



2007 Minerals Yearbook

COBALT

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World production of refined cobalt in 2007 was slightly lower than that of 2006. The United States did not mine or refine cobalt in 2007. 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 (2008b), world demand (consumption plus stock increases) for cobalt was slightly higher than that of 2006. European apparent demand was slightly lower than that of 2006. Although Chinese apparent demand continued to be adversely affected by the limited availability of raw material, overall Asian apparent demand was about 5% higher than that of 2006. U.S. apparent consumption of cobalt was lower than that of 2006, primarily because of a decrease in net imports. Cobalt prices trended upward, and the U.S. spot price exceeded \$40 per pound by yearend. The last time that this price was more than \$40 per pound was in 1979.

Salient U.S. and world cobalt statistics for 2007 and the previous 4 years are listed in table 1.

Cobalt is a strategic and critical metal used in many diverse commercial, industrial, and military applications. On a global basis, the leading use of cobalt is in rechargeable battery electrodes. Superalloys, which are used to make parts for gas turbine engines, are another major use for cobalt. Cobalt is also used to make airbags in 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 2007 (October 1, 2006, through September 30, 2007), the DNSC sold 388 metric tons (t) of cobalt metal valued at \$19.8 million under a basic ordering agreement (BOA) (table 2). This represented 24% of the 1,590-metric-ton (3.5-million-pound) maximum allowed for sale under the fiscal year 2007 Annual Materials Plan (AMP). At the end of the fiscal year, 26 t of cobalt had been sold but not shipped from the stockpile. The AMP for fiscal year 2008 (October 1, 2007, through September 30, 2008) maintained the maximum allowable sale of cobalt at 1,590 t (U.S. Department of Defense, 2008, p. 5, 7, 59).

During calendar year 2007, the DNSC sold 553 t of cobalt valued at \$36.1 million under the BOA. On December 31, the total uncommitted cobalt inventory held by the DNSC was 676 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 2007. 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 2007, there were three U.S. mine projects in the feasibility and permitting stages 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 completed a bankable feasibility study on its Idaho cobalt project and was in the final stages of permitting for its development. The company 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. Formation anticipated that the final mine permits would be granted in 2008. Once sufficient financing and bonding were in place, Formation would commence construction. Production of cobalt cathode was expected to begin 15 months later (Formation Capital Corp., 2008, p. 3, 5, 9).

Kennecott completed feasibility studies and decided to develop a small underground nickel-copper mine in the Eagle deposit in the Yellow Dog Plains area northwest of Marquette, MI. By early 2008, Kennecott had received all the State approvals needed to begin construction and was considering rehabilitating part of an abandoned mill in Humboldt Township to process crushed ore from Eagle and produce a concentrate for export. At the proposed rate of 16,000 t/yr of nickel, an estimated 450 t/yr of cobalt would be produced during a 7-year mine life, based on nickel and cobalt grades in the resource (Kennecott Eagle Minerals Co., 2008; Peppin, 2008; Rio Tinto plc, 2008, p. 18, 26).

PolyMet provided information to State and Federal regulatory agencies for 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 Cliffs-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 first 5 years of a 20-year mine life, approximately 330 t/yr of cobalt would be produced. PolyMet hoped to arrange financing and receive environmental and operating permits in time to begin production in late 2009. The company was considering the sale of copper-nickel concentrates during the construction and commissioning of the hydrometallurgical plant (PolyMet Mining Corp., 2008a, p. 14, 16, 21; 2008b, p. 2, 5–6).

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 eight U.S. cobalt processors. Information from this survey was used to prepare the statistics on cobalt consumption and stocks in table 3.

Osram Sylvania Inc. produced extra-fine cobalt metal powder as a byproduct of tungsten recovered from cemented carbide scrap in Towanda, PA. Allegheny Technologies Inc.'s Metalworking Products unit completed an expansion of the ammonium paratungstate production capacity at its Huntsville, AL, facility. The new plant, which became fully operational in 2007, could process tungsten ore concentrates and hard or soft scrap, which can contain cobalt (Allegheny Technologies Inc., 2008, p. 22, 32). Production and shipments of cobalt metal powder are withheld to avoid disclosing company proprietary data.

Consumption

U.S. apparent consumption for 2007, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 13% lower than that of 2006 (table 1). The decrease was primarily because net imports in 2007 were significantly lower than those of 2006.

U.S. reported consumption of cobalt in 2007 was slightly higher than that of 2006. Compared with consumption in 2006, metallurgical industries consumed slightly more cobalt, and the cobalt consumption for chemical uses was slightly 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, increased by 77% from that of 2006 (table 1). The price was lowest in mid-January at \$24.00 to \$25.50 per pound, increased to \$32.00 to \$34.00 per pound in mid-April, retreated to \$24.50 to \$25.50 in August, and then increased to a high of \$42.00 to \$44.00 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 \$29.61 per pound, and the annual average of weekly prices for Russian cobalt was \$29.37. Sales prices for 99.8% cobalt cathode reported by BHP Billiton ranged from \$24.00 to \$43.00 per pound.

Financial services company Credit Suisse Group launched a financial product based on cobalt in a joint venture with Swiss trading firm Glencore International AG. 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. The London Metal Exchange was also considering an over-the-counter trading platform for minor metals, including cobalt (Metal Bulletin, 2007b, c).

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 imported or produced in the United States. In 2007, net import reliance as a percentage of apparent consumption was 82%. Because there was no measurable U.S. primary cobalt production in 2007, this indicates that 82% of U.S. cobalt supply was from imports and stock releases of primary cobalt and 18% was from domestic or imported scrap.

In 2007, the United States imported 11% less cobalt than it did in 2006 (tables 4, 5). Ten countries supplied more than 90% of U.S. imports. Norway was the leading supplier, followed by Russia, Canada, China, Zambia, Finland, Belgium, Australia, Morocco, and Brazil.

The United States imported 41 t, gross weight, of unwrought cobalt alloys valued at \$2.6 million. Five countries supplied most of these materials—Morocco (37%), Japan (31%), the United Kingdom (14%), Finland (12%), and Austria (3%). The United States imported 1,210 t, gross weight, of cobalt waste and scrap valued at \$17.5 million. Nine countries supplied most of this material—Germany (30%), Ireland and the United Kingdom (15% each), Japan (9%), France and India (6% each), Canada (5%), and Austria and Tunisia (3% each). The United States also imported 206 t, gross weight, of wrought cobalt and cobalt articles valued at \$20.0 million. The leading suppliers of these materials were the United Kingdom (43%), Canada (16%), Germany (11%), Japan (10%), France (9%), and China and India (5% each).

U.S. exports of unwrought cobalt and cobalt contained in chemicals increased by 9% compared with those of 2006. As listed in table 6, the leading destinations for these exports were Japan, France, Canada, Belgium, and Ireland. The United States also exported 1,440 t, gross weight, of wrought metal and cobalt articles valued at \$89.3 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 2007. Expansions to those operations and greenfield projects that were forecast to begin producing between 2008 and 2012 are listed in table 8.

Australia.—BHP Billiton processed lateritic ore imported from Indonesia, New Caledonia, and the Philippines at its Yabulu nickel-cobalt refinery in Townsville, Queensland, and produced 1,800 t of cobalt as cobalt oxide hydroxide, a 13% increase from the 1,300 t produced in 2006 (BHP Billiton, 2007, p. 11; 2008a, p. 11).

In Western Australia, BHP Billiton's Nickel West operations 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. By yearend, BHP Billiton had completed plant construction and commissioning and produced 5,000 t of nickel-cobalt mixed hydroxide. BHP Billiton planned to begin processing the mixed hydroxide at its expanded Yabulu refinery as soon as sufficient quantities were available (BHP Billiton, 2008b).

Minara Resources Ltd. produced 1,884 t of cobalt as metal powder and briquettes from its Murrin Murrin nickel-cobalt laterite pressure-acid leaching operation east of Leonora, Western Australia, 10% less than the 2,096 t produced in 2006. The decrease was attributed to problems with the operation's acid plant, unplanned power outages, and scaling in the refinery. In addition, late in the year, the Murrin Murrin plant underwent a 7-week shutdown for statutory maintenance and refurbishment of the acid plant. By early 2008, Minara's demonstration plant for recovering nickel and cobalt by heap leaching stockpiled ore-reject material was operating at design capacity. The plant was to provide a second feed source to the Murrin Murrin refinery at a rate of approximately 2,000 t/yr of nickel and 150 t/yr of cobalt (Minara Resources Ltd., 2008).

OJSC MMC Norilsk Nickel acquired OM Group's nickel assets, which included the Cawse operations northwest of Kalgoorlie, Western Australia, and the Harjavalta nickel refinery in Finland. Intermediate nickel-cobalt carbonate produced by the Cawse high pressure acid leach plant was shipped to Harjavalta

for refining. Cawse had the capacity to produce carbonate containing 375 to 440 t/yr of cobalt (OJSC MMC Norilsk Nickel, 2006).

