kinshasa), Thomson Reuters Corp., December 16, 3 p.
- Belvedere Resources Ltd., 2009, Management's discussion & analysis for the year ended December 31, 2008: Vancouver, British Columbia, Canada, Belvedere Resources Ltd., April 30, 21 p.
- BHP Billiton, 2008, BHP Billiton production report for the nine months ended 31 March 2008: Melbourne, Australia, BHP Billiton news release, April 23, 15 p.
- BHP Billiton, 2009, BHP Billiton production report for the half year ended 31 December 2008: Melbourne, Australia, BHP Billiton news release, January 21, 15 p.
- Central African Mining & Exploration Company plc, 2008a, Circular re DRC joint venture acquisition and trading update: London, United Kingdom, Central African Mining & Exploration Company plc regulatory announcement, May 7. (Accessed May 20, 2008, at <http://investors.amec-plc.com/news-item?item=63451699872071>.)
- Central African Mining & Exploration Company plc, 2008b, Completion of DRC joint venture: London, United Kingdom, Central African Mining & Exploration Company plc regulatory announcement, March 25. (Accessed November 17, 2008, at <http://investors.amec-plc.com/news-item?item=62130996953986>.)
- Central African Mining & Exploration Company plc, 2008c, DRC update: London, United Kingdom, Central African Mining & Exploration Company plc regulatory announcement, November 19. (Accessed January 22, 2009, at <http://investors.amec-plc.com/news-item?item=70426726267523>.)
- Central African Mining & Exploration Company plc, 2008d, Preliminary results: London, United Kingdom, Central African Mining & Exploration Company plc regulatory announcement, July 17. (Accessed November 17, 2008, at <http://investors.amec-plc.com/news-item?item=65655017570504>.)
- Cobalt Development Institute, 2009a, 2008 production statistics: Cobalt News, no. 2, April, p. 3–4.
- Cobalt Development Institute, 2009b, 2009 first half production statistics: Cobalt News, no. 4, October, p. 3–4.
- Cobalt Development Institute and World Bureau of Metal Statistics, 2009, World cobalt statistics—2006–2008: Surrey and Ware, United Kingdom, May 2009, 284 p.
- Companhia Vale do Rio Doce, 2009, Form 20-F for the fiscal year ended December 31, 2008: Securities and Exchange Commission, 167 p.
- Copper Resources Corp., 2008, Unaudited interim report for the six months ended 30 June 2008: Johannesburg, South Africa, Copper Resources Corp., October 2, 10 p.
- CRU International Ltd., 2008, CRU monitor—Nickel cobalt intermediates: London, United Kingdom, CRU International Ltd., May, 14 p.
- First Nickel Inc., 2008, First Nickel places Lockerby Mine on care and maintenance: Toronto, Ontario, Canada, First Nickel Inc. news release, October 19, 1 p.
- First Quantum Minerals Ltd., 2009, Annual information form—As at December 31, 2008: Vancouver, British Columbia, Canada, First Quantum Minerals Ltd., 70 p.
- FNX Mining Company Inc., 2009, Annual report 2008: Toronto, Ontario, Canada, FNX Mining Company Inc., 112 p.

