

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 used to make parts for gas turbine aircraft engines. Cobalt is also used to make magnets; corrosion and wear-resistant alloys; high speed steels; cemented carbides and diamond tools; catalysts for the petroleum and chemical industries; drying agents for paints, varnishes, and inks; ground coats for porcelain enamels; pigments; 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 U.S. Government maintains significant quantities of cobalt metal in the National Defense Stockpile (NDS) for military, industrial, and essential civilian use during a national emergency.

World cobalt production continued to increase in 1995. As in the past few years, cobalt sales from the NDS and exports from Russia contributed to supply. Growth in Western World economies resulted in increased demand for cobalt. Prices remained high throughout the year.

With the exception of prices and reported production from foreign countries, 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 U.S. Government continued its sales of cobalt from the NDS. During fiscal year 1995 (October 1, 1994 through September 30, 1995), the Defense Logistics Agency (DLA) sold 1,890 tons of cobalt at a contract value of \$107 million. According to DLA's annual materials plan (AMP) for fiscal year 1996, the maximum amount of cobalt that could be sold in the year beginning October 1, 1995, would be 1,810 tons (4 million pounds).

The DLA held 12 cobalt offerings during calendar year 1995. Nine of the offers were on a sealed bid basis and three were on a negotiated bid basis. Between January and December, the DLA sold 2,740 tons of cobalt with a sales value of \$148 million. On December 31, the total uncommitted cobalt inventory held by the DLA was 20,000 tons (44.2 million pounds) and the quantity authorized for eventual disposal was 1,030 tons (2.3 million pounds).

In May, the Department of Defense (DOD) submitted its 1995 Report to the Congress on National Defense Stockpile Requirements. The report stated that changes in national security threats facing the United States significantly altered NDS requirements. As a result, the DOD recommended that

only three materials should be retained in the NDS: iridium, quartz crystal, and tantalum. If the recommendations were accepted by Congress, the entire cobalt inventory would be considered excess and available for disposal. The rate at which materials would be sold from the NDS would be determined in the AMP submitted for each fiscal year. The reduced goals were not approved by Congress by the year's end.

In June, the Treasury Department added La Compania General de Niquel (General Nickel S.A.) and three joint-venture subsidiaries owned by General Nickel and Sherritt Inc. to the U.S. Government's List of Blocked Persons and Specially Designated Nationals.¹ Companies listed as "specially designated nationals of Cuba" were subject to the prohibitions applicable to the Government of Cuba.

Production

There was no domestic mine or refinery production of cobalt in 1995. Formation Capital Corp., of Vancouver, BC, Canada, explored copper-cobalt-gold sulfide deposits on its Black Pine and Sunshine properties in Lemhi County, ID. Both properties are located in the Idaho Cobalt Belt which contains Noranda Mining Inc.'s Blackbird Mine.

U.S. processors made cobalt chemicals and cobalt metal powders from cobalt metal and (or) cobalt-bearing scrap. In 1995, U.S.-based OM Group, Inc. (OMG) purchased Hecla Mining Co.'s Apex facility in St. George, UT. The facility, renamed OMG Apex, Inc., used a hydrometallurgical process to produce cobalt chemicals from spent catalysts and other cobalt-bearing feed materials.

U.S. Geological Survey (USGS) data on chemical and metal powder production were developed from a voluntary survey of U.S. cobalt processors. Five of the seven companies canvassed for this survey responded. Estimates were made for the nonresponding companies. U.S. processors produced 1,470 tons of cobalt oxide and hydroxide, inorganic cobalt compounds, and organic cobalt compounds in 1995, 21% less than the 1,850 tons produced in 1994. 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 1995, shipments by U.S. processors included 1,460 tons of cobalt oxide and hydroxide, inorganic cobalt compounds, and organic cobalt compounds, a 16% decrease from 1994 shipments of 1,730 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. Spent petroleum catalysts were treated by at least four companies in 1995: AMAX Metals Recovery, Inc. in Braithwaite, LA; Dakota Catalyst Products of Williston, ND; Gulf Chemical and Metallurgical Corp. in Freeport, TX; and OMG-Apex in St. George, UT.