Norilsk acquired LionOre Mining International Ltd. and its three producing nickel sulfide operations in Western Australia—Black Swan, Lake Johnston, and Waterloo. Concentrates from Black Swan and Lake Johnston were processed at Boliden AB's smelter in Harjavalta, Finland, and the resulting matte was processed at Norilsk's Harjavalta, Finland, refinery; ores from Waterloo were sent to BHP Billiton's Nickel West operations for beneficiation (OJSC MMC Norilsk Nickel, undated b).

Sally Malay Mining Ltd. mined nickel-copper sulfide ores from its Sally Malay underground mine in Western Australia and produced concentrates containing 413 t of cobalt, a 6% increase from the 389 t produced in 2006. The concentrates were shipped to Jinchuan Group Ltd.'s operations in China under a life-of-mine sales agreement (Sally Malay Mining Ltd., 2007, 2008).

Fox Resources Ltd. restarted underground operations at its Radio Hill nickel-copper sulfide mine near Karratha, Western Australia, and shipped bulk nickel-copper concentrates to Jinchuan (Fox Resources Ltd., 2007).

Jubilee Mines NL signed a 1-year offtake agreement with BHP Billiton for the nickel sulfide concentrates produced from its Cosmos operation in Western Australia. The company's offtake agreement with Vale Inco Ltd. (formerly named CVRD Inco Ltd.) expired at the end of September 2007 (Jubilee Mines NL, 2007).

Zinifex Ltd. shipped zinc concentrates produced at its Century Mine in northern Queensland to the company's Budel smelter in the Netherlands, where cobalt was recovered as filter cake. In 2007, Zinifex transferred its lead and zinc smelting assets, including the Budel smelter, to Nyrstar NV (a joint venture between Zinifex and n.v. Umicore, S.A.) (Nyrstar NV, 2007, undated).

Numerous companies worked on copper and nickel projects that were to produce cobalt (table 8).

Belgium.—According to the Cobalt Development Institute (2008a), Umicore's 2007 cobalt refinery production was 2,825 t, slightly less than the 2,840 t produced in 2006. 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; Shanghai, China; and Cheonan, Republic of Korea.

Botswana.—Norilsk gained an 85% share in Tati Nickel Mining Co. (Proprietary) Ltd. when it acquired LionOre. Tati Nickel mined the Phoenix open pit and produced nickel-copper sulfide concentrates, some of which were toll-smelted by BCL Ltd. in Botswana and some of which were supplied to Jinchuan in China (OJSC MMC Norilsk Nickel, undated a).

Brazil.—Votorantim Metais Níquel S.A. (formed from the merger of Companhia Níquel Tocantins into Mineração Serra de Fortaleza S.A. in 2006) produced nickel matte from sulfide ores mined and smelted at Fortaleza de Minas, Minas Gerais

State, and cobalt cathode at its refinery in Sao Miguel Paulista, Sao Paulo State, from lateritic nickel-cobalt ore mined from Niquelandia, Goias State.

Burundi.—Artisanal mining of cobalt ore reportedly occurred in Ngozi Province (Sabushimike, 2007).

Canada.—Vale Inco produced 2,524 t of cobalt in 2007, 28% more than the 1,977 t produced in 2006. The company reported production was in the form of cathode, 1,304 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, 495 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 and nickel sulfide concentrates from Jubilee Mines NL's Cosmos nickel project in Western Australia. Vale reported the following distribution of sources for its cobalt production: Ontario, 727 t (665 t in 2006); Manitoba, 179 t (411 t in 2006); Voisey's Bay, 1,239 t (680 t in 2006); and external sources, 379 t (221 t in 2006) (Companhia Vale do Rio Doce, 2008, p. 38).

Xstrata Nickel produced 620 t of cobalt in concentrates from mines at Sudbury (671 t in 2006), 404 t of cobalt in concentrate from its Montcalm Mine northwest of Timmins, Ontario (431 t in 2006), and 523 t of cobalt in concentrate from its Raglan Mine in Quebec (486 t in 2006). Nickel-copper matte containing 2,498 t of cobalt was produced at the company's Sudbury smelter and refined at its Nikkelverk refinery in Norway. Some of the cobalt 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 included nickel sulfide ores mined in Ontario by First Nickel Inc. and PGM concentrates from North American Palladium Ltd.'s Lac des Iles Mine in northern Ontario. In 2007, Xstrata completed construction of a smelter-calciner at Sudbury for processing secondary nickel- and cobalt-bearing materials including battery-manufacturing scrap and used batteries, spent catalysts, and other materials (Tollinsky, 2008; Xstrata plc, 2008b).

The Fort Saskatchewan refinery of the joint venture of Sherritt International Corp. and General Nickel Co. S.A. produced 3,573 t of cobalt as metal powder and briquettes in 2007, 8% more than the 3,312 t produced in 2006. Approximately 87% 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 (table 8). As a result of a United States embargo on imports of products originating from Cuba, cobalt and nickel produced by Sherritt cannot be sold to customers in the United States (Sherritt International Corp., 2008, p. 7–8, 10).

FNX Mining Company Inc. mined nickel sulfide ore from its McCreedy West and Levack Mines in Sudbury containing 71 t of cobalt (38 t in 2006); the ore was processed by Vale Inco. Liberty Mines Inc. extracted nickel sulfide ores from its Redstone Mine southeast of Timmins, Ontario, and shipped concentrates to Jilin Jien Nickel Industry Company Ltd. in

China and, beginning in late 2007, to Xstrata Nickel in Sudbury (FNX Mining Company Inc., 2008, p. 10; Liberty Mines Inc., 2008, p. 8).

China.—China's production of refined cobalt was estimated to be approximately 15,200 t, which made it the world's leading producer. In 2007, 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); a small portion was from Cuba and elsewhere. One analyst estimated that China imported 13,945 t of cobalt contained in ores, concentrates, and semirefined materials in 2007, down from 16,300 t in 2006. Because of a ban on exports of unprocessed materials from Congo (Kinshasa), China's imports of cobalt ores and concentrates decreased significantly in 2007 compared with those of 2006, but its imports of semirefined materials increased (Baker, 2008, p. 6–9; Xu, 2008, p. 3–5).

The number of companies refining and/or processing cobalt in China has been estimated to be as high 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. In 2007, Jinchuan produced 6,032 t of 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 carbonates produced in China from imported cobalt concentrates; nickel-copper concentrates from Australia, GobiMin Inc.'s mines in the Hami region of northwestern China, Spain, and elsewhere; and nickel matte from BHP Billiton and other companies. Jinchuan also had offtake agreements for nickel concentrates from future production from the Avebury project in Australia and the Munali project in Zambia (Xu, 2006, p. 2; Li, 2007; Asian Metal Ltd., 2008; CRU International Ltd., 2008, p. 4; Interfax Ltd., 2008).

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, but a large portion continued to be gathered by tens of thousands of artisanal miners hand-picking cobalt-rich ores. These ores were sold to middlemen or trading houses, and either exported, primarily to China and India, or processed at numerous plants within Congo (Kinshasa) to semirefined materials such as cobalt carbonate or alliage blanc (an alloy of cobalt, copper, and iron). As discussed in the "China" section of this report, the Government of Congo (Kinshasa) banned the export of unprocessed cobalt ores and, for a period of time, cobalt concentrates to encourage more development of downstream processing within the country. As a result, in 2007, total cobalt exports from Congo (Kinshasa) decreased compared with those of 2006, exports of ores and concentrates decreased, and exports of semirefined cobalt materials increased (Baker, 2008, p. 6–8).

The Government of Congo (Kinshasa) initiated a 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. The review was not yet completed at yearend (Commission de Revisitation des Contrats Minières, 2007, p. 3–4).

The Government of Congo (Kinshasa) signed a multibillion dollar loan and infrastructure development package with China. Part of the loan was to be used to develop Congo (Kinshasa)'s mining industry, and was to be paid off in part by giving Chinese companies mining rights to some of Congo (Kinshasa)'s copper-cobalt concessions (Bavier, 2007).

State-owned producer La Générale des Carrières et des Mines (Gécamines) produced 606 t of refined cobalt, compared with 550 t in 2006 (Cobalt Development Institute, 2008a).

Boss Mining Sprl [a subsidiary of Central African Mining & Exploration Company plc (CAMEC)] mined ore from the Kababankola open pit and produced cobalt concentrates at the Kakanda concentrator. The concentrates were processed at CAMEC's Luita facility, where CAMEC was building a copper SX/EW plant on a modular basis. The first module was commissioned in March, and the plant produced more than 470 t of cobalt in carbonate by yearend. CAMEC planned to expand the plant's cobalt capacity in the next few years (table 8). Late in the year, the company signed a memorandum of understanding with Prairie International Ltd. to form a joint venture to develop and operate copper-cobalt mines at Mukondo Mountain and other concession areas in Congo (Kinshasa). Boss Mining, the Kakanda concentrator, and the Luita plant would be owned by the joint venture (Central African Mining & Exploration Company plc, 2007; 2008, p. 14, 21).