- Formation Capital Corp., 2009, Annual information form for the year ended February 28, 2009: Vancouver, British Columbia, Canada, Formation Capital Corp., 45 p.
- Fox Resources Ltd., 2009, December 2008 quarterly report: East Perth, Australia, Fox Resources Ltd., January 30, 11 p.
- George Forrest International S.A., [undated], CMSK—Compagnie Minière du Sud Katanga: Wavre, Belgium, George Forrest International S.A. (Accessed September 11, 2009, at <http://www.forrestgroup.com/uk/chap03/cmsk.html>.)
- Global Tungsten & Powders Corp., [undated], About us—Global Tungsten & Powders Corp.—History: Towanda, PA, Global Tungsten & Powders Corp. (Accessed January 21, 2009, via <http://www.globaltungsten.com/>.)
- Groupe ONA, 2007, Résultats du 3ème trimestre 2007: Casablanca, Morocco, Groupe ONA, 1 p.
- Groupe ONA, 2008, Information trimestrielle: Casablanca, Morocco, Groupe ONA press release, May 12, 7 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 Ltd., 2008, Norilsk forecasts Russian demand for cobalt to continue increasing at 20% a year: Metals & Mining Weekly, v. 18, issue 42 (859), October 17–23, p. 7.
- Katanga Mining Ltd., 2009, Management's discussion and analysis December 31, 2008: London, United Kingdom, Katanga Mining Ltd., 36 p.
- Kennecott Eagle Minerals Co., 2008, Kennecott completes State approval process for new U.P. Michigan nickel and copper mine: Marquette, MI, Kennecott Eagle Minerals Co. news release, February 7, 2 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., 2008, Management's discussion and analysis for the nine months ended September 30, 2008: Edmonton, Alberta, Canada, Liberty Mines Inc., November 12, 18 p.
- London Metal Exchange Ltd., The, [undated] a, Cobalt: London, United Kingdom. (Accessed April 7, 2009, at <http://www.lme.com/minormetals/cobalt.asp>.)
- London Metal Exchange Ltd., The, [undated] b, Proposed LME cobalt futures specification (CO): London, United Kingdom. (Accessed April 7, 2009, at <http://www.lme.com/minormetals/6256.asp>.)
- Lundin Mining Corp., 2009, Quarterly operations update—Aguablanca—Fourth quarter December 31, 2008. (Accessed March 12, 2009, at <http://www.lundinmining.com/s/QOU.asp?ReportID=340999>.)
- Metal Bulletin, 2007, Comment—Cobalt's new conduit: Metal Bulletin, no. 9011, September 3, p. 5.
- Metal Bulletin, 2008a, Chambishi halts cobalt and copper ops: Metal Bulletin, no. 9077, December 15, p. 11.
- Metal Bulletin, 2008b, India's Rubamin to start up DRC cobalt facility in June: Metal Bulletin, no. 9045, May 5, p. 12.
- Metal Bulletin, 2009, Kasese seeks new sources of feed for cobalt refinery: Metal Bulletin, no. 9100, June 1, p. 9.
- Metorex Ltd., 2008a, Annual report 2008: Johannesburg, South Africa, Metorex Ltd., 125 p.
- Metorex Ltd., 2008b, Copper cathode production commences at Ruashi II: Johannesburg, South Africa, Metorex Ltd. new release, April 14, 1 p.
- Metorex Ltd., 2009, Results presentation for the six months ended 31 December 2008: Johannesburg, South Africa, Metorex Ltd., March 3–4, 40 p.
- Minara Resources Ltd., 2009, 2008 annual report: Perth, Australia, Minara Resources Ltd., 92 p.
- Ministry of Infrastructure, Public Works, and Reconstruction, 2008, Contribution by the Minister on the occasion of the presentation of the accords signed between the Government of the Democratic Republic of the Congo and the People's Republic of China: Kinshasa, Congo (Kinshasa), Ministry of Infrastructure, Public Works, and Reconstruction, May 9. (Accessed July 13, 2009, at <http://www.infomine.com/publications/docs/Lumbi2008.pdf>.)
- Mirabela Nickel Ltd., 2008, Financial report—30 June 2008: Perth, Australia, Mirabela Nickel Ltd., 72 p.
- Mwana Africa PLC, 2008, Unaudited results for the six months to 30th September 2008: London, United Kingdom, Mwana Africa PLC, December 10, 15 p.
- n.v. Umicore, s.a., 2006, Half year results 2006: Brussels, Belgium, n.v. Umicore, s.a. press release, August 24, 29 p.
- n.v. Umicore, s.a., 2008, Half year results 2008: Brussels, Belgium, n.v. Umicore, s.a. press release, August 21, 28 p.
- Nyrstar NV, [undated], Budel: London, United Kingdom, Nyrstar NV. (Accessed April 17, 2009, at <http://production.investis.com/nyrstar/en/operations/netherlands/budel>.)
- OJSC MMC Norilsk Nickel, 2009a, Annual report 2008: Moscow, Russia, OJSC MMC Norilsk Nickel, 300 p.
- OJSC MMC Norilsk Nickel, 2009b, MMC Norilsk Nickel announces preliminary consolidated production results for 4th quarter 2008 and full year 2008: Moscow, Russia, OJSC MMC Norilsk Nickel, January 30, 1 p.
- OJSC MMC Norilsk Nickel, [undated], Norilsk Nickel Australia: Moscow, Russia, OJSC MMC Norilsk Nickel. (Accessed February 25, 2009, via http://www.nornik.ru/en/our_products/norilsknickelaustralia/.)
- OM Group, Inc., 2009a, Form 10-K—2008: Securities and Exchange Commission, 96 p.
- OM Group, Inc., 2009b, Final transcript—OMG—Q1 2009 OM Group Inc. earnings conference call: Cleveland, OH, OM Group, Inc., May 7, 15 p.
- OM Group, Inc., 2009c, Final transcript—OMG—Q2 2009 OM Group Inc. earnings conference call: Cleveland, OH, OM Group, Inc., August 6, 16 p.
- OZ Minerals Ltd., 2009, Business review—2008: Southbank, Australia, OZ Minerals Ltd., April 15, 23 p.
- Panoramic Resources Ltd., 2008, Quarterly report for the period ending 30 June 2008: Perth, Australia, Panoramic Resources Ltd., July 31, 11 p.
- Panoramic Resources Ltd., 2009, Quarterly report for the period ending 31 December 2008: Perth, Australia, Panoramic Resources Ltd., January 29, 9 p.
- Peppin, John, 2008, Kennecott looking at rehabbing Humboldt facility for refining: The Mining Journal, February 23. (Accessed May 6, 2008, at http://www.eagle-project.com/MJ_Humboldt%20022308.pdf.)
- Platts Metals Week, 2008a, Chambishi restarts cobalt furnace: Platts Metals Week, v. 79, no. 20, May 19, p. 5.
- Platts Metals Week, 2008b, KCM to resume cobalt production: Platts Metals Week, v. 79, no. 10, March 10, p. 7.
- Platts Metals Week, 2008c, Sumitomo to start new Ni plant on stream: Platts Metals Week, v. 79, no. 46, November 17, p. 16.
- PolyMet Mining Corp., 2009, Form 20-F—2009: Securities and Exchange Commission, 54 p.
- PT International Nickel Indonesia Tbk, 2008, 2007 annual report: Jakarta, Indonesia, PT International Nickel Indonesia Tbk, 210 p.
- PT International Nickel Indonesia Tbk, 2009, 2008 annual report: Jakarta, Indonesia, PT International Nickel Indonesia Tbk, 229 p.
- Rio Tinto plc, 2009, Rio Tinto announces underlying earnings of \$10.3 billion—Up 38 per cent: London, United Kingdom, Rio Tinto plc press release, February 12, 38 p.
- Shalina Resources Ltd., 2008, Chemaf SPRL fact sheet: Dubai, United Arab Emirates, Shalina Resources Ltd., May 1, 3 p.
- Sherritt International Corp., 2008, Management's discussion and analysis for the second quarter ended June 30, 2008: Toronto, Ontario, Canada, Sherritt International Corp., July 30, 42 p.
- Sherritt International Corp., 2009a, 2008 annual information form: Toronto, Ontario, Canada, Sherritt International Corp., March 23, 109 p.
- Sherritt International Corp., 2009b, 2008 annual report: Toronto, Ontario, Canada, Sherritt International Corp., 124 p.
- Taarland, Eric, 2009, The outlook for cobalt: The Cobalt Conference, Cobalt Development Institute, Lisbon, Portugal, May 13–14, 2009, Presentation, 31 p.
- Talvivaara Mining Co. Plc, 2009, Annual report 2008: Espoo, Finland, Talvivaara Mining Company Plc, 112 p.
- Tollinsky, Norm, 2008, Xstrata boosts recycling capacity: Sudbury Mining Solutions Journal, v. 5, no. 2, June 1, p. 1, 36.
- Thomson Reuters Corp., 2008, Update 1—Congo's Katanga lifts ban on 9 cobalt exporters: Kinshasa, Congo (Kinshasa), Thomson Reuters Corp. news release, June 6, 1 p.
- Thomson Reuters Corp., 2009, CRU/CESCO-Congo wrapping up mining review—Gecamines: Santiago, Chile, Thomson Reuters Corp. news release, April 2, 1 p.
- URSA Major Minerals Inc., 2009, URSA Major Minerals announces year-end financial results: Toronto, Ontario, Canada, URSA Major Minerals Inc. press release, April 30, 2 p.
- U.S. Department of Defense, 2009, Strategic and critical materials operations report to the Congress—Operations under the Strategic and Critical Materials Stock Piling Act during the period October 2007 through September 2008: Washington, DC, U.S. Department of Defense, 68 p.