Consumption

Apparent consumption (as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks) increased slightly in 1995. (*See table 1.*) The increase occurred in spite of a decrease in imports, the largest component of apparent consumption. Increased consumption from industry stocks was the main cause for the increase in apparent consumption (*See table 2.*) A slight decrease in exports and increased sales of cobalt from the NDS also contributed to the increase in apparent consumption.

Reported consumption was developed 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 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 USGS also canvassed 13 superalloy scrap recyclers to determine the consumption of secondary cobalt in superalloy production. Reported consumption and stocks data in tables 1 and 2 contain estimates to account for nonrespondents.

U.S. reported consumption for 1995 was basically the same as reported consumption for 1994. As a whole, metallurgical industries consumed 6% more cobalt in 1995 than in 1994. On an industry-by-industry basis, superalloy melters, steel producers, cemented carbide producers, magnetic alloy producers, and producers of mill products from metal powder consumed more cobalt in 1995 than they did in 1994, while producers of welding materials and other alloys consumed less cobalt in 1995 than in 1994. Total cobalt consumption for chemical uses decreased 13% in 1995. (*See table 2.*)

Prices

Market prices for cobalt were relatively high throughout the year. In January and early February, the U.S. spot cathode price reported by Platt's Metals Week was \$30 to \$31 per pound. Between late February and the end of October, the price fluctuated between \$27 per pound and \$30 per pound. In November, the price rose above \$30 per pound and it exceeded \$32 per pound in December. Platt's 1995 average annual U.S. spot cathode price was \$29.21 per pound.

Effective February 13, the reference price set by African producers La Générale des Carrières et des Mines (Gécamines) of Zaire and Zambia Consolidated Copper Mines Ltd. (ZCCM) was increased from \$25 per pound to \$27.50 per pound. The price applied to Zambian grade B/C cobalt (quality 3-4) and Zairian granules.

Foreign Trade²

Seven countries supplied more than 90% of U.S. imports of unwrought cobalt and cobalt in chemicals. Norway was the leading supplier, followed by Finland, Canada, Russia, Zaire, Zambia, and Belgium. Cobalt imports in 1995 were 5% lower than imports in 1994. Imports of cobalt from Russia and Zambia decreased significantly as compared with those of 1994, while imports from Belgium, Canada, Norway, and Zaire increased. (*See tables 3 and 4.*)

In 1995, the United States imported 98 tons, gross weight, of unwrought cobalt alloys valued at \$5.3 million. Six countries supplied 92% of these materials: Japan (39%), Sweden (16%), France (10%), Belgium and Germany (each 9%), and Canada (8%). The United States imported 880 tons, gross weight, of cobalt matte, waste, and scrap, valued at \$12.4 million. Eight countries supplied 91% of these materials: the United Kingdom (20%), Germany and South Africa (each 19%), Russia (11%), Canada (6%), and France, Japan, and Zaire (each 5%). The United States also imported 155 tons, gross weight, of wrought cobalt and cobalt articles valued at \$9.8 million. The leading suppliers of these materials were the United Kingdom (52%), Japan and Russia (each 11%), Canada (9%), and Germany (7%).

U.S. exports of unwrought cobalt and cobalt contained in chemicals decreased 5% as compared with exports in 1994. More than one-half of 1995 cobalt metal and chemical exports was shipped to four countries: Belgium, Canada, Japan, and the Netherlands. The remainder was shipped to 37 other countries. (*See table 5.*)

Exports also included 485 tons, gross weight, of wrought metal and cobalt articles valued at \$17.8 million. More than 80% of these materials was sent to seven countries: Norway (23%), Germany and Japan (each 14%), Canada (11%), and France and Switzerland (each 9%). The remainder was shipped to 25 other countries.