Gécamines and L'Enterprise Générale Malta Forrest S.P.R.L. produced 4,500 t of cobalt in copper-cobalt concentrates from the Luiswishi Mine, which were sold under a long-term supply contract to OMG (George Forrest International S.A., 2008).

Nikanor PLC mined ore from the Tilwezembe and Kananga open pit mines and produced 46,800 t of concentrate with an average grade of 13.08% copper and 5.79% cobalt at its Kolwezi concentrator. At midyear, the company entered a long-term offtake agreement with Swiss trading firm Glencore International AG for 100% of its output (Katanga Mining Ltd., 2008, p. 58).

Anvil Mining Ltd. produced copper-cobalt oxide concentrates from its Kulu tailings retreatment operation near Kolwezi, and began producing copper-cobalt oxide concentrates from its Kinsevere open pit operation near Lubumbashi. Some of the concentrates were smelted locally and some were exported.

The Big Hill smelter at Lubumbashi (operated as a joint venture between Gécamines, OMG, and S.A. Groupe George Forrest) processed stockpiled slag to produce a cobalt-copper alloy, which was sold to OMG's Kokkola refinery. In 2007, the smelter produced alloy containing 5,500 t of cobalt, up from the 4,300 t produced in 2006 (Metal Bulletin, 2007a; George Forrest International S.A., 2008).

Minière de Musoshi et Kinsenda S.A.R.L. (a joint venture of Copper Resources Corp., Sodiminco, and Metorex Ltd.)

processed copper-cobalt ore from its Kimono dumps and produced alliage blanc at its electric arc furnace at Musoshi. The amount of cobalt contained in exports of the alloy was 15 metric tons per month at midyear and was expected to increase by about 20% in the near term (Copper Resources Corp., 2007).

Chemaf SPRL's production of cobalt contained in carbonate increased to 2,599 t from 2,044 t in 2006. The company began construction on an SX-EW plant to produce cobalt cathode at its Lubumbashi refinery, which used copper-cobalt oxide ores extracted from the nearby Etoile Mine (Shalina Resources Ltd., 2008).

Numerous additional processing plants in Katanga Province, many of which were owned by Chinese companies, produced cobalt carbonate or cobalt-bearing alloys from cobalt concentrates.

Metorex Ltd. began open pit mining and produced copper-cobalt concentrates from freshly mined ore and minerals stockpiled by Gécamines from past mining operations at Ruashi and Etoile. The resulting concentrates were refined in Zambia at the company's Sable Zinc refinery (as discussed in the "Zambia" section of this report). Metorex worked on constructing phase 2 of the Ruashi project (table 8) and decided to continue operating the phase I plant after the phase 2 plant began operations. This was expected to add an additional 800 t/yr of cobalt production (Metorex Ltd., 2007, p. 23; 2008).

Katanga Mining Ltd. and Nikanor agreed to merge. The resulting company, which would retain the name Katanga Mining Ltd., would reunite 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 Lulu 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, Kolwezi concentrator, and plans to build a new copper and cobalt SX-EW refinery]. Forecasts for future output from these operations are listed in table 8. As part of a loan agreement with Glencore, Katanga agreed to sell 100% of the copper and cobalt it produced from all mines owned or subsequently acquired, except for that committed under preexisting sales agreements, to Glencore for a period of 10 years (Katanga Mining Ltd., 2008, p. 7–8).

Freeport-McMoRan Copper & Gold Inc. acquired Phelps Dodge Corp. and its Tenke Fungurume mine and refinery project northwest of Lubumbashi (table 8).

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 containing a record 33,661 t of nickel and cobalt, 13% more than the 29,855 t produced in 2006. All the mixed sulfides were sent to the joint venture's Fort Saskatchewan refinery in Canada. During the year, Moa Nickel worked on construction of the first and second phases of its expansion project (table 8) (Sherritt International Corp., 2008, p. 7, 10).

Unión del Níquel S.A. mined lateritic ores and produced nickel-cobalt mixed sulfides in Holguin Province at the Ernesto Che Guevara Mining and Metallurgical Combine at Punta Gorda. Nickel and cobalt of Cuban origin cannot be imported

into the United States because of a United States embargo on imports from Cuba.

Finland.—OMG's production of refined cobalt, as metal powders, briquettes, oxides, and compounds, was 7% higher than that of 2006. The company's Kokkola Chemicals Oy refinery processed raw materials sourced primarily from Australia, Congo (Kinshasa), Finland, and Russia. Before 2007, these included cobalt-copper alloy from the Big Hill smelter and concentrates from the Luiswishi Mine in Congo (Kinshasa), cobalt solution from its Harjavalta nickel refinery in Finland, and other materials, including low-grade ores and concentrates, sulfides, metallic feeds, and secondary materials (scrap). In early 2007, OMG finalized the sale of its nickel assets to Norilsk. As part of the agreement, the two companies established 5-year agreements for Norilsk to supply OMG with the following materials: up to 2,500 t/yr of 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 (OM Group, Inc., 2008, p. 21, 73).

Belvedere Resources Ltd. acquired the operating Hitura nickel-copper sulfide mine and concentrator from Outokumpu Mining Oy and completed its purchase of Finn Nickel Ltd., a private Finnish company with a number of nickel properties. Belvedere began mining from one of the Finn Nickel properties (Sarkiniemi), and reported that by yearend its production of cobalt in concentrate from the two mines was 64 t (Belvedere Resources Ltd., 2008, p. 2, 15, 17).

France.—The Eramet Group's production of cobalt chloride from its refinery at Sandouville increased by 19% compared with that of 2006. Feed for the refinery was nickel matte imported from Eramet subsidiary Le Nickel SLN's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2008a).

India.—According to the Cobalt Development Institute (2008a), India's cobalt production decreased by 17% from that of 2006. 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 was building a smelter in Congo (Kinshasa) for the production of alliage blanc, which would be exported to its plant near Vadodara, Gujarat State, for refining. The company planned to expand the cobalt capacity of its Indian plant to handle the increase in feed (table 8) (Cobalt Development Institute, 2008a; Metal Bulletin, 2008a).

Indonesia.—Lateritic nickel-cobalt ore was exported to QNI's Yabulu refinery for processing.

Japan.—Sumitomo Metal Mining Co., Ltd.'s production of electrolytic cobalt at its Niihama nickel refinery continued to increase in 2007 as a result of an increase in nickel-cobalt mixed sulfide feed from the Coral Bay Nickel Corp. plant in the Philippines. The refinery also processed nickel matte from P.T. Inco in Indonesia, BHP Billiton's Nickel West operations, and elsewhere (CRU International Ltd., 2008, p. 4).

Madagascar.—Sherritt acquired Dynatec Corp. and became the operator of the Ambatovy nickel laterite project, where construction commenced midyear (table 8) (Sherritt International Corp., 2008, p. 3, 10–11).

Morocco.—Cie. de Tifnout Tiranimine (CTT) increased the capacity of its processing plant at Bouazzer so that it would be able to produce twice the quantity of cobalt hydroxide, and inaugurated a cobalt oxide unit 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 QNI'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 20% lower than that of 2006. The cobalt originated from Xstrata Nickel mines in Canada 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 reduced supply of cobalt-bearing custom feed materials. Some of the custom feed used by Nikkelverk reportedly was supplied by Norilsk prior to its agreement to supply most of its cobalt to OMG (Platts Metals Week, 2007b; Xstrata plc, 2008a, p. 79; 2008b).

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

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 2007, construction was underway to double the plant's capacity (table 8). All the mixed sulfide produced by Coral Bay Nickel was refined by Sumitomo in Japan (Sumitomo Metal Mining Co., Ltd., 2008).

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. According to the Cobalt Development Institute (2008a), Norilsk produced 3,587 t of refined cobalt in 2007, a 25% decrease from the 4,759 t produced in 2006. The decrease was attributed to the fact that at midyear Norilsk ceased sending its cobalt intermediates to OJSC Ufaleynickel in the Ural Mountains for toll refining. Instead, the intermediates were sent to OM Group under the supply agreement established following the sale of OM Group's nickel assets to Norilsk, as discussed in the "Finland" section of this report (Metal Bulletin, 2008b).

Ufaleynickel's annual cobalt production decreased by more than one-half to 1,130 t from 2,493 t in 2006. The decrease was attributed to the cessation of toll-refining cobalt intermediates for Norilsk and Ufaleynickel's construction activities on its cobalt facilities (OJSC Ufaleynickel, 2008, p. 9–10).