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, 2009a, Annual report 2008: Zug, Switzerland, Xstrata plc, 208 p.

Xstrata plc, 2009b, Production report for 12 months ended 31 December 2008: Zug, Switzerland, Xstrata plc press release, January 29, 10 p.

Xu, Aidong, 2008, Status of China cobalt industry after DRC's new mining policy: The Cobalt Conference, Cobalt Development Institute, Toronto, Ontario, Canada, May 14–15, 2008, Presentation, 23 p.

Xu, Aidong, and Yang, Xiaofei, 2009, Analysis of China cobalt market: The Cobalt Conference, Cobalt Development Institute, Lisbon, Portugal, May 13–14, 2009, Presentation, 29 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.

Mining Journal Ltd., weekly.

Nickel. Ch. in *Canadian Minerals Yearbook*, Natural Resources Canada, Minerals and Metals Sector.

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

Roskill Information Services Ltd.

Ryan's Notes, weekly.

TABLE 1
SALIENT COBALT STATISTICS¹

(Metric tons, cobalt content, unless otherwise specified)

	2004	2005	2006	2007	2008
United States:					
Consumption:					
Reported	8,990	9,150	9,280	9,320 ^r	8,810
Apparent	9,950	11,800	11,000	9,630 ^r	10,100
Imports for consumption	8,720	11,100	11,600	10,300	10,700
Exports	2,500	2,440	2,850	3,100	2,850
Stocks, December 31:					
Industry ²	690	705	737	620 ^r	582
U.S. Government ³	2,660	1,550	1,290	676	473
Price, metal ⁴ dollars per pound	23.93	15.96	17.22	30.55	39.01
World, production:					
Mine	60,300 ^r	66,200 ^r	69,800 ^r	72,600 ^r	75,900 ^e
Refinery	48,500	54,100	53,800	53,300 ^r	57,600

^eEstimated. ^rRevised.

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

²Stocks held by cobalt processors and consumers.

³Defense National Stockpile Center. Data for 2004–06 include material committed for sale pending shipment; data for 2007–08 are uncommitted material only.

⁴Annual 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 SHIPMENTS¹

(Metric tons, cobalt content)

	2007	2008
Sales:		
Fiscal year ²	388	481
Calendar year	553	203
Shipments:³		
Fiscal year ²	481	493
Calendar year	617	203

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

²Twelve-month period ending September 30 of year stated.

³Calculated from yearend inventory levels. Data for 2006 include material committed for sale pending shipment; data for 2007–08 are uncommitted material only.

Source: Defense National Stockpile Center.

TABLE 3
U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT^{1,2}

(Metric tons, cobalt content)

	2007	2008
Consumption by end use:		
Steels	627 ^r	604
Superalloys	4,410 ^r	4,320
Alloys, excludes steels and superalloys:		
Magnetic alloys	385	368
Other alloys ³	225	226
Cemented carbides ⁴	726	827
Chemical and ceramic uses	2,880	2,410
Miscellaneous and unspecified	63	63
Total	9,320 ^r	8,810
Consumption by form:		
Chemical compounds, organic and inorganic ⁵	2,700	2,250
Metal	4,690 ^r	4,640
Purchased scrap	1,930	1,930
Total	9,320 ^r	8,810
Stocks, December 31:⁶		
Chemical compounds, organic and inorganic ⁵	178	203
Metal	382 ^r	307
Purchased scrap	60	72
Total	620 ^r	582

^rRevised.

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

²Includes estimates.

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

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

⁵Includes oxides.