World Review

Following a low point in 1993, world production of refined cobalt increased in 1994 and again in 1995. Refinery production reported by the seven Cobalt Development Institute (CDI)-member producers increased 13% from 14,900 tons in 1994 to 16,800 tons in 1995.³ The CDI estimated Western World cobalt supply, including production by CDI-member producers, production by non-CDI producers (with the exception of Russian production), Russian exports, and DLA sales, to be 24,800 tons. Demand was estimated at 23,000 to 24,000 tons.⁴

Australia.—In February, QNI Ltd. purchased the Queensland government's 20% share in the Queensland Nickel Joint Venture, making it the sole owner of the Yabulu nickel-cobalt refinery in Townsville, Queensland. During the year, QNI announced plans to expand the refinery by 15% to 20% and build a full-scale cobalt plant. The cobalt plant would convert Yabulu's cobalt sulfide to cobalt oxide-hydroxide. QNI planned to have the expansion completed by the end of 1996 and the cobalt plant operational in early 1997. At that time, cobalt sulfides would no longer be sent to OMG's Kokkola Chemicals Oy refinery in Finland for refining.

Yabulu's production during the 12-month period ending June 30, 1995, was 1,433 tons of cobalt in cobalt sulfide.⁵ Eighty-eight percent of the laterite feed for the refinery was imported from Indonesia and New Caledonia, 8% was from the company's Brolga Mine in Queensland, and the remainder was from the company's stockpile. Mining operations ceased at Brolga in July, following exhaustion of reserves. QNI researched alternate ore supplies for the refinery and the optimization of recovery rates for nickel and cobalt and considered the production of new nickel and cobalt products.

Western Mining Corp. (WMC) produced approximately 1,000 tons of cobalt in intermediate products as a byproduct of mining, smelting, and refining nickel sulfide ores in Western Australia.⁶ Some of the concentrates from WMC's Mount Keith Mine were sold to Outokumpu Oy for treatment at its Harjavalta refinery in Finland. Some of the nickel-copper-cobalt matte produced at WMC's Kalgoorlie smelter was exported to other refineries, including Sumitomo Metal Mining Co. of Japan. WMC's Kwinana refinery produced cobalt in a nickel-cobalt mixed sulfide, which has traditionally been refined by Sherritt in Canada.

Outokumpu Australia Pty. Ltd. produced nickel sulfide concentrates from its Forrestania Mine and concentrator southwest of Kalgoorlie, in Western Australia. The concentrates were exported to Finland for treatment at Outokumpu's Harjavalta refinery, where an estimated 100 tons of cobalt were recovered.⁷

Anaconda Nickel NL worked toward a bankable feasibility study on its Murrin Murrin nickel-cobalt project near Leonora, Western Australia. The Murrin Murrin project consisted of eight lateritic deposits with reported identified resources of 118 million tons of ore grading 1.14% nickel and 0.07% cobalt.⁸ Anaconda evaluated pressure acid leaching/hydrogen reduction technology to produce nickel metal powder, cobalt metal powder, cobalt sulfate, and intermediate nickel-cobalt sulfide. Anaconda planned to complete the study by mid-1996 and begin production in early 1998 at a rate of 46,000 tons per year nickel and 3,000 tons per year cobalt.⁹

Resolute Samantha Ltd. continued a feasibility study on its Bulong nickel-cobalt laterite deposit, located east of Kalgoorlie in Western Australia. The study included trial mining and continuous pilot-plant testing of pressure acid leaching of the ore, followed by solvent extraction, and nickel electrowinning. Cobalt could be produced as either sulfide or cathode. Resolute was considering developing the project in two stages: initial

annual production of approximately 6,600 tons nickel cathode and 500 to 550 tons cobalt, followed by an expansion to 17,000 tons nickel cathode and 1,200 to 1,400 tons cobalt.¹⁰

MIM Holdings Ltd. decided not to proceed with a project to produce cobalt from its Mount Isa copper operations. However, MIM and joint-venture partner Savage Resources Ltd. reported that they would proceed with the development of the Ernest Henry copper-gold deposit near Cloncurry, Queensland. The partners planned to begin production in 1997. Savage Resources hoped to find a partner to carry out a final feasibility study on a dedicated plant to produce 2,000 to 2,500 tons of cobalt from Ernest Henry's flotation mill tailings.¹¹

The following Western Australian nickel projects also have the potential to produce cobalt in the future: Dominion Mining Ltd.'s Yakabindie nickel sulfide project, the CRA Ltd./Outokumpu Oy Honeymoon Well nickel sulfide project, the Mining Project Investors Pty. Ltd./Outokumpu Black Swan nickel sulfide project, and Centaur Mining & Exploration Ltd.'s Cawse nickel laterite project. Two additional copper properties in Queensland also have the potential to produce cobalt: Cloncurry Mining NL's Great Australia copper mine and Majestic Resources NL's White Range copper-cobalt project near Cloncurry.

