

COBALT

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Cobalt is a strategic and critical metal used in many diverse industrial and military applications. The largest use of cobalt is in superalloys, which are alloys designed to resist stress and corrosion at high temperatures. Superalloys are used in turbine engine parts for aircraft jet engines and land-based industrial gas turbines. Cobalt is also used to make magnets for a wide range of motors, meters, and devices; corrosion and wear-resistant alloys for hardfacing and castings; and high speed steels for cutting tools. Cobalt metal powder acts as a binder in cemented carbides and diamond tools, which are used for metal cutting and forming, mining, and oil and gas drilling. Cobalt compounds are used in catalysts for the petroleum and chemical industries; drying agents for paints, varnishes, and inks; ground coats for porcelain enamels; pigments for ceramics, paints, and plastics; battery electrodes; steel-belted radial tires; and magnetic recording media.

The United States is the world's largest consumer of cobalt, but has no domestic production, so it relies on imports to meet its primary cobalt needs. The United States stocks significant quantities of cobalt metal in the National Defense Stockpile (NDS) for military, industrial, and essential civilian use during a national emergency.

World cobalt supply and demand were estimated to be in a close balance during 1994. World production increased, reversing a trend of decreasing production that began in 1991. Cobalt sales from the NDS and exports from Russia continued to contribute to supply. World cobalt demand increased as the western world's economies improved, although increased use of secondary and intermediate materials lessened the demand for primary metal. Cobalt prices increased rapidly in January, then fluctuated within the \$20 to \$30 per pound range for the remainder of the year.

With the exception of prices, all data in this report have been rounded to three significant digits. Totals and percentages were calculated from unrounded numbers.

Legislation and Government Programs

The Defense Logistics Agency (DLA) continued its bimonthly sales of cobalt from the NDS. The sales were intended to bring the

NDS cobalt inventory down to 18,300 metric tons (40.4 million pounds) as set in the U.S. Department of Defense 1992 Report to the Congress on National Defense Stockpile Requirements. Approximately 181 tons (400,000 pounds) of cobalt granules was available on the second Wednesday of each month and 68 tons (150,000 pounds) of cobalt rondelles was available on the fourth Wednesday of each month. The DLA made awards at prices close to those quoted by Metal Bulletin for 99.3% cobalt.

The DLA sold 1,800 tons of cobalt during fiscal year 1994 (October 1, 1993 through September 30, 1994). Sixty-eight percent of the cobalt sold was granules and 32% was rondelles. The sales represented 86% of the quantity allowable for sale under the Annual Materials Plan (AMP) for fiscal year 1994—2,090 tons (4.6 million pounds). According to DLA's AMP for fiscal year 1995, the maximum amount of cobalt that could be sold in the year beginning October 1, 1994, would be 1,720 tons (3.8 million pounds). The quality of the granules and rondelles available for sale in fiscal year 1995 was reduced to a maximum cobalt content of 99.22%.

The DLA sold 1,720 tons of cobalt during calendar year 1994. Sixty-four percent of the cobalt sold was granules and 36% was rondelles. At yearend, the total uncommitted cobalt inventory held by the DLA was approximately 21,900 tons and the quantity authorized for eventual disposal was 3,760 tons.

Production

There was no domestic mine or refinery production of cobalt in 1994. U.S. processors made cobalt chemicals and cobalt metal powders from cobalt metal and/or cobalt-bearing scrap. U.S. Bureau of Mines (USBM) data on chemical and metal powder production were developed from a voluntary survey of U.S. cobalt processors. Seven of the eight companies canvassed on this survey responded. Estimates were made for the nonresponding company. U.S. processors produced 1,850 tons of cobalt oxide and hydroxide, inorganic cobalt compounds, and organic cobalt compounds in 1994, 6% less than the 1,980 tons produced in 1993. Because this figure includes production of intermediate forms, it does not represent net

production. Shipments are defined as sales, transfers, or consumption to make end-use products such as paint driers and catalysts. In 1994, shipments by U.S. processors included 1,730 tons of cobalt oxide and hydroxide, inorganic cobalt compounds, and organic cobalt compounds, a slight decrease from 1993 shipments of 1,790 tons. Two processors made extra-fine cobalt metal powder in the United States. Carolmet, owned by Union Minière S.A. of Belgium, made cobalt metal powder from imported primary metal at its Laurinburg, NC, plant. Osram Sylvania Inc. made cobalt metal powder from recycled materials in Towanda, PA. Production and shipments of cobalt metal powder are withheld to avoid disclosing company proprietary data.

U.S. cobalt supply included secondary cobalt from alloy scrap, cemented carbide scrap, and spent catalysts. Cobalt intermediate products were recovered from spent petroleum catalysts by AMAX Metals Recovery, Inc. in Braithwaite, LA; Dakota Catalyst Products of Williston, ND; and Gulf Chemical and Metallurgical Corp. in Freeport, TX.

Consumption

Domestic data on cobalt consumption were developed by the USBM from three separate, voluntary surveys of U.S. operations. Most of the data on cobalt chemical uses were obtained from the cobalt processors survey. The second survey covered a broad range of metal-consuming companies, such as superalloy producers, magnetic alloy producers, and tungsten carbide producers. For this survey, more than 100 cobalt consumers were canvassed on a monthly or annual basis. The USBM also canvassed 13 superalloy scrap recyclers to determine the consumption of secondary cobalt in superalloy production. The data in tables 1 and 2 contain estimates to account for nonrespondents.

U.S. reported consumption was 7% higher than reported consumption for 1993. As a whole, metallurgical industries consumed 11% more cobalt in 1994 than in 1993. On an industry-by-industry basis, superalloy melters, cemented carbide producers, producers of welding materials, magnetic alloy producers, and producers of other alloys consumed more cobalt in 1994 than they did in 1993, while

steel producers and producers of mill products from metal powder consumed less cobalt in 1994 than in 1993. Total cobalt consumption for chemical uses was essentially the same in 1994 and 1993. Consumption in pigments, decolorizers, and driers increased, while consumption in catalysts, ground coat frits, and feed materials decreased. (See table 2.)