⁶Stocks held by cobalt processors and consumers.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM¹

	2007			2008		
	Gross weight (metric tons)	Cobalt content ² (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content ² (metric tons)	Value (thousands)
Metal ³	8,960	8,960	\$487,000	8,430	8,430	\$618,000
Oxides and hydroxides	1,020	738	44,400	1,110	800	63,400
Other forms:						
Acetates	213	51	2,830	439	105	3,140
Carbonates	523	241	15,100	1,100	508	31,800
Chlorides	228	57	2,970	177	44	1,280
Sulfates	988	267	10,100	2,990	806	13,700
Grand total	11,900	10,300	563,000	14,200	10,700	732,000

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

²Estimated from gross weights.

³Unwrought cobalt, excluding alloys and waste and scrap.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY¹

Country of origin	Metal ²			Oxides and hydroxides			Other forms ³			Total		
	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)
2007:												
Argentina	--	--	--	--	--	--	16	4	\$564	16	4	\$564
Australia	642	642	\$36,600	--	--	--	--	--	--	642	642	36,600
Belgium	301	301	14,600	421	303	\$20,000	144	39	1,460	866	643	36,100
Brazil	239	239	14,000	--	--	--	5	2	101	244	241	14,100
Canada	1,390	1,390	69,200	(6)	(6)	5	--	--	--	1,390	1,390	69,200
China	907	907	50,000	184	132	6,420	647	212	11,300	1,740	1,250	67,800
Congo (Kinshasa)	40	40	1,370	--	--	--	--	--	--	40	40	1,370
Finland	257	257	12,000	259	187	10,800	619	217	12,100	1,130	660	34,900
France	23	23	1,850	5	4	248	--	--	--	28	27	2,090
Germany	14	14	867	4	3	255	--	--	--	18	17	1,120
India	13	13	774	1	1	68	125	33	1,200	139	47	2,040
Japan	186	186	10,800	1	1	41	12	3	127	199	189	10,900
Korea, Republic of	41	41	875	(6)	(6)	8	19	4	167	60	46	1,050
Morocco	399	399	22,300	--	--	--	--	--	--	399	399	22,300
Norway	1,970	1,970	111,000	--	--	--	--	--	--	1,970	1,970	111,000
Russia	1,550	1,550	84,600	--	--	--	(6)	(6)	2	1,550	1,550	84,600
South Africa	86	86	4,310	10	7	395	--	--	--	96	93	4,700
Sweden	4	4	164	--	--	--	--	--	--	4	4	164
Uganda	144	144	7,540	--	--	--	--	--	--	144	144	7,540
United Kingdom	13	13	611	134	96	5,870	366	101	4,020	514	211	10,500
Zambia	738	738	43,400	--	--	--	--	--	--	738	738	43,400
Other	4	4	171	6	4	297	(6)	(6)	2	10	8	470
Total	8,960	8,960	487,000	1,020	738	44,400	1,950	616	31,100	11,900	10,300	563,000
2008:												
Argentina	--	--	--	--	--	--	134	34	538	134	34	538
Australia	757	757	60,200	--	--	--	--	--	--	757	757	60,200
Belgium	353	353	21,800	518	373	28,100	69	22	1,330	939	748	51,300
Brazil	110	110	8,540	--	--	--	219	61	1,270	329	171	9,810
Canada	1,360	1,360	89,100	21	15	1,100	--	--	--	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	106,000
Congo (Kinshasa)	28	28	1,140	--	--	--	--	--	--	28	28	1,140
Finland	441	441	34,300	178	128	11,000	2,760	879	27,400	3,380	1,450	72,600
France	27	27	2,830	(6)	(6)	7	1	(6)	6	28	28	2,840
Germany	13	13	1,040	12	9	1,230	--	--	--	25	21	2,270
India	21	21	1,220	--	--	--	719	194	2,760	740	215	3,980
Japan	143	143	12,300	2	1	106	--	--	--	145	144	12,400

See footnotes at end of table.

TABLE 5—Continued

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

Country of origin	Metal ²			Oxides and hydroxides			Other forms ³			Total		
	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)	Gross weight (metric tons)	Cobalt content ⁴ (metric tons)	Value ⁵ (thousands)
Korea, Republic of	12	12	\$295	--	--	--	9	4	\$256	21	16	\$552
Morocco	444	444	33,100	--	--	--	--	--	--	444	444	33,100
Norway	1,400	1,400	115,000	--	--	--	--	--	--	1,400	1,400	115,000
Russia	1,390	1,390	93,900	--	--	--	--	--	--	1,390	1,390	93,900
South Africa	178	178	17,000	1	1	\$60	--	--	--	179	178	17,000
Uganda	20	20	1,980	--	--	--	--	--	--	20	20	1,980
United Kingdom	32	32	1,780	119	86	7,480	541	184	10,900	692	302	20,200
Zambia	456	456	35,200	--	--	--	--	--	--	456	456	35,200
Other	8	8	480	8	6	416	28	8	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	732,000

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.²Unwrought cobalt, excluding alloys and waste and scrap; includes cobalt cathode and cobalt metal powder; may include intermediate products of cobalt metallurgy.³Includes cobalt acetates, cobalt carbonates, cobalt chlorides, and cobalt sulfates.⁴Estimated from gross weights.⁵Customs value.⁶Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF COBALT IN 2008, BY COUNTRY^{1,2}