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. In 1995, UM refined an estimated 1,200 tons of cobalt.¹² This production did not include UM's conversion of refined cobalt metal to powders and chemicals, which was considered downstream processing.

Brazil.—Cia. Niquel Tocantins (CNT) refined lateritic nickel ore from Niquelandia, Goiás State, at its refinery in Sao Miguel Paulista, Sao Paulo State. Problems during the latter part of the year reduced CNT's cobalt production from its typical level of 240 tons per year to approximately 180 tons. Increases in operating costs threatened future nickel and cobalt production by CNT.¹³

RTZ Mineração, a subsidiary of RTZ Corp. Plc. of the United Kingdom, began developing the Fortaleza de Minas nickel sulfide project in Minas Gerais State. The project was to include a mine, concentrator, smelter, and refinery. RTZ planned to begin production in 1998. Byproduct cobalt would be refined elsewhere.¹⁴

Canada.—Falconbridge's Sudbury Division produced 1,574 tons of contained cobalt, a 16% increase from 1,357 tons produced in 1994.¹⁵ One-third of this cobalt was from nickel-copper ores mined at the company's Sudbury, Ontario, operations. The remaining two-thirds was from custom feed materials. Cobalt-containing nickel-copper matte from Falconbridge's Sudbury smelter was refined at the company's Nikkelverk plant in Norway.

Falconbridge continued with the development of its Raglan nickel-copper property in the Ungava region of northern Quebec. The company planned both open pit and underground mining. Concentrates milled at Raglan would be smelted at Sudbury and the matte produced would be refined in Norway.

An estimated 20,800 tons of nickel, 5,200 tons of copper, and 330 tons of cobalt would be recovered annually from Raglan ores.¹⁶ Production was scheduled to begin by late 1997.

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. In 1995, Inco's cobalt production returned to a more typical level of 1,362 tons.¹⁷

In June, Inco acquired a combined direct and indirect interest of 30% in Diamond Fields Resources Inc.'s Voisey's Bay deposit. Voisey's Bay is a large high-grade nickel-copper-cobalt-sulfide deposit located approximately 35 kilometers southwest of Nain in northeastern Labrador. It has the potential for extremely low-cost nickel production after taking into account revenues generated from byproduct copper and cobalt. A detailed feasibility study on Voisey's Bay was due in 1996. The study was to target production at a minimum annual rate of 60,000 tons of nickel, 40,000 tons of copper, and between 1,400 and 2,300 tons of cobalt.¹⁸ Production could be expanded to 120,000 tons of nickel and 90,000 tons of copper,¹⁹ depending on the nickel market. Cobalt output will depend on the recovery rate, which in turn will depend on whether the ore is treated by a pyrometallurgical or hydrometallurgical process.²⁰

In December 1994, Sherritt's refinery at Fort Saskatchewan, Alberta, became one of the assets of the 50 to 50 joint-venture between Sherritt and General Nickel of Cuba. The Cobalt Refinery Co. produced 1,730 tons²¹ of cobalt metal powders in 1995, a 5% decrease from the 1,820 tons produced in 1994. Most of the feed to the refinery was in the form of nickel-cobalt sulfides from Moa Bay, Cuba. Cobalt from The Cobalt Refinery Co. cannot be sold to U.S. customers because of an embargo on imports of products originating from Cuba. (*See also Legislation and Government Programs section of this report.*)

In late November, Sherritt was reorganized into two separate companies. Sherritt Inc. retained the company's fertilizer business and Specialty Products Division. Sherritt's 50% share in the joint-venture with Cuba's General Nickel, its engineering and metallurgical technologies business, non-Canadian oil and gas interests, and other Cuban businesses were transferred to Sherritt International Corp.