South Africa.—Cobalt was mined as a byproduct from the Nkomati nickel sulfide mine and nine PGM mines. 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 planned to increase 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. 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 (Harding, 2007; Anglo Platinum Ltd., 2008, p. 78–79).

Spain.—Lundin Mining Corp. acquired the Aguablanca open pit nickel sulfide mine and processing plant in Badajoz Province through a takeover of Rio Narcea Gold Mines, Ltd. The mine produced nickel-copper concentrate containing an estimated 160 t of cobalt, which it sold to Jinchuan under a long-term sales agreement (Lundin Mining Corp., 2008).

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 mid-2012 (Blue Earth Refineries Inc., 2008, p. 13).

Zambia.—Mopani Copper Mines Plc produced approximately 1,700 t of cobalt metal at its Nkana cobalt refinery, 18% more than the 1,438 t produced in 2006. Most of the cobalt originated from the company's Nkana underground copper-cobalt mine (First Quantum Minerals Ltd., 2008, p. 25).

Chambishi Metals plc produced 2,635 t of cobalt metal at its Chambishi refinery, 18% less than the 3,227 t produced in 2006. The decrease in production was attributed to three unscheduled shutdowns, problems with power, and a shortage of feed. 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 (Metal Bulletin, 2008b; Cunico Resources Resources N.V., undated).

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga and Konkola operations. The company reportedly terminated its cobalt concentrate supply contract with Chambishi Metals and announced plans to resume cobalt production from the Nchanga open pit in early 2008. Production was forecast to reach approximately 200 metric tons per month of cobalt in ore (Platts Metals Week, 2007a; 2008).

Metorex produced cobalt carbonate at its Sable copper electrowinning plant near Kabwe from purchased copper-cobalt concentrates and from copper-cobalt concentrates produced from stockpiled and freshly mined ore at the company's Ruashi operations in Congo (Kinshasa). Production increased to 391 t of cobalt, compared with 53 t produced in 2006, the plant's first year of operation (Metorex Ltd., 2007, p. 19; 2008).

Zimbabwe.—Bindura Nickel Corp. worked to improve the capacity and extend the lives of its Shangani and Trojan nickel sulfide mines. In early 2008, the company completed construction of a new concentrator at Trojan. Cobalt hydroxide is one of the products from the company's nickel refinery (Mwana Africa PLC, 2008, p. 13). Aquarius Platinum Ltd. produced 64 t of cobalt from its Mimosa platinum mine, compared with 61 t in 2006. The concentrates were refined by Impala in South Africa (Aquarius Platinum Ltd., 2007, p. 14; 2008, p. 19).

Outlook

During the first half of 2008, the worldwide demand for cobalt reportedly was slightly higher than that of the first half of 2007, and world availability of refined cobalt (as measured by production and U.S. Government shipments) was 5% higher than that of the first half of 2007. During 2008, production from new operations or expansions of existing operations began in Australia, Canada, Congo (Kinshasa), Cuba, Finland, and Zambia. Numerous additional brownfield and greenfield projects that would add to future world cobalt supply were in the planning and development stages. After reaching a high of more than \$50 per pound in early 2008, the trend in the price of cobalt cathode was downward for the remainder of the year, with the exception of a temporary increase during late summer-early fall. Low cobalt, copper, and nickel prices and the serious downturn in the global financial markets in late 2008 were expected to delay financing, construction, and startup of some new production (Cobalt Development Institute, 2008b).

References Cited

- Allegheny Technologies Inc., 2008, Form 10-K—2007: Securities and Exchange Commission, 86 p.
- Anglo Platinum Ltd., 2008, 2007 annual report: Johannesburg, South Africa, Anglo Platinum Ltd., 242 p.
- Aquarius Platinum Ltd., 2007, Second quarter 2007 financial year production results: Hamilton, Bermuda, Aquarius Platinum Ltd., January 25, 26 p.
- Aquarius Platinum Ltd., 2008, Second quarter 2008 production results: Hamilton, Bermuda, Aquarius Platinum Ltd., January 24, 24 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.
- Bavier, Joe, 2007, Congo seeks more new partners after huge China loan: Goma, Congo (Kinshasa), Reuters Ltd., December 6. (Accessed December 11, 2007, at <http://africa.reuters.com/top/news/usnBAN656488.html>.)
- Belvedere Resources Ltd., 2008, Management's discussion & analysis for the year ended December 31, 2007: Vancouver, British Columbia, Canada, Belvedere Resources Ltd., April 28, 22 p.
- BHP Billiton, 2007, BHP Billiton production report for the nine months ended 31 March 2007: Melbourne, Australia, BHP Billiton news release, April 24, 15 p.
- BHP Billiton, 2008a, BHP Billiton production report for the half year ended 31 December 2007: Melbourne, Australia, BHP Billiton news release, January 23, 15 p.
- BHP Billiton, 2008b, BHP Billiton quarterly report on exploration and development activities—Quarter ended 31 December 2007: Melbourne, Australia, BHP Billiton news release, January 23, 4 p.
- Blue Earth Refineries Inc., 2008, Form 20-F—2007: Securities and Exchange Commission, 75 p.
- Central African Mining & Exploration Company plc, 2007, CAMEC signs MOU to create new DRC joint venture company: London, United Kingdom, Central African Mining & Exploration Company plc news release, November 7, 2 p.
- Central African Mining & Exploration Company plc, 2008, Annual report and financial statements 2008: London, United Kingdom, Central African Mining & Exploration Company plc, 147 p.
- Cobalt Development Institute, 2008a, 2007 production statistics: Cobalt News, no. 2, April, p. 3–4.
- Cobalt Development Institute, 2008b, 2008 first half production statistics: Cobalt News, no. 4, October, p. 3–4.
- Commission de Revisitation des Contrats Minières, 2007, Rapport des travaux: Kinshasa, Congo (Kinshasa), Ministère des Mines, v. 1, November, 228 p.
- Companhia Vale do Rio Doce, 2008, Form 20-F for the fiscal year ended December 31, 2007: Securities and Exchange Commission, 145 p.