Country of destination	Metal ³		Oxides and hydroxides		Acetates		Chlorides		Total	
	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Cobalt content ⁵ (metric tons)	Value ⁴ (thousands)
Argentina	24	\$1,360	--	--	--	--	--	--	24	\$1,360
Australia	7	297	--	--	--	--	--	--	7	297
Belgium	370	12,300	63	\$4,010	140	\$3,650	--	--	448	20,000
Brazil	23	834	6	249	(6)	6	--	--	28	1,090
Canada	141	5,160	166	3,140	62	669	1	\$16	275	8,990
China	5	230	--	--	8	96	1	13	7	339
France	486	24,300	--	--	--	--	--	--	486	24,300
Germany	159	13,000	1	62	2	4	--	--	161	13,100
Hong Kong	(6)	34	5	6	33	15	--	--	12	54
India	19	1,350	39	250	--	--	--	--	47	1,600
Ireland	532	17,900	(6)	9	--	--	--	--	532	17,900
Italy	13	1,030	(6)	5	--	--	--	--	13	1,040
Japan	253	21,700	45	1,780	--	--	20	298	290	23,800
Korea, Republic of	98	1,460	39	1,490	8	281	29	432	135	3,660
Mexico	14	1,240	75	3,590	39	758	(6)	8	77	5,590
Morocco	11	131	--	--	--	--	--	--	11	131
Netherlands	21	1,730	40	3,220	--	--	--	--	49	4,950
Panama	69	426	--	--	--	--	--	--	69	426
Poland	6	208	--	--	--	--	--	--	6	208
Singapore	7	523	29	859	--	--	--	--	28	1,380
Spain	3	167	3	115	--	--	--	--	5	282
Switzerland	11	797	--	--	--	--	--	--	11	797
Tunisia	14	307	--	--	--	--	--	--	14	307
United Kingdom	74	3,490	7	35	--	--	(6)	10	79	3,530
Venezuela	1	32	15	600	--	--	--	--	12	632
Other	24	1,510	(6)	6	2	66	--	--	25	1,590
Total	2,380	112,000	531	19,400	295	5,550	51	776	2,850	137,000

-- Zero.

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

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

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

⁴Free alongside ship value.

⁵Estimated from gross weights.

⁶Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
 WORLD ANNUAL COBALT REFINERY
 CAPACITY, DECEMBER 31, 2008^{1, 2}

(Metric tons, cobalt content)

Country	Capacity
Australia	5,700
Belgium	1,500
Brazil	1,420
Canada	6,110
China ^c	30,000
Congo (Kinshasa) ^c	6,000
Finland	10,000
France	500
India	1,560
Japan ^c	1,120
Morocco ^c	1,750
Norway	5,200
Russia ^c	6,000
South Africa ^c	750
Uganda	720
Zambia	8,200
Total	86,500

^cEstimated.

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

²Refinery products include cobalt metal, metal powders, oxides, and/or salts.

TABLE 8
COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2013^{1,2}

Projected year of first production	Country	Project and company ³	Project type ⁴	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2009 ⁵	Australia	Browns Oxide Compass Resources Ltd. and Hunan Nonferrous Metals Corp. Ltd.	new mine and relocated and refurbished refinery	copper	copper-cobalt-nickel oxide ore	1,000	Cobalt-nickel carbonate.
2009 ⁶	Do.	Heap-leach expansion Minara Resources Ltd. and Glencore International AG	expansion of demonstration plant	nickel	stockpiled nickel-cobalt laterite ore reject material	750 ^{e,7}	Nickel-cobalt solution.
2009 ⁶	Do.	Lucky Break Metallica Minerals Ltd. and Metals Finance Corp.	new mine and combined vat and heap-leaching operation	do.	nickel-cobalt laterite ore	NA	Nickel-cobalt carbonate.
2009	Brazil	Santa Rita Mirabela Nickel Ltd.	new mine and beneficiation plant	do.	nickel-copper-cobalt-platinum group metals-gold sulfide ore	450 ^e	Nickel concentrate.
2009 ⁶	Canada	Fort Saskatchewan expansion Sherritt International Corp.	expansion of existing refinery	do.	nickel-cobalt sulfide	4,600 ^{e,7}	Cobalt metal powder and briquettes.
2009	Do.	Nickel Rim South Xstrata Nickel	new mine	do.	nickel-copper-cobalt-precious metals sulfide ore	NA	Nickel-copper-cobalt-precious metals sulfide ore.
2009	China	Cobalt plant, phase I Ganzhou Anhua Cobalt Industrial Co., Ltd.	replace existing refinery	cobalt	NA	2,000 ⁷	NA.
2009	Congo (Kinshasa)	Luilu Metallurgical Plant, phase 2 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	refurbishment of existing refinery	copper	copper-cobalt oxide and sulfide concentrates	6,000 ⁷	Cobalt cathode.
2009	Do.	Luita Central African Mining & Exploration Co. (CAMEC)	expansion of existing plant	do.	copper-cobalt ore	8,000 ⁷	Cobalt carbonate.
2009	Do.	Luita SX-EW line Central African Mining & Exploration Co. (CAMEC)	addition to existing plant	cobalt	cobalt in solution	3,200 ⁸	Cobalt cathode.
2009	Do.	Ruashi, phase 2 Metorex Ltd. and La Générale des Carrières et des Mines (Gécamines)	new mine and refinery	copper	copper-cobalt ore	3,500	Cobalt carbonate.
2009	Do.	Tenke Fungurume, phase I Freeport-McMoRan Copper & Gold Inc., Lundin Mining Corp., and La Générale des Carrières et des Mines (Gécamines)	new mine, processing plant, and refinery	do.	copper-cobalt oxide, mixed oxide/sulfide, and sulfide ores	8,000	Intermediate cobalt hydroxide.
2009	Do.	NA China Overseas Engineering Corp. (COVEC)	new refinery	do.	copper-cobalt concentrate	1,500	Cobalt cathode.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2013^{1,2}