Apparent consumption, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, increased 15% in 1994 to approximately 8,400 tons. A 14% increase in cobalt imports and significant sales of cobalt from the NDS contributed to the large increase in apparent consumption. However, if some of this cobalt went into stocks that were not reported to the USBM, the calculated apparent consumption would be higher than actual consumption. If this is the case, a corresponding seemingly low apparent consumption will result in the next few years when these stocks are consumed.

Stocks

As indicated above, cobalt stocks remain an important component of supply, but information on actual quantities is not readily available from all sources. Wide ranges in estimates of stock levels can result when a distinction is not made between stocks of refined cobalt and intermediate materials. Movement of stocks between producers, processors, consumers, governments, and traders can make it difficult to quantify actual consumption. The total amount of cobalt contained in stocks held by U.S. cobalt processors and consumers was 13% higher at yearend 1994 than at yearend 1993. (See table 2.)

Prices

Market prices for cobalt were high throughout the year. (See figure 1.) The U.S. spot cathode price reported by Platt's Metals Week was lowest during the first week in January when it was approximately \$18 per pound and highest in late December, when it was approximately \$30 per pound. Platt's 1994 average annual U.S. spot cathode price was \$24.66 per pound.

Metal Bulletin reported market prices for two grades of cobalt—minimum 99.3% cobalt and higher quality minimum 99.8% cobalt. Prices for the two grades of cobalt more or less paralleled one another. In early January, 99.3% cobalt was quoted at about \$2 per pound less than 99.8% cobalt. From mid-January until mid-August, price quotes for 99.3% cobalt were between \$3.50 and \$5.50 per pound lower than quotes for 99.8% cobalt. The price differential

narrowed to \$1 per pound in early December, then widened by yearend to about \$2.50 per pound.

In late January, La Générale des Carrières et des Mines (Gécamines) of Zaire and Zambia Consolidated Copper Mines Ltd. (ZCCM) met to review the cobalt market and decide on 1994 cobalt pricing. Gécamines and ZCCM agreed to maintain the price at \$18 per pound, but decided to change from a fixed annual producer price to a more flexible 3-month reference price. The change from a producer price to a reference price gave the producers the flexibility of taking free market prices into account when establishing their sales prices. On May 20, the reference price was increased to \$21 per pound, applicable to Zambian grade B cobalt (quality 3 and 4) and Zairian granules. On October 13, the reference price was increased to \$25 per pound.

Foreign Trade¹

U.S. imports of unwrought cobalt and cobalt in chemicals increased 14% in 1994. More than 90% of these imports were supplied by seven countries. Zambia was the leading supplier of cobalt to the United States, followed by Norway, Finland, Russia, Canada, Zaire, and Belgium. Cobalt imports from Belgium, Finland, and Russia increased significantly in 1994 as compared with imports in 1993. (See figure 2 and tables 3 and 4.)

In 1994, the United States imported 103 tons, gross weight, of unwrought cobalt alloys valued at \$3.5 million. Six countries supplied 87% of these materials: Sweden (20%), the Republic of South Africa (17%), Japan and the United Kingdom (15% each), Canada (11%), and Germany (9%). The United States imported 756 tons, gross weight, of cobalt matte, waste, and scrap, valued at \$8.9 million. Six countries supplied more than 90% of these materials: the United Kingdom (27%), Russia (22%), the Republic of South Africa (18%), France (13%), Germany (7%), and Belgium (5%). The United States also imported 185 tons, gross weight, of wrought cobalt and cobalt articles valued at \$8.4 million. The leading suppliers of these materials were the United Kingdom (49%), Japan (19%), and Germany (18%), followed by Canada (7%), and France (6%).

U.S. exports of unwrought cobalt and cobalt contained in chemicals increased 71% as compared with exports in 1993, bringing them back to the levels exported during 1990 through 1992. Nearly 60% of 1994 cobalt metal and chemical exports was shipped to four countries: Canada, France, Japan, and Mexico. The remainder was shipped to 37 other countries.

(See table 5.)

Exports also included 665 tons, gross weight, of wrought metal and cobalt articles valued at \$24.5 million. More than 90% of these materials was sent to seven countries: Belgium (45%), France (13%), Norway (10%), Japan (9%), Canada (8%), and the United Kingdom and India (each 4%). The remainder was shipped to 22 other countries. In addition, the United States exported 71 tons, gross weight, of material under the category entitled, "Cobalt ores and concentrates." The material, valued at \$558,000 was sent to Canada.

World Review

World cobalt production increased in 1994, reversing the trend of decreasing production that began in 1991. Refinery production reported by the seven Cobalt Development Institute (CDI) member producers increased 7% from 13,800 tons in 1993 to 14,900 tons in 1994.² Falconbridge Ltd., OM Group, Inc., and Sherritt Inc. reported record-high production levels in 1994. Production by Gécamines also increased in 1994, while production by Inco Ltd., Sumitomo Metal Mining Co. Ltd., and ZCCM decreased. The CDI estimated Western World cobalt supply, including production by CDI-member producers, production by non-CDI producers (with the exception of Russian production), secondary production by CDI processors, Russian exports, and DLA sales, to be 22,900 tons. The CDI estimated 1994 demand to be between 21,500 and 22,000 tons, balancing supply.

Australia.—In the 12-month period ending June 30, 1994, QNI Ltd. produced 1,390 tons of cobalt in cobalt sulfide at the Yabulu nickel-cobalt refinery in Townsville, Queensland. More than 90% of the laterite feed for the refinery was imported from Indonesia and New Caledonia. The remainder was from the company's Brolga Mine in Queensland. QNI's cobalt sulfide was sold to OM Group for refining at its Kokkola Chemicals Oy refinery in Finland. During the year, QNI expanded its research and development program. In addition to continuing a study on the potential for upgrading its cobalt sulfide to value-added products, QNI planned to improve its cobalt recovery rates and to investigate processing methods for new ores and concentrates.³

Western Mining Corp. (WMC) produced intermediate cobalt products as a byproduct of mining, smelting, and refining nickel sulfide ores in Western Australia. Some of the nickel-copper-cobalt matte produced at WMC's Kalgoorlie smelter was exported to other refiners, including Sumitomo Metal Mining Co. of Japan. The remainder was refined by WMC

at its Kwinana nickel refinery. The Kwinana refinery produced cobalt in a nickel-cobalt mixed sulfide, which has traditionally been refined by Sherritt Inc. in Canada.