- Copper Resources Corp., 2007, Interim report for the six months ended 30 June 2007: Johannesburg, South Africa, Copper Resources Corp., October 1, 10 p.
- CRU International Ltd., 2008, CRU monitor—Nickel cobalt intermediates: London, United Kingdom, CRU International Ltd., May, 14 p.
- Cunico Resources N.V., [undated], Chambishi Metals: Amsterdam, Netherlands, Cunico Resources N.V. (Accessed December 5, 2008, at http://www.cunicoresources.com/o/cc_p_chambishi.php.)
- First Quantum Minerals Ltd., 2008, 2007 annual report: Vancouver, British Columbia, Canada, First Quantum Minerals Ltd., 76 p.
- FNX Mining Company Inc., 2008, 2007 annual report: Toronto, Ontario, Canada, FNX Mining Company Inc., 76 p.
- Formation Capital Corp., 2008, Annual information form for the year ended February 29, 2008: Vancouver, British Columbia, Canada, Formation Capital Corp., 46 p.
- Fox Resources Ltd., 2007, Quarterly report March 2007: Leederville, Australia, Fox Resources Ltd., April 30, 11 p.
- George Forrest International S.A., 2008, Communiqué du Groupe Forrest—Fiscalite 2007 et ITIE: Brussels, Belgium, George Forrest International S.A. press release, May 27. (Accessed October 3, 2008, at <http://www.forrestgroup.com/flash/uk/chap06/infos45.html>.)
- Groupe ONA, 2007, Résultats du 3ème trimestre 2007: Casablanca, Morocco, Groupe ONA, 1 p.
- Groupe ONA, 2008, Résultats de l'exercice 2007: Casablanca, Morocco, Groupe ONA, 1 p.
- Harding, A.J., 2007, Cobalt, *in* South Africa's mineral industry 2006/2007: Pretoria, South Africa, Mineral Economics Directorate, p. 83–87.
- Interfax Ltd., 2008, Jinchuan Group to offtake nickel concentrate from Vietnamese mine: China Mining & Metals Weekly, v. 7, issue 17, April 26–May 9, 2008, p. 17.
- Jubilee Mines NL, 2007: Jubilee secures new nickel off-take agreement: West Perth, Australia, Jubilee Mines NL ASX/media release, August 27, 1 p.
- Katanga Mining Ltd., 2008, Annual information form for the year ended December 31, 2007: London, United Kingdom, Katanga Mining Ltd., 87 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, Annual information form for the year ended December 31, 2007: Edmonton, Alberta, Canada, Liberty Mines Inc., 64 p.
- Lundin Mining Corp., 2008, Quarterly operations update—Aguablanca—Fourth quarter December 31, 2007. (Accessed April 22, 2008, at <http://www.lundinmining.com/s/QOU.asp?ReportID=289881>.)
- Metal Bulletin, 2007a, [untitled]: Metal Bulletin, no. 8977, January 8, p. 10.
- Metal Bulletin, 2007b, Comment—Cobalt's new conduit: Metal Bulletin, no. 9011, September 3, p. 5.
- Metal Bulletin, 2007c, LME will wait to focus on minor metals trading: Metal Bulletin, no. 8988, March 26, p. 16.
- Metal Bulletin, 2008a, India's Rubamin to start up DRC cobalt facility in June: Metal Bulletin, no. 9045, May 5, p. 12.
- Metal Bulletin, 2008b, Production by CDI members fell in 2007: Metal Bulletin, no. 9041, April 7, p. 10.
- Metorex Ltd., 2007, Annual report 2007: Johannesburg, South Africa, Metorex Ltd., 96 p.
- Metorex Ltd., 2008, Consolidated unaudited interim results for the period ended 31 December 2007: Johannesburg, South Africa, Metorex Ltd., February 20, 8 p.
- Minara Resources Ltd., 2008, Full year report 2007: Perth, Australia, Minara Resources Ltd., 5 p.
- Mwana Africa PLC, 2008, Annual report 2008: London, United Kingdom, Mwana Africa PLC, 88 p.
- Nyrstar NV, 2007, Nyrstar completes transfer of zinc and lead smelting assets from Umicore and Zinifex: Brussels, Belgium, Nyrstar NV press release, September 3, 5 p.
- Nyrstar NV, [undated], Introduction: London, United Kingdom, Nyrstar NV. (Accessed May 8, 2008, at <http://www.budelzink.nl/en/processen/algemeen.htm>.)
- OJSC MMC Norilsk Nickel, 2006, Acquisition of OM Group's nickel business assets: Moscow, Russia, OJSC MMC Norilsk Nickel, November 20, 6 p. (Accessed December 13, 2006, at <http://www.nornik.ru/upload/2006-11-20-pr-eng.pdf>.)
- OJSC MMC Norilsk Nickel, [undated]a, Norilsk Nickel Africa: Moscow, Russia, OJSC MMC Norilsk Nickel (Accessed May 7, 2008, at http://www.nornik.ru/en/our_products/norilsknickelafrica/.)
- OJSC MMC Norilsk Nickel, [undated]b, Norilsk Nickel Australia: Moscow, Russia, OJSC MMC Norilsk Nickel (Accessed July 3, 2008, at http://www.nornik.ru/en/our_products/norilsknickelaustralia/.)
- OJSC Ufaleynickel, 2008, Annual report for 2007: Verkhny Ufaley, Russia, OJSC Ufaleynickel, 72 p.
- OM Group, Inc., 2008, 2007 annual report: Cleveland, OH, OM Group, Inc., 89 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, 2007a, Chambishi to lose \$300,000/day due to cobalt furnace shutdown: Platts Metals Week, v. 78, no. 5, January 29, p. 3.
- Platts Metals Week, 2007b, DLA may exhaust cobalt end-March 2008—Traders: Platts Metals Week, v. 78, no. 50, December 10, p. 13.
- Platts Metals Week, 2008, KCM to resume cobalt production: Platts Metals Week, v. 79, no. 10, March 10, p. 7.
- PolyMet Mining Corp., 2008a, Advancing toward production—U.S. copper nickel & precious metals: BMO Capital Markets 2008 Global Metals and Mining Conference, Hollywood, FL, February 24–27, 2008, Presentation, 30 p.
- PolyMet Mining Corp., 2008b, Management discussion and analysis for the year ended 31 January, 2008: Vancouver, British Columbia, Canada, PolyMet Mining Corp., April 29, 27 p.
- Rio Tinto plc, 2008, 2007 annual report: London, United Kingdom, Rio Tinto plc, 136 p.
- Sabushimike, Gorgon, 2007, Cobalt discovery excites: East African Business Week (Kampala), September 24. (Accessed October 1, 2007, at <http://allafrica.com/stories/200709250835.html>.)
- Sally Malay Mining Ltd., 2007, Quarterly report for the period ended 30 June 2007: Perth, Australia, Sally Malay Mining Ltd., July 31, 10 p.
- Sally Malay Mining Ltd., 2008, Quarterly report for the period ended 31 December 2007: Perth, Australia, Sally Malay Mining Ltd., January 31, 11 p.
- Shalina Resources Ltd., 2008, Chemaf SPRL fact sheet: Dubai, United Arab Emirates, Shalina Resources Ltd., 3 p.
- Sherritt International Corp., 2008, Annual information form—2007: Toronto, Ontario, Canada, Sherritt International Corp., March 28, 90 p.
- Sumitomo Metal Mining Co., Ltd., 2008, Coral Bay Nickel Corporation revises construction costs for HPAL plant #2: Tokyo, Japan, Sumitomo Metal Mining Co., Ltd. press release, February 18, 1 p.
- Tollinsky, Norm, 2008, Xstrata boosts recycling capacity: Sudbury Mining Solutions Journal, v. 5, no. 2, June 1, p. 1, 36.
- U.S. Department of Defense, 2008, Strategic and critical materials operations report to the Congress—Operations under the Strategic and Critical Materials Stock Piling Act during the period October 2006 through September 2007: Washington, DC, U.S. Department of Defense, 68 p.
- Xstrata plc, 2008a, Annual report 2007: Zug, Switzerland, Xstrata plc, 279 p.
- Xstrata plc, 2008b, Production report for 12 months ended 31 December 2007: Zug, Switzerland, Xstrata plc press release, February 25, 8 p.
- Xu, Aidong, 2006, China's status in world cobalt market: The Cobalt Conference, Cobalt Development Institute, Marrakech, Morocco, May 17–18, 2006, Presentation, 14 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.

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.
 Interactive Tariff and Trade Dataweb. U.S. International Trade Commission.
 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 Antaike 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)

	2003	2004	2005	2006	2007
United States:					
Consumption:					
Reported	8,030	8,990	9,150	9,280 ^r	9,340
Apparent	10,000	9,950	11,800	11,000 ^r	9,600
Imports for consumption	8,080	8,720	11,100	11,600	10,300
Exports	2,710	2,500	2,440	2,850	3,100
Stocks, December 31:					
Industry ²	649	690	705	737 ^r	651
U.S. Government ³	4,290	2,660	1,550	1,290	676
Price, metal ⁴ dollars per pound	10.60	23.93	15.96	17.22	30.55
World, production:					
Mine	52,900 ^r	58,600 ^r	63,400 ^r	65,900 ^r	65,500 ^e
Refinery	43,200 ^r	48,500 ^r	54,100 ^r	53,800 ^r	53,500

^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 2003–06 includes material committed for sale pending shipment; 2007 is 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)

	2006	2007
Sales:		
Fiscal year ²	200	388
Calendar year	256	553
Shipments: ³		
Fiscal year ²	341	481
Calendar year	260	617

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

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

³Calculated from yearend inventory levels. Yearend data for 2005 and 2006 include material committed for sale pending shipment; yearend data for 2007 are uncommitted material only.

Source: Defence National Stockpile Center.

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

(Metric tons, cobalt content)

	2006	2007
Consumption by end use:		
Steels	700	725
Superalloys	4,170 ^r	4,340
Alloys, excludes steels and superalloys:		
Magnetic alloys	386	385
Other alloys ³	224	225
Cemented carbides ⁴	808 ^r	726
Chemical and ceramic uses	2,920	2,880
Miscellaneous and unspecified	63	63
Total	9,280 ^r	9,340
Consumption by form:		
Chemical compounds, organic and inorganic ⁵	2,760	2,700
Metal	4,510 ^r	4,710
Purchased scrap	2,010	1,930
Total	9,280 ^r	9,340
Stocks, December 31: ⁶		
Chemical compounds, organic and inorganic ⁵	196	178
Metal	412 ^r	413
Purchased scrap	129	60
Total	737 ^r	651

^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

	2006			2007		
	Gross weight (metric tons)	Cobalt content ² (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content ² (metric tons)	Value (thousands)
<u>Metal³</u>	9,950	9,950	\$302,000	8,960	8,960	\$487,000
<u>Oxides and hydroxides</u>	1,180	847	29,400	1,020	738	44,400
<u>Other forms:</u>						
Acetates	536	129	3,520	213	51	2,830
Carbonates	1,010	465	15,100	523	241	15,100
Chlorides	63	16	683	228	57	2,970
Sulfates	717	194	4,920	988	267	10,100
Grand total	13,500	11,600	356,000	11,900	10,300	563,000