Projected year of first production	Country	Project and company ³	Project type ⁴	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2009 ⁶	Cuba	Moa Joint Venture Expansion, phase 2 Moa Nickel S.A. (Sherritt International Corp. and General Nickel Co. S.A.)	expansion of existing plant	nickel	nickel-cobalt laterite ore	4,300 ^{e,7}	Nickel-cobalt sulfide.
2009	Finland	Hautalampi Belvedere Resources Ltd.	new mine	do.	nickel-copper-cobalt sulfide ore	960	Nickel-cobalt concentrate.
2009	India	Refinery expansion Rubamin Ltd.	expansion of existing refinery	cobalt	ores, concentrates, intermediates, and scrap	1,000 ⁷	Cobalt cathode, powder, oxide, and salts.
2009	Japan	Niihama expansion Sumitomo Metal Mining Co., Ltd.	do.	nickel	nickel-cobalt sulfide and nickel matte	1,800 ⁷	Cobalt cathode.
2009	New Caledonia	Vale Inco Nouvelle-Calédonie (formerly Goro) 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	do.	nickel-cobalt laterite ore	4,600 to 5,500	Cobalt carbonate.
2009	Philippines	Coral Bay Phase 2 Coral Bay Nickel Corp. (Sumitomo Metal Mining Co., Ltd., Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp.)	double production at existing HPAL processing plant	do.	do.	1,500 ⁷	Nickel-cobalt sulfide.
2009 ⁶	Russia	Uralgidronikel Russian Nickel Co.	new mine and refinery	do.	nickel-cobalt ore	1,000	Cobalt cathode.
2009 ⁶	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.
2009	Zambia	Chambishi Copper Smelter China Nonferrous Metal Mining Group Co. Ltd. and Yunnan Copper Industry Group Co. Ltd.	new smelter	copper	copper-cobalt concentrates	2,800	NA.
2009 ⁶	Do.	Muliashi Oxide Caps Luanshya Copper Mines Plc	new mines and refinery	do.	copper-cobalt oxide ores	1,500	Cobalt hydroxide.
2009 ⁶	Do.	Nama Caledonia Mining Corp.	new mine and pyrometallurgical plant or refinery	cobalt	iron-rich cobalt-copper oxide ore or cobalt-copper oxide ore	10,000	Ferrocobalt or cobalt hydroxide.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2013^{1,2}

Projected year of first production	Country	Project and company ³	Project type ⁴	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2010	Australia	Rocklands Group Copper CuDeco Ltd.	new mine and beneficiation plant	copper	copper-cobalt-gold oxide and sulfide ore	NA	Cobaltic-pyrite concentrate.
2010	Canada	Lockerby Depth First Nickel Inc.	expansion of existing mine	nickel	nickel-copper-cobalt sulfide ore	80 ⁷	Nickel-copper-cobalt sulfide ore.
2010 ⁶	Do.	Nunavik Nickel Canadian Royalties Inc.	new mine and beneficiation plant	do.	nickel-copper-cobalt platinum group metals sulfide ore	425 ⁹	Nickel concentrate.
2010	China	Nickel-cobalt refinery Jiangxi Rare Earth and Rare Metals Tungsten Group Co. Ltd. and Ipilán joint venture	new refinery	do.	nickel-cobalt hydroxide	600	NA.
2010	Do.	Plant expansion Zhejiang Huayou Cobalt Co.	expansion of existing plant	cobalt	cobalt concentrates	10,000 ⁷	Cobalt salts.
2010	Do.	Refinery expansion Jinchuan Group Ltd.	expansion of existing refinery	nickel	nickel-copper matte	10,000 ⁷	Cobalt cathode and other.
2010 ⁶	Congo (Kinshasa)	Kalukundi H & J Swanepoel Family Trust sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and refinery	copper	copper-cobalt oxide ore	3,800 to 6,000	Cobalt cathode.
2010	Do.	Kipoi, phase I Congo Minerals sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and beneficiation plant	do.	do.	NA	stockpiled cobalt ore.
2010	Do.	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	do.	copper-cobalt tailings	5,800	Cobalt hydroxide.
2010	Do.	Likasi plant Rubamin Ltd.	expansion of existing smelter	do.	copper-cobalt ore	2,000 ⁷	Alliage blanc.
2010	Do.	SX-EW plant for cobalt Chemaf SPRL	addition to existing refinery	do.	do.	6,000	Co cathode.
2010 ⁶	Finland	Keivitsa First Quantum Minerals Ltd. (acquired Scandinavian Minerals Ltd.)	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum group metals-gold sulfide ore	380 ^{e,9}	Nickel-cobalt-platinum group metals concentrate.
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 Resource Development Co.	new mine, beneficiation plant, and HPAL processing plant	do.	nickel-cobalt laterite ore	3,300	Nickel-cobalt hydroxide.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2013^{1,2}