Late in the year, WMC commissioned its Mount Keith nickel sulfide mine in Western Australia. WMC planned to produce about 140,000 tons of concentrates per year, grading about 20% nickel and 0.5% cobalt.⁴ One-half of the concentrates were to be smelted at Kalgoorlie and one-half were to be sold to Outokumpu Oy for treatment at its Harjavalta refinery in Finland.

WMC decided to withdraw from the Bulong project, leaving Resolute Resources Ltd. with 100% ownership. Resolute planned to continue the feasibility study on the nickel-cobalt laterite deposit, located east of Kalgoorlie in Western Australia. Estimates of potential cobalt production from the Bulong deposit ranged from 1,270 tons to 2,400 tons per year.^{5,6} Samantha Gold NL of Perth, Western Australia, acquired Resolute Resources late in the year.

Outokumpu Australia Pty. Ltd. produced about 250 tons of cobalt in nickel sulfide concentrates from its Forrestania Mine southwest of Kalgoorlie, in Western Australia.⁷ The concentrate was exported to Finland for treatment at Outokumpu's Harjavalta refinery.

MIM Holdings Ltd. and Savage Resources Ltd. studied the feasibility of mining the Ernest Henry copper-gold deposit near Cloncurry, Queensland. Preliminary hydrometallurgical research indicated that about 3,000 tons of cobalt could be recovered annually from the flotation mill tailings.⁸ In addition, MIM completed a feasibility study on the bacterial leaching of cobalt from its Mount Isa copper concentrates. Potential cobalt production from the Mount Isa Mine was estimated at 600 tons per year.⁹

Belgium.—Union Minière (UM) converted cobalt metal, residues, and other cobalt-bearing materials into cobalt metal powders, oxides, hydroxide, and chloride at its facilities in Olen, Belgium. Early in the year, UM began treating cobalt-bearing residues from the zinc refining industry. This cobalt is considered primary cobalt production. An estimate of Union Minière's refinery capacity is included in table 6. Cobalt products made from refined metal and secondary materials are not considered primary production and are excluded from the estimate. In September, UM concluded a contract to purchase cobalt-bearing raw materials from Russian nickel-cobalt producer Severonickel in Monchegorsk, on the Kola Peninsula.

Canada.—In 1994, Falconbridge produced 620 tons of cobalt from nickel-copper ores at its Sudbury, Ontario, operations, a decrease from

the 770 tons produced in 1993. Falconbridge also produced 740 tons of cobalt from custom feed, as compared with 770 tons in 1993.¹⁰ Cobalt-containing nickel-copper matte from the Sudbury smelter was refined at Falconbridge's Nikkelverk refinery in Norway.

Inco produced cobalt oxide at its Thompson, Manitoba, refinery and cobalt cathode at its Port Colborne, Ontario, refinery. Feed materials for the two refineries originated from nickel mines in Thompson, Manitoba, and Sudbury, Ontario, respectively. Inco produced 1,130 tons of cobalt in 1994, a 20% decrease from its 1993 production of 1,410 tons.¹¹ The decrease in production was the result of planned cutbacks in nickel production and accidents at Inco's Ontario and Thompson operations.

Sherritt refined nickel-cobalt materials from Cuba and elsewhere at its Fort Saskatchewan refinery in Alberta. In 1994, Sherritt completed the expansion and modernization of the refinery, bringing its cobalt capacity to 2,000 tons per year. A record 1,820 tons of cobalt was produced at Fort Saskatchewan, an increase of 49% over the 1,220 tons produced in 1993.¹² In December, Sherritt established a joint-venture enterprise with its Cuban feed materials supplier. The Fort Saskatchewan refinery became part of the joint-venture's assets (*see Cuba section of this report.*) Sherritt's Westaim research subsidiary, a partnership with the Governments of Alberta and Canada, developed a unique process to produce lithium cobalt dioxide powder for rechargeable lithium ion batteries. Sherritt planned to commission a pilot plant for the production of these powders in 1995.

Ego Resources Ltd. began construction of a cobalt recovery plant near the historic silver mining town of Cobalt, in eastern Ontario. The plant was designed to use a hydrometallurgical process developed by Ego Resources' wholly owned subsidiary, Cobatec Ltd. Ego planned to produce cobalt compounds from local silver-cobalt ores and tailings. The plant was to have an annual capacity of 300 tons contained cobalt.

China.—In 1994, China consumed an estimated 1,650 tons of cobalt and produced an estimated 1,200 tons of cobalt metal, oxide, and salts.¹³ Cobalt was produced from both domestic and imported raw materials. At Jinchuan, Gansu Province, cobalt metal was produced as a byproduct of nickel from the refining of domestic nickel sulfide ores. Jinchuan's future cobalt production was expected to increase as a result of a two-fold expansion of the refinery's nickel capacity. The Ganzhou cobalt refinery in Jiangxi Province produced cobalt metal and salts from cobalt arsenide concentrates imported from Morocco. Minor production sites included the

Zibo Cobalt Works in Shandong Province, where cobalt metal was produced from iron ore from Shandong Province and copper ore from Shanxi Province.