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)
2006:												
Australia	449	449	\$12,500	--	--	--	--	--	--	449	449	\$12,500
Belgium	254	254	7,900	360	259	\$9,460	62	20	\$610	676	533	18,000
Brazil	265	265	7,930	--	--	--	17	7	245	282	272	8,180
Canada	967	967	29,500	--	--	--	--	--	--	967	967	29,500
China	1,210	1,210	36,800	235	169	4,800	339	134	3,740	1,780	1,510	45,400
Congo (Kinshasa)	31	31	744	--	--	--	--	--	--	31	31	744
Finland	268	268	9,980	347	250	8,530	985	381	12,000	1,600	899	30,500
France	14	14	936	30	22	1,280	--	--	--	44	36	2,220
Germany	17	17	821	5	4	370	--	--	--	22	21	1,190
India	27	27	705	--	--	--	339	92	1,980	366	118	2,690
Japan	202	202	6,240	1	(6)	35	5	1	51	208	204	6,330
Korea, Republic of	12	12	125	--	--	--	36	9	299	48	20	424
Morocco	257	257	7,490	--	--	--	--	--	--	257	257	7,490
Norway	2,230	2,230	66,900	--	--	--	--	--	--	2,230	2,230	66,900
Philippines	--	--	--	--	--	--	49	20	963	49	20	963
Russia	2,630	2,630	79,900	--	--	--	--	--	--	2,630	2,630	79,900
South Africa	73	73	2,060	--	--	--	272	65	1,390	345	138	3,460
Sweden	4	4	132	--	--	--	--	--	--	4	4	132
Uganda	133	133	3,760	--	--	--	--	--	--	133	133	3,760
United Kingdom	26	26	640	194	140	4,880	213	70	2,840	433	236	8,360
Zambia	885	885	26,800	--	--	--	--	--	--	885	885	26,800
Other	(6)	(6)	37	4	3	76	10	4	160	14	7	273
Total	9,950	9,950	302,000	1,180	847	29,400	2,330	803	24,200	13,500	11,600	356,000
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

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)	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—Continued:											
Korea, Republic of	41	41	(6)	(6)	\$8	19	4	\$167	60	46	\$1,050
Morocco	399	399	--	--	--	--	--	--	399	399	22,300
Norway	1,970	1,970	--	--	--	--	--	--	1,970	1,970	111,000
Russia	1,550	1,550	--	--	--	(6)	(6)	2	1,550	1,550	84,600
South Africa	86	86	10	7	395	--	--	--	96	93	4,700
Sweden	4	4	--	--	--	--	--	--	4	4	164
Uganda	144	144	--	--	--	--	--	--	144	144	7,540
United Kingdom	13	13	134	96	5,870	366	101	4,020	514	211	10,500
Zambia	738	738	--	--	--	--	--	--	738	738	43,400
Other	4	4	6	4	297	(6)	(6)	2	10	8	470
Total	8,960	8,960	1,020	738	44,400	1,950	616	31,100	11,900	10,300	563,000

-- 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 2007, 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)	Gross weight (metric tons)	Value ⁴ (thousands)	Gross weight (metric tons)	Value ⁴ (thousands)	Cobalt content ⁵ (metric tons)	Value ⁴ (thousands)
Argentina	33	\$1,220	101	\$182	--	--	--	--	--	--	--	105	105	\$1,410
Australia	20	147	--	--	--	--	--	--	--	--	--	20	20	147
Belgium	309	8,050	--	--	123	\$1,340	--	--	--	--	--	338	338	9,390
Brazil	1	116	--	--	3	43	--	--	--	--	--	2	2	159
Canada	340	8,380	64	1,630	15	164	2	\$32	2	\$32	2	390	390	10,200
China	4	177	10	145	3	36	(6)	5	(6)	5	5	12	12	363
Colombia	--	--	5	121	(6)	4	--	--	--	--	--	4	4	124
Costa Rica	--	--	12	151	--	--	--	--	--	--	--	8	8	151
Dominican Republic	37	114	--	--	--	--	--	--	--	--	--	37	37	114
France	462	15,600	--	--	--	--	--	--	--	--	--	462	462	15,600
Germany	106	6,960	2	27	15	122	--	--	--	--	--	112	112	7,110
Guatemala	56	171	--	--	--	--	--	--	--	--	--	56	56	171
India	14	750	21	83	12	113	--	--	--	--	--	32	32	946
Ireland	322	10,100	(6)	3	--	--	--	--	--	--	--	322	322	10,100
Italy	6	319	--	--	--	--	--	--	--	--	--	6	6	319
Japan	293	6,810	521	21,100	--	--	--	--	--	--	--	669	669	27,900
Korea, Republic of	178	1,930	1	30	5	173	--	--	--	--	--	180	180	2,130
Mexico	7	498	29	1,170	55	614	(6)	4	(6)	4	4	42	42	2,280
Netherlands	52	3,020	2	38	--	--	--	--	--	--	--	53	53	3,060
Singapore	8	415	86	3,520	--	--	--	--	--	--	--	70	70	3,940
Sweden	15	377	--	--	--	--	--	--	--	--	--	15	15	377
Switzerland	19	446	--	--	--	--	--	--	--	--	--	19	19	446
United Kingdom	115	2,870	--	--	--	--	--	--	--	--	--	115	115	2,870
Venezuela	--	--	10	261	--	--	--	--	--	--	--	7	7	261
Other	23	847	(6)	13	(6)	5	--	--	--	--	--	23	23	865
Total	2,420	69,300	863	28,400	232	2,610	3	45	3	45	3	3,100	3,100	100,000

-- 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 1/2 unit.

Source: U.S. Census Bureau.

TABLE 7
WORLD ANNUAL COBALT REFINERY
CAPACITY, DECEMBER 31, 2007^{1,2}

(Metric tons, cobalt content)

Country	Capacity
Australia	6,000
Belgium	1,500
Brazil	1,420
Canada ^e	5,980
China ^e	30,000
Congo (Kinshasa) ^{e, 3}	15,000
Finland	10,000
France	500
India	1,560
Japan ^e	1,100
Morocco ^e	1,650
Norway	5,200
Russia ^e	6,000
South Africa ^e	750
Uganda	720
Zambia	8,200
Total	95,600

^eEstimated.

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.

³Refurbishment necessary to achieve stated capacity.

TABLE 8
COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2012^{1,2}

Projected year of first production	Country	Project and company	Project type ³	Principal metal	Ore/feed type ⁴	Annual production capacity (metric tons, cobalt content)	Cobalt product ⁴
2008	Australia	Avebury Nickel Allegiance Mining NL	new mine and beneficiation plant	nickel	Ni sulfide ore	170 ^e	Ni concentrate.
2008	do.	Browns Oxide Compass Resources NL and Hunan Nonferrous Metals Corp.	new mine and relocated and refurbished refinery	copper	Cu-Co-Ni oxide ore	1,000	Co-Ni carbonate.
2008	do.	Copernicus Nickel Sally Malay Mining Ltd. and Thundelarra Exploration Ltd.	new mine	nickel	Ni-Cu sulfide ore	55 ⁵	Ni-Cu sulfide ore.
2008	do.	Yabulu expansion BHP Billiton	expansion of existing refinery	do.	Ni-Co hydroxide	3,500 ⁶	Co oxide hydroxide.
2008	Canada	Bucko Lake Crowflight Minerals Inc. and Xstrata Nickel	new mine and relocated beneficiation plant	do.	Ni-Cu-Co-Au-PGM sulfide ore	70 ^e	Ni concentrate.
2008	do.	Shakespeare Ursa Major Minerals Inc.	new mine and beneficiation plant	copper-nickel	Cu-Ni-Co-precious metals sulfide ore	260 ⁵	Cu-Ni concentrate.
2008	China	Cobalt plant, phase I Ganzhou Anhua Cobalt Industry Co. Ltd.	replace existing refinery	cobalt	NA	2,000 ⁶	NA.
2008	do.	Refinery expansion Jinchuan Group Ltd.	expansion of existing refinery	nickel	Ni-Cu matte	8,000 ⁶	Co cathode and other.
2008	Congo (Kinshasa)	Kamoto-Dima, phase I Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	rehabilitate and reopen existing underground mine, beneficiation plant, and refinery; develop new open pit mines	copper	Cu-Co oxide and sulfide ores	2,000 ^e	Co cathode.
2008	do.	Likasi plant Rubamin Ltd.	new smelter	do.	Cu-Co ore	720	alliage blanc.
2008	do.	Mukondo Mountain Central African Mining & Exploration Co. (CAMEC), Prairie International Ltd., La Générale des Carrières et des Mines (Gécamines)	restart existing mine	do.	do.	12,000	Cu-Co ore.
2008	do.	Ruashi, phase 2 Metorex Ltd. and La Générale des Carrières et des Mines (Gécamines)	new mine and refinery	do.	do.	3,500	Co hydroxide.
2008	Cuba	Moa Bay expansion, phase I Moa Nickel S.A.	expansion of existing plant	nickel	Ni-Co laterite ore	3,450 ^{e,6}	Ni-Co sulfide.
2008	Finland	Talvivaara Talvivaara Mining Co. Ltd.	new mine and bioheap leaching operation	do.	Ni-Zn-Cu-Co sulfide ore	1,200	Do.
2008	Zambia	Muliashi Luanshya Copper Mines Plc	new mines and refinery	copper	Cu-Co oxide and sulfide ores	2,000	Co hydroxide.
2008	do.	Munali Nickel Albidon Ltd.	new mine and beneficiation plant	nickel	Ni-Cu-Co-PGM sulfide ore	480	Ni concentrate.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2012^{1,2}