Ego Resources Ltd. completed construction of its Cobatec refinery near the historic silver mining town of Cobalt, Ontario, and began producing cobalt carbonate at midyear. The refinery uses a hydrometallurgical process to treat stockpiled and freshly mined ores from local mines. During the year, the process was adapted to treat cobalt-containing "copper cake" from electrolytic zinc production. At year's end, Ego finalized plans to commit a large part of the refinery's capacity to supply H. C. Starck GmbH & Co. KG of Goslar, Germany, with special cobalt compounds for a term of 10 years. Starck will use the compounds to make cobalt suboxide, which is used to make rechargeable nickel metal hydride batteries. Ego was considering increasing the refinery's capacity from its original 270 tons per year cobalt in compounds to 540 tons per year in 1996.

Cameco Corp. of Saskatoon, Saskatchewan, investigated the feasibility of recovering cobalt and nickel from stockpiled uranium tailings. Cameco was considering building a plant at its Key Lake operation which could recover approximately 260 tons of cobalt and 3,200 tons of nickel annually for a period of 11 years.²²

China.—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. 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.—Moa Nickel S.A. mined nickel-cobalt laterites at Moa Bay and produced mixed sulfides containing 20,652 tons of nickel and cobalt.²³ Most of these sulfides were refined by The Cobalt Refinery Co. in Fort Saskatchewan, Alberta, Canada. Moa Nickel S.A. and The Cobalt Refinery Co. were two of three companies in the 50 to 50 joint-venture owned by General Nickel of Cuba and Sherritt Inc. of Canada. In late November, Sherritt's share in the joint-venture was transferred to Sherritt International Corp. (*See Canada section of this report.*)

Australian and South African mining companies considered developing nickel laterite deposits in Cuba. WMC had a memorandum of understanding with state-owned Commercial Caribbean Nickel S.A. (CCN) to evaluate and possibly develop the Pinares de Mayari West deposit in Holguín Province. WMC was to have a 65% share in the joint venture. Anglo American Corp. reportedly had discussions with CCN on a project in the Moa region of Holguín Province. Gencor Ltd. planned to form a joint venture with state-owned Geominera S.A. to evaluate and develop the San Felipe deposit in Camaguey Province. Gencor subsidiary Malecon Minerals and Metals Holdings Ltd. was to manage the company's 75% share in the venture. Exploration of the deposit was expected to take 5 to 7 years. The joint venture planned to mine and process the ore to nickel and cobalt which would be refined elsewhere.²⁴

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

Finland.—OMG's Kokkola Chemicals Oy refinery produced 3,610 tons of cobalt in cobalt metal powders, oxides, and salts,²⁵ a 20% increase over the 3,000 tons produced in 1994. The refinery used cobalt sulfide from QNI 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, OMG completed construction of a carboxylates facility at Kokkola. Cobalt carboxylates are used by chemical processing, coatings, and tire industries. OMG also expanded the Kokkola plant's capacity to produce cobalt salts and was increasing the plant's capacity to produce extra fine cobalt powder.

Outokumpu Metals and Resources Oy completed the

expansion and modernization of its Harjavalta nickel refinery. The modernization included a new metallurgical process developed to treat high-magnesium nickel concentrates imported from the Mount Keith and Forrestania Mines in Western Australia. In addition, Outokumpu was installing a 500-ton-per-year cobalt recovery plant. The plant would treat cobalt intermediates formerly processed at OMC's Kokkola refinery. Production of cobalt metal powder at Harjavalta was expected to begin in 1996.

Japan.—Sumitomo produced electrolytic cobalt, cobalt oxide, and cobalt salts as a byproduct of nickel production at its Niihama Nickel Refinery in Ehime Prefecture. Sumitomo's 1995 metal production was more than 40% greater than its metal production in 1994.