Cuba.—Cuban laterites were refined to nickel-cobalt sulfides at Moa Bay and nickel oxide and oxide sinter at Nicaro and Punta Gorda. Most of the nickel-cobalt sulfides from Moa Bay were sent to Sherritt in Fort Saskatchewan, Canada, to be further refined. In December, Sherritt finalized a joint-venture agreement with La Compania General de Niquel S.A. (General Nickel) to mine, refine, and market nickel and cobalt. The agreement established three corporations, each owned 50-50 by Sherritt and General Nickel. Moa Nickel S.A. was to be responsible for mining and processing operations at Moa Bay; The Cobalt Refinery Company Inc. was to be responsible for metal refining at Fort Saskatchewan; and The International Cobalt Company Inc. was to be responsible for sales and marketing. The Cuban government granted mining concessions to the joint venture sufficient to supply the Moa Bay plant for approximately 25 years and additional reserves that could extend production for a further 25 years. The joint venture planned to upgrade the Moa Bay facilities and expand annual production to the design capacity of approximately 24,000 tons of nickel-cobalt sulfide, containing about 2,200 tons cobalt, by the year 2000.¹⁴

In September, WMC agreed in principle to form a joint venture with state-owned Commercial Caribbean Nickel S.A. (CCN) to assess and, if viable, develop the Pinares de Mayari West laterite deposit in Holguín Province. Preliminary data provided by CCN suggested that the deposit contains more than 200 million tons of ore with an average grade of more than 1% nickel and 0.1% cobalt. WMC would earn a 65% share in the project by funding delineation drilling, metallurgical testing, and a feasibility study.¹⁵

Nickel and cobalt of Cuban origin cannot be imported into the United States because of a U.S. embargo on imports from Cuba.

Finland.—OM Group's Kokkola Chemicals Oy refinery produced a record 3,000 tons of cobalt in cobalt metal powders, oxides, and salts,¹⁶ a 36% increase over the 2,200 tons produced in 1993. The refinery uses cobalt sulfide from QNI Ltd. in Queensland, Australia, cobalt slag from Gécamines in Zaire, and cobalt hydroxide sludge from Outokumpu's Harjavalta, Finland, refinery as its raw materials feed. During the year, OM Group began construction of a carboxylates facility at Kokkola. Cobalt carboxylates are used by chemical processing, coatings, and tire industries.

Japan.—Sumitomo produced electrolytic

cobalt, cobalt oxide, and cobalt salts as a byproduct of nickel production at its Niihama Nickel Refinery in Ehime Prefecture. Japanese cobalt capacity in table 6 was revised to reflect Sumitomo's current capacity. In addition, standby capacity for Nippon Mining Co. Ltd.'s nickel-cobalt refinery at Hitachi, Ibaraki Prefecture, was removed because Nippon no longer has the capacity to produce cobalt.

According to Japan's Ministry of International Trade and Industry (MITI), 1994 Japanese cobalt consumption increased 4% to 2,520 tons. Cobalt consumption by industry was reported as follows: cobalt in catalysts decreased 4% to 371 tons; cobalt in hard metal tools increased 8% to 299 tons; cobalt in magnetic materials decreased 11% to 486 tons; cobalt in specialty steels decreased 14% to 591 tons; cobalt in tube, plate, rod, and wire increased 18% to 275 tons; and cobalt in other uses increased 76% to 501 tons. Hitachi Metals Europe GmbH estimated total cobalt consumption, including chemical uses not covered by MITI, to increase 3% from 4,360 tons in 1993 to 4,580 tons in 1994.¹⁷ Japan imported 5,650 tons of cobalt in 1994, a 41% increase over imports in 1993. Hitachi Metals estimated a stock buildup of nearly 1,000 tons in 1994.

Mexico.—International Curator Resources Ltd. of Vancouver, British Columbia, continued its investigation of the Boleo copper-cobalt property near Santa Rosalia, Baja California. The company estimated a combined drill-indicated and inferred resource of 140 million tons of ore containing 2 million tons of copper and 113,000 tons of cobalt.¹⁸ Part of the deposit would be amenable to open pit mining. International Curator planned to continue the drilling program, mine planning, and metallurgical testwork to bring the project to feasibility stage in 1996 and production in 1997. Based on results to date, the company estimated an annual production of 50,000 tons of copper and 3,000 tons of cobalt.

New Caledonia.—Lateritic nickel ore from four mining companies in New Caledonia was exported to QNI's Yabulu nickel-cobalt refinery in Queensland, Australia, for processing. Nickel matte from Société Métallurgique Le Nickel's Doniambo smelter was sent to Eramet-SLN's refinery in Sandouville-LeHavre, France, where it was refined into nickel cathode, nickel chloride, and cobalt chloride. Inco continued to develop a hydrometallurgical process to treat lateritic ore from its Goro nickel-cobalt property in southern New Caledonia. The company planned to begin a feasibility study in 1995.

Norway.—The Falconbridge Nikkelverk refinery produced a record 2,820 tons of cobalt cathode in 1994,¹⁹ a 17% increase from the

2,410 tons produced in 1993. Feedstock for the refinery was in the form of matte from company operations in Sudbury, Canada; BCL Ltd. in Botswana; and Norilsk Nickel in Russia. Since 1990, Falconbridge has gradually increased the Nikkelverk refinery's annual cobalt capacity from 2,000 tons to 2,900 tons.

Russia.—Russian cobalt continued to contribute to Western supply in 1994. Estimates of Russian cobalt exports in 1994 ranged from 1,000 tons to more than 3,500 tons. Estimates of 1994 production ranged from as low as 1,000 tons to more than 6,000 tons. Most of the cobalt produced in Russia is a byproduct of Russian nickel mining and/or refining. Nickel and cobalt production in Russia involves a complex flow of ores, concentrates, and mattes between various production sites. Russian nickel-cobalt production is organized into two "Complexes." Norilsk Nickel Complex's production is from nickel sulfide ores mined, smelted, and refined at Norilsk in Siberia and at various locations on the Kola Peninsula. In recent years, Norilsk Nickel has also toll-refined nickel and cobalt-bearing scrap and residues at its Monchegorsk refinery at Kola. Yuzhural Nickel Complex's smelters and refineries are in the Ural Mountains. Feedstock to Yuzhural Nickel's plants has included nickel laterites mined from the Ural region, cobalt-arsenide concentrates mined and beneficiated in the Tuva Autonomous Republic, nickel-cobalt sulfides from Cuba, and white alloy from Zaire.