Projected year of first production	Country	Project and company	Project type ³	Principal metal	Ore/feed type ⁴	Annual production capacity (metric tons, cobalt content)	Cobalt product ⁴
2009	Australia	Lucky Break Metallica Minerals Ltd. and Metals Finance Corp.	new mine and combined vat and heap leaching operation	nickel	Ni-Co laterite ore	NA	Ni-Co carbonate.
2009	Brazil	Santa Rita Mirabela Nickel Ltd.	new mine and beneficiation plant	do.	Ni-Cu-Co-PGM-Au sulfide ore	450 ^e	Ni concentrate.
2009	Canada	Fort Saskatchewan expansion Sherritt International Corp.	expansion of existing refinery	do.	Ni-Co sulfide	4,800 ^{e,6}	Co metal powder and briquettes.
2009	Congo (Kinshasa)	Luita Central African Mining & Exploration Co. (CAMEC)	expansion of existing plant	copper	Cu-Co ore	8,000 ⁶	Co carbonate.
2009	do.	NA China Overseas Engineering Corp. (COVEC)	new refinery	do.	Cu-Co concentrate	1,500	Co cathode.
2009	do.	Kamoto-Dima, phase 2 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	expansion of production	do.	Cu-Co oxide and sulfide ores	3,000 ⁶	Do.
2009	do.	Kamoto-Dima, phase 3 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	do.	do.	do.	NA	Do.
2009	do.	SX-EW plant for cobalt Chemaf SPRL	addition to existing refinery	do.	Cu-Co ore	6,000	Do.
2009	do.	Tenke Fungurume Freeport-McMoRan Copper & Gold Inc., Lundin Mining Corp., and La Générale des Carrières et des Mines (Gécamines)	new mine, processing plant, and refinery	do.	Cu-Co oxide, mixed oxide/sulfide, and sulfide ores	10,000	Intermediate Co hydroxide and/or Co cathode.
2009	Cuba	Moa Bay expansion, phase 2 Moa Nickel S.A.	expansion of existing plant	nickel	Ni-Co laterite ore	4,300 ^{e,6}	Ni-Co sulfide.
2009	India	Refinery expansion Rubamin Ltd.	expansion of existing refinery	cobalt	ores, concentrates, intermediates, and scrap	1,000 ⁶	Co cathode, powder, oxide, and salts.
2009	Japan	Niihama expansion Sumitomo Metal Mining Co., Ltd.	do.	nickel	Ni-Co sulfide and Ni matte	1,800 ⁶	Co cathode.
2009	Kazakhstan	Shevchenko Oriental Resources Plc	new mine and atmospheric tank leaching plant	do.	Ni-Co laterite ore	NA	Ni-Co hydroxide.
2009	New Caledonia	Goro Vale Inco, Sumic Nickel Netherlands b.v. (Sumitomo Metal Mining Co., Ltd. and Mitsui & Co., Ltd.), and Société de Participation Minère du Sud Calédonien S.A.S.	new mine and HPAL processing plant	do.	do.	4,600	Co carbonate.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2012^{1,2}

Projected year of first production	Country	Project and company	Project type ³	Principal metal	Ore/feed type ⁴	Annual production capacity (metric tons, cobalt content)	Cobalt product ⁴
2009	Philippines	Coral Bay expansion 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	nickel	Ni-Co laterite ore	1,500 ⁶	Ni-Co sulfide.
2009	Russia	Uralgidronikel Russian Nickel Co.	new mine and refinery	do.	Ni-Co ore	1,000	Co cathode.
2009	Turkey	Caldag European Nickel PLC	mine and heap leaching operation	do.	Ni-Co laterite ore	1,200	Ni-Co hydroxide.
2009	United States (Idaho)	Idaho Cobalt Formation Capital Corp.	new mine and refinery	cobalt	stratiform Co-Cu-Au ore	1,625	Co cathode or salts.
2009	Vietnam	Ban Phuc Asian Mineral Resources Ltd. and Mechanical Engineering Company of Son La Province	new mine and beneficiation plant	nickel	Ni sulfide ore	170	Ni concentrate.
2009	Zambia	Chambishi Copper Smelter China Nonferrous Metal Mining Group Co. Ltd. and Yunnan Copper Industry Group Co. Ltd.	new smelter	copper	Cu-Co concentrates	2,800	NA.
2009	do.	Mokambo ICS Copper Systems Ltd.	new refinery (EMEW process)	do.	Cu-Co ore	50 ^e	Co carbonate.
2009	do.	Nama Caledonia Mining Corp.	new mine and refinery	cobalt	Co-Cu oxide ore	10,000	Co hydroxide.
2009	do.	New Nchanga smelter Konkola Copper Mines Plc	new smelter	copper	Cu-Co concentrates	1,500	alliage rouge.
2010	Australia	Leinster Nickel Sulphide Tailings Western Consolidated Nickel Pty. Ltd. (a subsidiary of Braemore Resources Plc)	new processing plant	nickel	Ni sulfide tailings	NA	NA.
2010	do.	Nornico Metallica Minerals Ltd.	new mine and heap leaching operation	do.	Ni-Co laterite ore	NA	Ni-Co carbonate or hydroxide.
2010	Cameroon	Nkamouna Geovic Mining Corp.	new mine and refinery	cobalt	do.	4,200 ⁵	Co oxide.
2010	Canada	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished mill, and refinery	gold	Au-Co-Bi ore	1,640	Co cathode.
2010	do.	Nunavik Nickel (formerly called Raglan South Nickel) Canadian Royalties Inc.	new mine and beneficiation plant	nickel	Ni-Cu-Co-PGM sulfide ore	425 ⁵	Ni concentrate.
2010	China	Refinery expansion Jinchuan Group Ltd.	expansion of existing refinery	do.	Ni-Cu matte	10,000 ⁶	Co cathode and other.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2012^{1,2}

Projected year of first production	Country	Project and company	Project type ³	Principal metal	Ore/feed type ⁴	Annual production capacity (metric tons, cobalt content)	Cobalt product ⁴
2010	Congo (Kinshasa)	Kalukundi H & J Swanepoel Family Trust Sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and refinery	copper	Cu-Co oxide ore	4,200	Co cathode.
2010	do.	Kamoto-Dima, phase 4 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	expansion of production	do.	Cu-Co oxide and sulfide ores	8,000 ⁶	Do.
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.	Cu-Co tailings	5,800	Co hydroxide.
2010	do.	KOV Nikanor PLC and La Générale des Carrières et des Mines (Gécamines)	rehabilitate and reopen existing mine, refurbish beneficiation plant, and build new refinery	do.	Cu-Co oxide ore	27,500	Co hydroxide. ⁷
2010	do.	Likasi plant Rubamin Ltd.	expand existing smelter	do.	Cu-Co ore	3,000 ⁶	alliage blanc.
2010	Finland	Kevitsa Scandinavian Minerals Ltd.	new mine and beneficiation plant	nickel	Ni-Cu-Co-PGM-Au sulfide ore	130 ^{6,5}	Ni concentrate.
2010	Madagascar	Ambatovy Joint Venture Sherritt International Corp., Sumitomo Corp., Korea Resources Corp., SNC-Lavalin Group Inc.	new mine, HPAL processing plant, and refinery	do.	Ni-Co laterite ore	5,600	Co metal powder and briquettes.
2010	Mexico	El Boleo Baja Mining Corp.	new mine and refinery	copper	Cu-Co-Zn-Mn oxide and sulfide ores	3,100	Co cathode.
2010	Papua New Guinea	Ramu China Metallurgical Group Corp., Jinchuan Group Ltd., Jilin Jien Nickel Industry Co. Ltd., Jiuquan Iron & Steel Group Co. Ltd., Highlands Pacific Ltd., Mineral Resource Development Co., MCC Ramu NiCo Ltd., Mineral Resource Madang Ltd.	new mine, beneficiation plant, and HPAL processing plant	nickel	Ni-Co laterite ore	3,300	Ni-Co sulfide.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2012^{1,2}