Projected year of first production	Country	Project and company ³	Project type ⁴	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2010 ⁶	South Africa	Base Metals Refinery Anglo Platinum Ltd.	expansion of existing refinery	nickel	nickel-cobalt-platinum group metals converter matte	825 ^{e,7}	Cobalt sulfate.
2010	Do.	Independence Platinum Independence Platinum Ltd. (subsidiary of Braemore Resources Plc)	new smelter (ConRoast process)	platinum group metals-nickel	platinum group metals-cobalt sulfide concentrates	NA	Nickel-copper-cobalt-iron-platinum group metals alloy.
2010	Do.	Nkomati Large Scale Expansion African Rainbow Minerals Ltd. and OJSC MMC Norilsk Nickel	expansion of existing mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum group metals sulfide and chromite ores	550 ^{e,7}	Nickel concentrate.
2010	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	1,200	Nickel-cobalt hydroxide.
2010	United States (Idaho)	Idaho Cobalt Formation Capital Corp.	new mine and refinery	cobalt	stratiform cobalt-copper-gold ore	1,625	Cobalt cathode or salts.
2010 ⁶	United States (Michigan)	Eagle Kennecott Eagle Minerals Co.	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	nickel-copper sulfide ore	400 ^e	Copper-nickel concentrate.
2011 ⁶	Australia	Mutooroo Havilah Resources NL	new mine, beneficiation plant, and refinery	copper	copper-cobalt sulfide ore	1,200	Cobalt hydroxide.
2011 ⁶	Do.	Niwest GME Resources Ltd.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	1,400	Nickel-cobalt sulfide.
2011 ⁶	Do.	Nornico Metallica Minerals Ltd.	do.	do.	do.	NA	do.
2011	Canada	Maskwa Mustang Minerals Corp.	new mine and concentrator	do.	nickel sulfide ore	150 ^e	Nickel concentrate.
2011	Do.	Raglan Mine Xstrata Nickel	expansion of existing mine, stage I	do.	nickel-copper-cobalt-platinum group metals sulfide ore	NA	do.
2011	Congo (Kinshasa)	Luita Central African Mining & Exploration Co. (CAMEC)	expansion of existing plant	copper	copper-cobalt ore	12,000 ⁷	Cobalt carbonate.
2011 ⁶	Finland	Kylylahti Vulcan Resources Ltd.	new mine and beneficiation plant	do.	copper-zinc-cobalt-nickel-gold sulfide ore	1,925 ⁹	Zinc-cobalt-copper-nickel concentrate.
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: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2013^{1,2}

Projected year of first production	Country	Project and company ³	Project type ⁴	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2011	Philippines	Acoje Rusina Mining NL, European Nickel PLC, and DMCI Mining Corp.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	930 ⁹	Nickel-cobalt hydroxide.
2011 ⁶	Russia	Belininskoye Deposit Russian Nickel Co.	new mine and refinery	do.	nickel-cobalt ore	1,000	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	Zambia	New Nchanga smelter Konkola Copper Mines Plc	expand production from existing smelter	do.	copper-cobalt concentrates	3,000 ⁷	Alliage rouge.
2012	Australia	Gladstone Nickel, stage I Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	6,200	Cobalt metal.
2012 ¹⁰	Brazil	Niquel do Vermelho Vale Inco	new mine, HPAL processing plant, and refinery	do.	do.	2,800	Cobalt cathode.
2012	Cameroon	Nkamouna Geovic Ltd. and Société National d'Investissement du Cameroun	new mine and refinery	cobalt	do.	4,400 ⁹	Cobalt briquettes, carbonate, or oxide.
2012	Canada	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished mill, and refinery	gold	gold-cobalt-bismuth ore	1,800 ⁹	Cobalt cathode.
2012 ⁶	China	Yellow Mountain GobiMin Inc.	new mine	nickel	nickel-copper sulfide ore	300 ^e	Nickel-copper sulfide ore.
2012	Congo (Kinshasa)	Luilu Metallurgical Plant, phase 3 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	refurbishment and expansion of existing refinery	copper	copper-cobalt oxide and sulfide concentrates	9,000 ^{7,11}	Cobalt cathode and hydroxide.
2012	Finland	Talvivaara Talvivaara Mining Co. Ltd.	expand existing operation	nickel	nickel-zinc-copper-cobalt sulfide ore	1,800 ⁷	Nickel-cobalt sulfide.
2012	Mexico	El Boleo Baja Mining Corp., Korea Resources Corp., L.S. Nikko Copper Inc., Hyundai Hysco Co. Ltd., SK Networks Co. Ltd., and Iljin Copper Foil Co. Ltd.	new mine and refinery	copper	copper-cobalt-zinc-manganese oxide and sulfide ores	1,500	Cobalt cathode.
2012	Philippines	Taganito Sumitomo Metal Mining Co., Ltd. and Taganito Mining Corp.	new HPAL processing plant	nickel	nickel-cobalt laterite ore	2,500	Nickel-cobalt sulfide.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2013^{1,2}

Projected year of first production	Country	Project and company ³	Project type ⁴	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2012	South Africa	Independence Platinum Independence Platinum Ltd. (subsidiary of Braemore Resources Plc)	new hydrometallurgical leach plant	platinum group metals-nickel	nickel-copper-cobalt iron-platinum group metals alloy	NA	Cobalt intermediate.
2013 ⁶	Australia	Wingellina Nickel Metals X Ltd. and Jinchuan Group Ltd.	new mine and HPAL processing plant	nickel	nickel-cobalt laterite ore	3,250 ⁹	Nickel-cobalt hydroxide.
2013	Canada	Voisey's Bay commercial nickel processing plant Vale Inco	new refinery	do.	nickel-copper-cobalt sulfide concentrate	2,500	Cobalt cathode.
2013	Congo (Kinshasa)	Luilu Metallurgical Plant, phase 4 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	refurbishment and expansion of existing refinery	copper	copper-cobalt oxide and sulfide concentrates	10,000 ^{7,11}	Cobalt cathode and hydroxide.
2013	Do.	NA Sicomines Sarl (Chinese consortium and La Générale des Carrières et des Mines (Gécamines))	new mine(s)	do.	copper-cobalt ore	NA	NA.
2013	Indonesia	Weda Bay Eramet S.A. and PT Antam Tbk	new mine and hydrometallurgical plant	nickel	nickel-cobalt laterite ore	2,500	NA.
2013	Philippines	Mindoro, phase I (limonite ore) Intex Resources ASA	new mine, HPAL processing plant, and refinery	do.	do.	3,000	Cobalt sulfate.