South Africa, Republic of.—Cobalt was produced as a byproduct of South Africa's platinum industry. Two companies produced refined cobalt: Rustenburg Base Metal Refiners Pty. Ltd. produced cobalt sulfate and Impala Platinum Ltd. produced cobalt metal powder. A third company, Western Platinum Ltd., produced nickel sulfate containing minor amounts of cobalt. According to South Africa's Minerals Bureau, 1994 refinery production increased to 258 tons, contained cobalt. Local cobalt sales increased 87% to 86 tons, contained cobalt, while exports decreased 9% to 179 tons, contained cobalt.

Uganda.—The Kasese Cobalt Co. Ltd., owned by Uganda's state-owned Kilembe Mines Ltd., Bureau de Recherches Géologiques et Minières (BRGM) of France, and Normandy Poseidon subsidiary La Source, continued to evaluate a process for the bacterial extraction of cobalt from pyrite concentrates stockpiled at the Kilembe copper mines. The studies confirmed that engineering designs based on the pilot plant at Kasese were feasible on a full plant scale. Construction of a bioleaching/solvent extraction/electrowinning plant was planned for early 1996. The plant was to have the capacity

to produce 1,000 tons of cobalt cathode per year. Kasese Cobalt Co. anticipated that sufficient concentrates were available for 12 years of production.²⁰

Zaire.—Gécamines reported a 50% increase in its cobalt production, from 2,200 tons in 1993 to 3,300 tons in 1994.²¹ These production figures include cobalt contained in materials that require further refining. Detailed information on cobalt production by type was not available, so the amount of finished metal produced in 1994 was estimated. Gécamines produced primarily granules, low-quality Likasi cathode, alloys, and mattes. Only a small amount of high-quality cathode was produced. Both the quantity and quality of the cobalt produced were related to the type of feed materials processed. In 1994, the production of concentrates continued to be impacted by a lack of ore feed, so cobalt hydrates and other intermediate materials were the predominant feed to the refineries.²²

Gécamines outlined the investment necessary to bring its mine production back to former levels. An estimated \$60 million would be needed to rehabilitate the Kamoto Mine, which suffered a major mine collapse in 1990. The funds would be used to install an underground crusher to replace the one lost in the collapse, excavate access ramps to the new mining area, and reequip the mine. An additional \$200 million per year would be needed over a 4-year period to remove overburden from open pit mines in Gécamines' Western Group. Past delays in overburden removal significantly impacted production from the open pit mines. Gécamines planned to have an in-pit rock-crushing plant and conveyor belt system for removal of overburden at the KOV open pit operational by mid-1995. Gécamines also stated the need to rehabilitate its concentrators and refineries, improve cobalt recovery rates at the concentrators and refineries, and maintain adequate supplies of consumables such as lime and acid for the refineries.

In October, Gécamines signed an agreement to sell a minimum of 15,000 metric tons of cobalt slag to OM Group. The slag would be processed at OM Group's Kokkola refinery in Finland.

Zambia.—ZCCM produced 2,640 tons of cobalt metal between January and December 1994, a decrease of 37% from the 4,210 tons produced in calendar year 1993.²³ The decrease in production was because ZCCM began treating low grade ore in 1993. In addition to the lower grade, the ore had a more complex mineralogy, which adversely affected the recovery rates at the concentrators. ZCCM expected to continue treating low grade ore

until the fourth quarter of 1995, when high grade ore from the Nchanga open pit would become available.

ZCCM investigated various options for increasing production from existing operations. The company estimated that it could increase its cobalt production by 650 tons per year by improving the recovery rates at its cobalt plants. In addition, ZCCM estimated that an additional 2,000 tons of cobalt could be recovered each year from smelter slags.²⁴ Qasim Mining Enterprises Ltd. (QME) of Lusaka, Zambia, negotiated with ZCCM regarding the right to recover cobalt from some of the smelter slag stockpiled at Nkana. Colossal Resources Corp. of Vancouver, BC, agreed to finance the design and construction of a cobalt extraction plant in exchange for a 60% share in a joint venture with QME. Colossal was considering a two-stage process to recover the cobalt. The slag would be processed pyrometallurgically to produce a cobalt-copper-iron alloy, then the alloy would be refined hydrometallurgically to produce cobalt metal.

By yearend, the government of Zambia had not decided how to proceed with privatizing ZCCM. However, the government's relaxation of restrictions on prospecting resulted in a number of international mining companies expressing interest in prospecting and exploration in Zambia.

Outlook

The cobalt market continues to adjust to the loss of Zaire as the dominant supplier. Several cobalt refiners have steadily increased capacities and production levels. Sales of cobalt from the DLA and cobalt exports from Russia added to supply and helped to balance the market over the past few years. However, when the African producers lost their dominance in the market they also lost control of the price. As a result, cobalt prices have varied widely over the past few years in response to perceived imbalances between supply and demand.

The combined effect of high prices during 1994 and Zaire's inability to rapidly increase its output has opened up opportunities for new producers and for expanded production by current producers. In mid-1995, Ego Resources of Canada began producing cobalt as a primary product. Plans are also underway to produce primary cobalt in Uganda. Byproduct cobalt production is being considered at new mining projects in Australia, Canada, Mexico, New Caledonia, and Tanzania. Decisions on how to proceed with each project will depend on the markets for the primary metals to be produced, either nickel or copper.

High prices have made cobalt recovery from

secondary and intermediate materials economically feasible. Cobalt slags from Zaire are being refined in Finland. The refining of Zambian slags is being evaluated. Some cobalt processors have shifted to using lower quality metal, intermediate, and/or secondary materials for the production of powders and salts, lessening the demand for high-grade cobalt metal.

World cobalt demand is expected to increase as the economies of the major consuming countries improve. However, the CDI points out that changes in technology and increases in recycling and economy of use since the late 1970's have dampened cobalt growth. The CDI estimates that cobalt consumption (excluding Russia) will remain at 23,000 tons plus or minus 2,000 tons. However, they point out that cobalt use in batteries, growth in developing geographic markets such as China and India, or a resurgence in consumption by former Soviet Union could increase future world consumption beyond that range.²⁵

¹Import duties on cobalt materials are published in the U.S. International Trade Commission's Harmonized Tariff Schedule of the United States (1994), USITC Publication 2690.