Mexico.—International Curator Resources Ltd. of Vancouver, British Columbia, continued its investigation of the Boleo copper-cobalt deposit near Santa Rosalia, Baja California. The deposit consists of a series of flat-lying beds of oxide and (or) sulfide ores, some of which would be amenable to open pit mining. Exploration by the company expanded the "geological resource" to 167 million tons containing 2 million tons of copper and 125,000 tons of cobalt.²⁶ International Curator was considering a leaching/solvent extraction/electrowinning process. Based on a hypothetical 7 million tons per year open pit operation, annual production was estimated at 45,000 tons copper and 3,600 tons cobalt.²⁷ International Curator planned additional drilling to expand reserves, further metallurgical studies to optimize recovery rates, mine strategy, and completion of a final feasibility study by late 1996.

Morocco.—Cobalt has been mined intermittently from the Bou Azzer District in the Anti-Atlas mountains of central Morocco since the 1930's. In recent years, Cie. de Tifnout Tiranimine (CTT) has produced between 3,000 and 4,000 tons of concentrates, grading approximately 11% cobalt, which it has sent to China for refining. In 1995, CTT completed construction of an electrolytic cobalt refinery with an estimated capacity of 300 tons per year. CTT planned to begin producing high quality cathode in 1996. Cobalt cathode was expected to be produced in addition to existing production of concentrates for export.²⁸

New Caledonia.—Lateritic nickel ore from four mines 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 began a detailed study of its 85%-owned Goro nickel-cobalt property in southern New Caledonia. Drilling on the property revealed a resource of 165 million tons of lateritic ore grading 1.6% nickel and 0.16% cobalt.²⁹ Ore from the deposit was treated in a pilot plant at Inco's laboratories near Toronto, Canada. A primary objective of the study was to evaluate the economic viability of pressure acid leaching and solvent extraction to recover nickel and cobalt.

Norway.—Falconbridge produced 2,804 tons of cobalt cathode at its Nikkelverk refinery in 1995,³⁰ about the same amount as it produced in 1994. Feedstock for the refinery was in the form of matte from company operations in Sudbury, Canada, and BCL Ltd. in Botswana. For the first time in many years, no matte was received from Norilsk Nickel in Russia.

Philippines.—Late in the year, a consortium of investors reached an agreement with the Philippine Government to acquire and rehabilitate the Nonoc nickel mine and refinery complex. The consortium, called Pacific Nickel Holdings, consisted of two London-based investors, Minproc Engineering of Australia, and Hong Kong bank Wheelock NatWest. As part of the rehabilitation, Pacific Nickel was considering refining the nickel-cobalt sulfide to produce cobalt.³¹

Russia.—Russian cobalt continued to contribute to Western supply in 1995. The State Customs Committee of the Russian Federation reported Russian exports of 2,483 tons of cobalt metal, oxide, and salts (sulfate, nitrate, and chloride). Total exports, including 612 tons of foreign-owned cobalt that was toll-refined in Russia and estimates for cobalt contained in carbonate and ferrocobalt, were approximately 3,300 tons.³²

Russian cobalt is a byproduct of Russia's nickel industry. Nickel and cobalt production in Russia involves a complex flow of ores, flotation concentrates, precipitates, and mattes between various production sites. The main feed materials are domestic nickel-copper sulfide ores, nickel laterite ores from Russia and Kazakhstan, and imported nickel- and cobalt-bearing secondary materials. Refined cobalt is produced at four locations: Norilsk Nickel Joint Stock Co. refineries at Norilsk in Siberia and Monchegorsk on the Kola Peninsula; the Ufaleynickel Joint Stock Co. refinery at Verkhniy Ufaley in the Ural Mountains; and the Yuzhuralnickel Joint Stock Co. refinery at Orsk, also in the Ural Mountains. Norilsk Nickel planned to increase its cobalt production at the Severonickel refinery in Monchegorsk and has been investigating technology to produce electrolytic cobalt.

South Africa.—Cobalt was produced as a byproduct of South Africa's platinum industry. Rustenburg Base Metal Refiners Pty. Ltd. produced cobalt sulfate and Impala Platinum Ltd. produced cobalt metal powder. Western Platinum Ltd. produced nickel sulfate containing minor amounts of cobalt.