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

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

²Projects in feasibility or later stages of development in 2008. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2013, but not enough information was available to include them.

³SX-EW solvent extraction—electrowinning.

⁴HPAL High pressure acid leach.

⁵Compass Resources Ltd. went into receivership in early 2009; project status unknown.

⁶Startup date provided before project postponement was announced; no information is available on the length of delay.

⁷Total capacity following expansion.

⁸SX-EW line will not increase total plant capacity.

⁹Average production.

¹⁰Project's technical and economic viability under evaluation.

¹¹8,000 metric tons per year cobalt as cathode; remaining cobalt as hydroxide.

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

(Metric tons, cobalt content)

Country ³	2004	2005	2006	2007	2008 ^c
Australia ^{e, 4}	5,600	5,600	6,000	5,900	6,100
Botswana ⁵	223	326	303	242	337 ⁶
Brazil ^e	1,400	1,400	1,100	1,400	1,200
Canada ⁷	5,060	5,767	7,115	8,692 ^r	8,644 ^{p, 6}
China ^e	1,260	2,100	1,840	6,100 ^{r, 6}	6,000
Congo (Kinshasa) ^{e, 8}	20,200	24,500	27,100	25,300	31,000
Cuba ⁹	3,554	4,798 ^r	5,602 ^r	4,540 ^r	3,175 ⁶
Finland ^e	100	100	100	115	105 ⁶
Indonesia ¹⁰	1,700	1,600	1,600	1,600	1,300
Morocco ^{e, 11}	1,600	1,600	1,500	1,600 ^r	1,700
New Caledonia ¹²	2,726	1,769	1,629	1,620	1,600
Philippines ^e	100	300 ^r	900 ^r	1,000 ^r	1,000
Russia ^{e, 11}	6,000	6,300	6,300	6,300	6,200
South Africa ^e	610	620	600	600	590
Zambia ^{e, 13}	10,000	9,300	8,000	7,500 ^r	6,900
Zimbabwe ^{e, 14}	140	100	110	100	85
Total	60,300 ^r	66,200 ^r	69,800 ^r	72,600 ^r	75,900

^eEstimated. ^pPreliminary. ^rRevised.

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

²Table includes data available through June 10, 2009. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from cobalt, copper, nickel, platinum, or zinc operations.

³In addition to the countries listed, 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.

⁴Cobalt content of lateritic nickel ore, nickel concentrate, and zinc concentrate originating from Australia. 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: 2004—5,600; 2005—4,900; 2006–07—5,500; and 2008—5,100.

⁵Reported cobalt content of pelletized nickel-copper matte.

⁶Reported figure.

⁷Assay content of cobalt in concentrates produced.

⁸Cobalt content of concentrates, tailings, and slags.

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

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

¹¹Cobalt content of concentrates.

¹²Cobalt 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, were estimated to be as follows: 2004—1,400 (revised); 2005–06—1,200 (revised); 2007—1,400 (revised); and 2008—1,200.

¹³Cobalt content of concentrates and slags.

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

TABLE 10
COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY^{1,2}

(Metric tons, cobalt content)

Country ³	2004	2005	2006	2007	2008
Australia, metal powder and oxide hydroxide ^e	3,880	3,150	3,700	3,680	3,620
Belgium, metal powder, oxide, hydroxide ⁴	2,947	3,298	2,840	2,825	3,020
Brazil, metal	1,155	1,136	902	1,148	994
Canada, metal, metal powder, oxide	5,144	5,090	5,198	5,620	5,605 ^p
China, metal, metal powder, oxide, salts ^{e,5}	8,000	12,700	12,700	13,200 ^r	18,200
Congo (Kinshasa), metal ⁶	735	600	550	606	1,439
Finland, metal powder and salts ⁷	7,893	8,171	8,582	9,173 ^r	9,645
France, chloride	199	280	256	305	311
India, metal and salts	545	1,220	1,184	980	858
Japan, metal	429	471	920	1,084	1,071
Morocco, metal and oxide	1,594	1,613	1,405	1,591	1,711
Norway, metal	4,670	5,021	4,927	3,939	3,719
Russia, unspecified ^{e,8}	4,800	5,000	5,000	3,800	2,500
South Africa, metal powder and sulfate	309	268	267	307	244 ^p
Uganda, metal	436	638	674	698	663
Zambia, metal	5,791	5,422	4,665	4,335 ^r	3,991
Total	48,500	54,100	53,800	53,300 ^r	57,600

^eEstimated. ^pPreliminary. ^rRevised.

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

²Table includes data available through June 10, 2009. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

³In addition to the countries listed, Poland may produce some cobalt, but information is inadequate to make reliable estimates of production.

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

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

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

⁷Production reported by the Geological Survey of Finland.

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