²The Cobalt Development Institute (Wickford, Essex, United Kingdom). Statistics and Review 1994. Cobalt News, v. 2, Apr. 1995, pp. 13-14.

³QNI Ltd. 1994 Annual Report, 48 pp.

⁴Matheson, P. J. Cobalt Production and Potential in Australia and Western Pacific Rim. Pres. at Cobalt 94: Opportunities, Problems, and Survival Strategies, Vienna, VA, Nov. 2-4, 1994; available from Gorham/Intertech Consulting, 411 U.S. Route One, Portland, ME 04105.

⁵Reid, J. G. More Cobalt from Australia. Pres. at New Cobalt News 1995, Toronto, Ontario, Canada, May 9-10, 1995; available from the Cobalt Development Institute, 22 Riverside House, Wickford, Essex, SS11 8BB, United Kingdom.

⁶Work cited in footnote 4.

⁷Work cited in footnote 4.

⁸Metal Bulletin. Ernest Henry Copper Project Awaits Final Go-Ahead. No. 7951, Feb. 2, 1995, p. 5.

⁹Work cited in footnote 4.

¹⁰Falconbridge Ltd. 1994 Annual Report, 56 pp.

¹¹Work cited in footnote 2.

¹²Work cited in footnote 2.

¹³Song, X. Y. Cobalt Outlook in China. Pres. at Cobalt 94: Opportunities, Problems, and Survival Strategies, Vienna, VA, Nov. 2-4, 1994; available from Gorham/Intertech Consulting, 411 U.S. Route One, Portland, ME 04105.

¹⁴Canada NewsWire. Cuba and Sherritt Conclude Cobalt/Nickel Joint Venture Agreement. Dec. 2, 1994, 2 pp.

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Sherritt Inc. 1994 Annual Report, 47 pp.

¹⁵Platt's Metals Week. WMC to Develop Cuban Nickel Deposit. V. 65, No. 39, Sept. 26, 1994, p. 5.

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¹⁶Work cited in footnote 2.

¹⁷Miyamura, K. The Asian Market. Pres. at New Cobalt News 1995, Toronto, Ontario, Canada, May 9-10, 1995; available from the Cobalt Development Institute, 22 Riverside House, Wickford, Essex, SS11 8BB, United Kingdom.

¹⁸International Curator Resources Ltd. 1994 Annual Report, 19 pp.

¹⁹Work cited in footnote 2.

²⁰Mining Journal (London). Uganda Ready for Kilembe Cobalt. V. 324, No. 8331, June 16, 1995, p. 438.

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TABLE 1
SALIENT COBALT STATISTICS 1/

(Metric tons cobalt content unless otherwise specified)

	1990	1991	1992	1993	1994
<u>United States:</u>					
<u>Consumption:</u>					
Reported	7,520 r/	7,190 r/	6,370 r/	6,420 r/	6,870
Apparent	7,640	7,790	6,590 r/	7,310	8,400
Imports for consumption	6,530	6,920	5,760	5,950	6,780
Exports	1,340	1,540	1,420	795	1,360
Stocks, December 31 2/	1,850	1,620	840 r/	819 r/	926
<u>Price: Metal, per pound</u>					
Average U.S. spot cathode 3/	\$10.09	\$16.92	\$22.93	\$13.79	\$24.66
Yearend producer 4/	\$8.40	\$11.00	\$18.00	\$18.00	\$25.00
<u>World: Production</u>					
Mine	42,300 r/	32,500 r/	26,800 r/	20,600 r/	18,500 e/
Refinery	27,300	24,800	21,900	16,800 r/	18,500 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Stocks held by cobalt processors and consumers.

3/ Prices for 1990-92 are weighted averages of weekly prices reported by Metals Week; prices for 1993-94 are annual average prices reported by Platt's Metals Week.

4/ Price established by La Générale des Carrières et des Mines and Zambia Consolidated Copper Mines Ltd.

TABLE 2
U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT 1/ 2/

(Metric tons cobalt content)

	1993	1994
Consumption by end use:		
Steel:		
Stainless and heat-resisting	41	28
Tool	59	81
Superalloys	2,530 r/	2,760
Alloys (excludes steels and superalloys):		
Magnetic alloys	569 r/	693
Welding materials (structural and hard-facing) 3/	255 r/	294
Other alloys 4/	95	99
Cemented carbides 5/	569	723
Chemical and ceramic uses:		
Catalysts	935	871
Drier in paint or related usage	732	809
Pigments	193	198
Miscellaneous and unspecified 6/	433	320
Total	6,420 r/	6,870
Consumption by form:		
Chemical compounds (organic and inorganic) 7/	2,040	2,000
Metal	2,810 r/	3,360
Purchased scrap	1,570	1,510
Total	6,420 r/	6,870
Stocks , December 31 8/		
Chemical compounds (organic and inorganic) 7/	307	292
Metal	354 r/	479
Purchased scrap	158	155
Total	819 r/	926

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes estimates.

3/ Includes wear-resistant alloys.

4/ Includes nonferrous alloys.

5/ Includes diamond bit matrices, cemented and sintered carbides, and cast carbide dies or parts.

6/ Includes feed or nutritive additive, full alloy steel, glass decolorizer, ground coat frit, and mill products made from metal powder.

7/ Includes oxides.

8/ Stocks held by cobalt processors and consumers.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM 1/

(Metric tons unless otherwise specified)

	1993	1994
Metal: 2/		
Gross weight	5,390	5,890
Cobalt content 3/	5,390	5,890
Value thousands	\$166,000	\$248,000
Oxides and hydroxides:		
Gross weight	444	763
Cobalt content 3/	320	549
Value thousands	\$12,600	\$26,100
Other forms:		
Acetates:		
Gross weight	13	157
Cobalt content 3/	3	38
Value thousands	\$141	\$1,760
Carbonates:		
Gross weight	57	93
Cobalt content 3/	26	43
Value thousands	\$980	\$2,010
Chlorides:		
Gross weight	17	89
Cobalt content 3/	4	22
Value thousands	\$157	\$815
Sulfates		
Gross weight	754	906
Cobalt content 3/	204	245
Value thousands	\$6,040	\$7,560
Total:		
Gross weight	6,670	7,890
Cobalt content 3/	5,950	6,780
Value thousands	\$186,000	\$286,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unwrought cobalt, excluding alloys and waste and scrap.