Projected year of first production	Country	Project and company	Project type ³	Principal metal	Ore/feed type ⁴	Annual production capacity (metric tons, cobalt content)	Cobalt product ⁴
2010	South Africa	Independence Platinum Independence Platinum Ltd. (subsidiary of Braemore Resources Plc)	new smelter (ConRoast process)	PGM-nickel	PGM-Ni-Cu-Co sulfide concentrates	NA	Ni-Cu-Co-Fe-PGM alloy.
2010	do.	Nkomati Large Scale Expansion OJSC MMC Norilsk Nickel and African Rainbow Minerals Ltd.	expansion of existing mine and beneficiation plant	nickel	Ni-Cu-Co-PGM sulfide and chromite ores	1,000 ^{e,6}	Ni concentrate.
2010	United States (Michigan)	Eagle Kennecott Eagle Minerals Co.	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	Ni-Cu sulfide ore	450 ^e	Cu-Ni concentrate.
2010	United States (Minnesota)	NorthMet PolyMet Mining Corp.	new mine and refinery	copper	Cu-Ni-PGM sulfide ore	360	Ni-Co hydroxide.
2011	Australia	Gladstone Nickel, stage 1 Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery	nickel	Ni-Co laterite ore	6,164	Co metal.
2011	do.	Mutooroo Havilah Resources NL and Heilongjiang Resources Ltd.	new mine, beneficiation plant, and refinery	copper	Cu-Co sulfide ore	1,200	Co hydroxide.
2011	do.	Niwest GME Resources Ltd.	new mine and heap leach operation	nickel	Ni-Co laterite ore	1,400	Ni-Co sulfide.
2011	Brazil	Montes Claros de Goias Votorantim Metais Níquel S.A.	new mine	do.	do.	NA	Ni-Co laterite ore.
2011	Canada	Raglan Mine Xstrata Nickel	expansion of existing mine	do.	Ni-Cu-Co-PGM sulfide ore	NA	Ni concentrate.
2011	do.	Voisey's Bay commercial nickel processing plant Vale Inco	new refinery	do.	Ni-Cu-Co sulfide concentrate or matte ⁸	2,460 or 900 ⁸	Co cathode.
2011	Congo (Kinshasa)	Luita Central African Mining & Exploration Co. (CAMEC)	expansion of existing plant	copper	Cu-Co ore	12,000 ⁶	Co carbonate.
2011	Finland	Kylylahti Vulcan Resources Ltd.	new mine and beneficiation plant	do.	Cu-Zn-Co-Ni-Au sulfide ore	1,900	Zn-Co-Cu-Ni concentrate.
2011	Russia	Belinskoye deposit Russian Nickel Co.	new mine and refinery	nickel	Ni-Co ore	1,000	Co cathode.
2011	South Africa	Base Metals Refinery Anglo Platinum Ltd.	expansion of existing refinery	do.	Ni-Co-PGM converter matte	825 ^{e,6}	Co sulfate.
2011	do.	Nkomati Activox Refinery OJSC MMC Norilsk Nickel and African Rainbow Minerals Ltd.	new refinery	do.	Ni-Cu-Co-PGM concentrate	NA	Co carbonate.
2012	Brazil	Niquel do Vermelho Vale Inco	new mine, HPAL processing plant, and refinery	do.	Ni-Co laterite ore	2,800	Co cathode.

See footnotes at end of table.

TABLE 8—Continued
 COBALT: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2012^{1,2}

Projected year of first production	Country	Project and company	Project type ³	Principal metal	Ore/feed type ⁴	Annual production capacity (metric tons, cobalt content)	Cobalt product ⁴
2012	China	Yellow Mountain GobiMin Inc.	new mine	nickel	Ni-Cu sulfide ore	300 ^e	Ni-Cu sulfide ore.
2012	Philippines	Taganito Sumitomo Metal Mining Co., Ltd. and Taganito Mining Corp.	new HPAL processing plant	do.	Ni-Co laterite ore	2,500	Ni-Co sulfide.
2012	South Africa	Independence Platinum Independence Platinum Ltd. (subsidiary of Braemore Resources Plc)	new hydrometallurgical leach plant	PGM-nickel	Ni-Cu-Co-Fe-PGM alloy	NA	Co intermediate.

^eEstimated. 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 2007. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2012, but not enough information was available to include them.

³EMEW Electrometals Technologies Ltd. electrowinning. HPAL High pressure acid leach.

⁴Au, gold. Bi, bismuth. Co, cobalt. Cu, copper. Fe, iron. Mn, manganese. Ni, nickel. PGM, platinum-group metals. Zn, zinc.

⁵Average production.

⁶Total capacity following expansion.

⁷May later produce cathode (12,000 metric tons per year).

⁸Capacity and feed will depend on process.

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

(Metric tons, cobalt content)

Country ³	2003	2004	2005	2006	2007 ^e
Australia ^{e,4}	6,000 ^r	5,600 ^r	5,600 ^r	6,000 ^r	5,900
Botswana ⁵	294	223	326	303	242 ⁶
Brazil ^e	1,300 ^r	1,400 ^r	1,400 ^r	1,100 ^r	1,400
Canada ⁷	4,327	5,060	5,767	7,115 ^r	8,261 ^{p,6}
China ^e	700	1,260	2,100	1,840 ^r	2,000
Congo (Kinshasa) ^{e,8}	14,800	20,200	24,500	27,100 ^r	25,300
Cuba ⁹	3,274	3,554	3,768	3,500 ^r	3,800
Finland ^e	100	100	100	100	115
Kazakhstan ^e	-- ^r	-- ^r	-- ^r	-- ^r	--
Morocco ^{e,10}	1,391 ⁶	1,600	1,600	1,500	1,500
New Caledonia ¹¹	2,602	2,726	1,769	1,629 ^r	1,620
Philippines ^e	100	100	100	700	800
Russia ^{e,10}	6,100 ^r	6,000 ^r	6,300 ^r	6,300 ^r	6,300
South Africa ^e	480 ^r	610 ^r	620 ^r	600 ^r	600
Zambia ^{e,12}	11,300	10,000	9,300	8,000	7,600
Zimbabwe ^{e,13}	130 ^r	140 ^r	100 ^r	110 ^r	100
Total	52,900 ^r	58,600 ^r	63,400 ^r	65,900 ^r	65,500

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

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 18, 2008. 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, Indonesia, 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: 2003—6,000 (revised); 2004—5,600 (revised); 2005—4,900 (revised); 2006—5,500 (revised); and 2007—5,500.

⁵Reported cobalt content of pelletized nickel-copper matte.

⁶Reported figure.

⁷Assay content of cobalt in concentrates produced. The cobalt content, in metric tons, of all products derived from ores of Canadian origins, including cobalt oxide shipped to the United Kingdom for further processing and nickel-copper matte shipped to Norway for refining, was reported to be as follows: 2003—1,842; 2004—2,085; 2005—2,391; 2006—2,899 (revised); and 2007—3,211.

⁸Cobalt content of concentrates, tailings, and slags.

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

¹⁰Cobalt content of concentrates.

¹¹Cobalt content of limonitic nickel laterite ores mined. Quantities of cobalt contained in intermediate or refined metallurgical products (cobalt chloride and cobalt oxide hydroxide) produced from New Caledonian ores exported to Australia and France, in metric tons, was estimated to be as follows: 2003—2,600 (revised); 2004—2,730 (revised); 2005—1,770 (revised); 2006—1,900 (revised); and 2007—1,920.

¹²Cobalt content of concentrates and slags.

¹³Estimated 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	2003	2004	2005	2006	2007
Australia, metal powder and oxide hydroxide ^e	3,840	3,880	3,150	3,700 ^r	3,680
Belgium, metal powder, oxide, hydroxide ⁴	1,704	2,947	3,298	2,840	2,825
Brazil, metal	1,097	1,155	1,136	902	1,148
Canada, metal, metal powder, oxide	4,233	5,144	5,090	5,198 ^r	5,620 ^p
China, metal, metal powder, oxide, salts ^{e, 5}	4,580	8,000	12,700	12,700	13,300
Congo (Kinshasa), metal ⁶	1,200 ^e	735	600	550	606
Finland, metal powder and salts ⁷	7,989	7,893	8,171	8,582	9,158
France, chloride	181	199	280	256	305
India, metal and salts	255	545	1,220	1,184	980
Japan, metal	379	429	471	920	1,084
Morocco, metal	1,431	1,594	1,613	1,405	1,591
Norway, metal	4,556	4,670	5,021	4,927	3,939
Russia, unspecified ^{e, 8}	4,900 ^r	4,800 ^r	5,000 ^r	5,000 ^r	3,800
South Africa, metal powder and sulfate	271	309	268	267	307
Uganda, metal	--	436	638	674	698
Zambia, metal	6,620	5,791	5,422	4,665	4,435
Total	43,200 ^r	48,500 ^r	54,100 ^r	53,800 ^r	53,500

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

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 18, 2008. 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, Germany and 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 for 2003–06 reported by the Geological Survey of Finland; production for 2007 reported by OM Group Inc.

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