3/ Estimated from gross weights.

Source: Bureau of the Census; minor adjustments by the U.S. Bureau of Mines.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY 1/

Country of origin	Metal 2/			Oxides and hydroxides			Other forms 3/			Total		
	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thou- sands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thou- sands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thou- sands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thou- sands)
1993:												
Belgium	109	109	\$6,290	158	114	\$5,040	21	7	\$306	288	230	\$11,600
Brazil	--	--	--	--	--	--	2	(5/)	23	2	(5/)	23
Canada	790	790	23,200	20	14	449	13	6	222	823	810	23,900
China	--	--	--	2	1	76	--	--	--	2	1	76
Finland	433	433	16,300	158	114	4,080	784	217	6,600	1,370	764	26,900
France	37	37	3,110	6	4	383	--	--	--	43	41	3,490
Germany	120	120	7,680	--	--	--	(5/)	(5/)	2	120	120	7,680
Japan	2	2	198	18	13	221	(5/)	(5/)	5	21	15	423
Norway	1,090	1,090	32,500	--	--	--	--	--	--	1,090	1,090	32,500
Russia	539	539	14,500	4	3	82	20	6	141	562	548	14,700
South Africa, Republic of	41	41	1,270	--	--	--	--	--	--	41	41	1,270
United Kingdom	24	24	738	77	56	2,280	3	1	22	104	80	3,040
Zaire	627	627	21,400	--	--	--	--	--	--	627	627	21,400
Zambia	1,560	1,560	38,500	--	--	--	--	--	--	1,560	1,560	38,500
Other	22	22	712	--	--	--	--	--	--	22	22	712
Total	5,390	5,390	166,000	444	320	12,600	842	237	7,320	6,670	5,950	186,000
1994:												
Belgium	95	95	5,300	306	220	12,300	30	8	389	431	323	18,000
Canada	663	663	32,000	68	49	2,340	22	10	457	753	722	34,800
China	46	46	1,660	1	1	15	42	11	295	88	57	1,970
Finland	622	622	29,000	279	201	8,310	955	265	8,570	1,860	1,090	45,900
France	49	49	4,090	8	6	518	--	--	--	57	55	4,610
Germany	148	148	9,740	(5/)	(5/)	25	13	3	85	162	152	9,850
Japan	(5/)	(5/)	21	10	7	281	1	(5/)	12	11	8	314
Mexico	--	--	--	--	--	--	9	3	54	9	3	54
Netherlands	19	19	206	--	--	--	(5/)	(5/)	5	20	20	212
Norway	1,200	1,200	55,300	--	--	--	--	--	--	1,200	1,200	55,300
Russia	896	896	26,000	73	52	1,690	90	27	1,350	1,060	975	29,100
South Africa, Republic of	17	17	608	--	--	--	20	5	132	37	23	740
United Kingdom	64	64	2,330	17	13	572	62	15	799	144	92	3,700
Zaire	466	466	22,400	--	--	--	--	--	--	466	466	22,400
Zambia	1,580	1,580	58,700	--	--	--	--	--	--	1,580	1,580	58,700
Other	11	11	470	--	--	--	--	--	--	11	11	470
Total	5,890	5,890	248,000	763	549	26,100	1,250	347	12,100	7,890	6,780	286,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unwrought cobalt, excluding alloys and waste and scrap.

3/ Cobalt sulfates, cobalt chlorides, cobalt carbonates, and cobalt acetates.

4/ Estimated from gross weights.

5/ Less than 1/2 unit.

Source: Bureau of the Census; minor adjustments by the U.S. Bureau of Mines.

TABLE 5
U.S. EXPORTS OF COBALT IN 1994, 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)
Australia	1	\$29	16	\$419	--	--	--	--	13	\$447
Belgium	60	898	--	--	--	--	--	--	60	898
Brazil	48	2,120	12	193	4	\$41	--	--	58	2,350
Canada	183	5,180	10	221	2	18	1	\$7	191	5,420
Chile	--	--	8	237	--	--	--	--	5	237
Colombia	--	--	8	270	(6/)	5	--	--	6	275
Finland	56	328	--	--	--	--	--	--	56	328
France	66	1,310	47	1,490	--	--	1	11	100	2,810
Germany	80	1,430	--	--	--	--	--	--	80	1,430
Hong Kong	2	81	8	291	--	--	--	--	8	372
India	5	70	--	--	6	86	--	--	6	155
Indonesia	15	702	--	--	--	--	--	--	15	702
Italy	2	109	8	228	3	120	--	--	8	457
Japan	334	13,800	33	780	--	--	--	--	357	14,600
Korea, Republic of	5	252	2	60	--	--	(6/)	3	6	315
Mexico	13	627	103	1,900	181	1,620	1	15	131	4,170
Netherlands	91	3,510	--	--	(6/)	8	--	--	91	3,520
Panama	--	--	(6/)	5	1	6	--	--	(6/)	12
Spain	--	--	--	--	36	262	--	--	9	262
Taiwan	5	167	34	743	38	375	9	114	41	1,400
Turkey	(6/)	4	--	--	15	99	--	--	4	103
United Kingdom	70	986	2	10	10	137	--	--	74	1,130
Venezuela	--	--	22	125	--	--	--	--	16	125
Other	18	860	15	445	--	--	--	--	29	1,300
Total	1,050	32,500	327	7,420	297	2,780	12	151	1,360	42,800

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

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

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

4/ Free alongside ship (f.a.s.) value.

5/ Estimated from gross weights.

6/ Less than 1/2 unit.

Source: Bureau of the Census; minor adjustments by the U.S. Bureau of Mines.

TABLE 6
WORLD ANNUAL COBALT
REFINERY CAPACITY,
DECEMBER 31, 1994 1/

(Metric tons cobalt content)

Country	
Belgium 2/	1,200
Brazil	300
Canada 3/	3,900
China e/	500
Finland e/ 2/	3,000
France 4/	600
Japan 2/	480
Norway	2,900
Russia e/	8,000
South Africa, Republic of e/ 5/	750
United States 6/	900
Zaire	18,000
Zambia	5,000
Total	45,500

e/ Estimated.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.

2/ Includes oxide and salts.

3/ Includes oxide.

4/ Cobalt chloride.

5/ Includes sulfate.

6/ Standby capacity.

TABLE 7
COBALT: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, cobalt content)

Country 3/	1990	1991	1992	1993	1994 e/
Albania e/ 4/	600	600	20	10	10
Australia e/ 5/	1,200	1,400	1,600	1,700	2,100
Botswana 6/	205	208	208	205 r/	200
Brazil e/	400	400	400	400	400
Canada 7/	5,470	5,270	5,100	5,110 r/	4,330 8/
Cuba e/ 9/	1,460 r/	1,120 r/	1,150 r/	1,030 r/	1,000
Morocco 10/	194	325	461	397	440
New Caledonia e/ 11/	800	800	800	800	800
Russia e/ 12/	XX	XX	4,000	3,300	3,300
South Africa, Republic of e/	350	350 r/	350	350	350
U.S.S.R. e/ 12/ 13/	5,500	5,000	XX	XX	XX
Zaire 10/ 14/	19,000	9,900	5,700	2,460	2,000
Zambia 10/ 15/	7,000	6,990	6,910	4,750 r/	3,500
Zimbabwe e/ 16/	102	105	80	90 r/	100
Total	42,300 r/	32,500 r/	26,800 r/	20,600 r/	18,500

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 19, 1995. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from copper, nickel, platinum, or zinc operations. Morocco was the only country where cobalt was mined as a primary product.

3/ In addition to the countries listed, Bulgaria, China, Germany, Indonesia, and Poland are known to produce ores that contain cobalt, but information is inadequate for reliable estimates of output levels. Other copper-, nickel-, platinum-, or zinc-producing nations may also produce ores containing cobalt as a byproduct component, but recovery is small or nil.

4/ Calculated from reported and estimated weight of nickeliferous ore.

5/ Figures represent quantities of cobalt contained in intermediate metallurgical products (cobalt sulfide; nickel-cobalt sulfide, and nickel matte) produced from Australian and imported ores. Cobalt content of lateritic nickel ore, nickel concentrate, and zinc concentrate originating in Australia was estimated as follows, in metric tons:

1990--1,870; 1991--1,670; 1992--1,270; 1993--1,320 (revised); and 1994--1,270.

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

7/ Figures represent the assay content of cobalt in concentrates produced. The cobalt content of all products derived from ores of Canadian origins, including cobalt oxide shipped to the United Kingdom for further processing and nickel-copper-cobalt matte shipped to Norway for refining, was reported as follows, in metric tons: 1990--2,180; 1991--2,170; 1992--2,220; 1993--2,150 (revised); and 1994--1,920.

8/ Reported figure.

9/ Determined from reported nickel-cobalt content of sulfide production. Data not comparable with those prior to 1990.

10/ Cobalt content of concentrates.

11/ Series represents estimated recoverable content of ores and intermediate metallurgical products exported from New Caledonia to France. The estimated cobalt content of total ores mined is as follows, in metric tons: 1990--6,000; 1991--6,000; 1992--6,000; 1993--6,000; and 1994--6,000.

12/ All production in the U.S.S.R. from 1990-91 came from Russia.

13/ Dissolved in Dec. 1991.

14/ In addition to concentrates, cobalt hydrates and scrap are used as feed to the refineries. Cobalt content of these materials was as follows, in metric tons: Hydrates: 1990--3,190; 1991--5,480; 1992--4,110; 1993--1,000 (estimated); and 1994--4,000 (estimated). Scrap: 1990--49; 1991--517; 1992--1,110; 1993--180 (estimated); and 1994--not available.

15/ Fiscal years beginning Apr. 1 of that stated. Cobalt content of ore milled was as follows, in metric tons: 1990--10,900; 1991--11,000; 1992--11,400; 1993--9,480 (revised); and 1994--8,500 (estimated).

16/ Estimated cobalt content of ore.

TABLE 8
COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons, cobalt content)

Country 3/	1990	1991	1992	1993	1994 e/
Albania: Oxide e/	20	15	3	1	--
Brazil: Metal e/	240	240	240	240	240
Canada: Metal (including metal powder and oxide)	2,060	2,250	2,210	2,700	2,950 4/
China: Metal e/	325	300	220	190 r/	200
Finland (metal powder and salts)	1,300	1,500	2,100	2,200	3,000 4/
France: Chloride	150	123	120 r/	144 r/	138 4/
Japan: Metal	199	185	105	191 r/	161 4/
Norway: Metal	1,830	1,980	2,290	2,410	2,820 4/
Russia: Unspecified e/ 5/	XX	XX	4,500	4,000	4,000
South Africa, Republic of:					
Metal (powder) e/	70	60	65	50	65
Sulfate e/	179	149	169	122	193
Total	249	209	234	172	258 4/
U.S.S.R.: Unspecified e/ 5/ 6/	6,300	5,100	XX	XX	XX
Zaire: Metal 7/	9,950	8,110	5,050	831	2,200 4/
Zambia: Metal 8/	4,670	4,740	4,800	3,710 r/	2,500
Total metal	19,300 r/	17,900 r/	15,000 r/	10,300 r/	11,100
Total salts 9/	349 r/	287 r/	292 r/	267 r/	331
Total unspecified	7,600 r/	6,600 r/	6,600 r/	6,200 r/	7,000
Grand total	27,300	24,800	21,900	16,800 r/	18,500

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 19, 1995. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

3/ In addition to the countries listed, Belgium, Germany, and Slovakia may recover cobalt from imported materials, but production is not reported, and information is inadequate to make reliable estimates of production.

4/ Reported figure.

5/ All production in the U.S.S.R. from 1990-91 came from Russia.

6/ Dissolved in Dec. 1991.

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

8/ Fiscal years beginning Apr. 1 of that stated.

9/ Includes oxide.