Tanzania.—Sutton Resources Ltd. and BHP Minerals International Exploration Inc. continued exploring the Kabanga nickel-copper-cobalt sulfide deposit and the adjacent Kagera concessions in northwestern Tanzania. Preliminary evaluations on Kabanga concluded that the deposit could support a mine, concentrator, and smelter capable of producing high grade matte with an annual metal content of 29,000 tons of nickel, 4,800 tons of copper, and 2,000 tons of cobalt.³³

Uganda.—Kasese Cobalt Co. Ltd. (KCCL) planned to begin building a cobalt refinery at Kasese, southwestern Uganda, in mid-1996. The refinery was to use bioleaching followed by solvent extraction and electrowinning to recover cobalt from pyrite concentrates stockpiled during more than 20 years of copper production from the Kilembe Mine. KCCL expected to begin production in early 1998. Feasibility studies indicated

that sufficient concentrates are available for about 10 years of production based on a refinery capacity of 1,000 tons of cobalt cathode per year.

KCCL is owned by Uganda's state-owned Kilembe Mines Ltd. (45%) and LaSource Cie. Minière SAS of Paris, France (55%). In September, LaSource agreed to exchange its 55% share in Kasese for 75% of Banff Resources, Ltd. of Vancouver, British Columbia.

In addition to its 55% interest in the Kasese project, Banff has an option agreement with Kilembe Mines Ltd. to earn a 65% interest in the Kilembe Mine by completing a feasibility study and arranging financing for production. Banff began a sampling and drilling program to evaluate mine reserves and a prefeasibility study for the rehabilitation of the mine, which has been on care-and-maintenance since 1978. Cobalt mined from Kilembe could be treated at the Kasese refinery.

Zaire.—Over the previous few years, Gécamines directed its limited resources towards producing cobalt rather than copper. To boost cobalt output, Gécamines refined stockpiled cobalt hydrates at its hydrometallurgical plants, converted cobalt-nickel hydrates to matte and alloys at the Panda Electric Foundry, and refloated wastes at the Kolwezi concentrator.

In order to bring production back to former levels, Gécamines will need to revive its mining operations. To meet this objective, Gécamines plans to quickly process or sell intermediate products, then reinvest the income generated into the mining and metallurgical operations. In December, OMG agreed to purchase a minimum of 30,000 metric tons of cobalt and nickel concentrate from Gécamines. The concentrate would be processed at OMG's Kokkola refinery in Finland. In past years, OMG has purchased cobalt slag from Gécamines.

During the year, Gécamines worked towards restoring production at some of its larger mines and towards developing several small cobalt-rich deposits. Gécamines completed the first phase of the installation of an in-pit rock crusher and conveyor belt system at the large Kamoto-Oliveira-Virgule (KOV) open pit at Kolwezi. Gécamines also investigated financing for the rehabilitation of the Kamoto underground mine, which suffered a major mine collapse in 1990. In terms of developing smaller cobalt-rich deposits, Gécamines began production at the Kamoya Mine northwest of Likasi and reportedly signed a letter of intent with Union Minière to reopen the Kasombo Mine west of Lubumbashi.³⁴

Several new development projects for copper and cobalt production were also under consideration. The projects, which would be joint-ventures between Gécamines and foreign partners, included developing the Tenke-Fungurume deposits, building a plant to produce white alloy from Lubumbashi slag, and building a refinery to process Kolwezi flotation tailings.³⁵

Zambia.—ZCCM produced 2,934 tons of cobalt metal between January and December 1995, an increase of 11% from the 2,639 tons produced in calendar year 1994, but still below cobalt production levels of 4,200 tons to 4,800 tons in the early 1990's.³⁶ ZCCM's low cobalt production during the past 2 years has been primarily the result of a decrease in ore grade at the Nchanga open pit. In addition to the lower grade, the ore had a

more complex mineralogy, which adversely affected the recovery rates at the concentrators. Ground control problems at the Baluba Mine also contributed to the decrease in cobalt production. Production from the Baluba Flats area was suspended while the mining method was evaluated and ground supports were installed. ZCCM expected cobalt output to improve in 1996 when it was to return to processing higher grade ore from the Nchanga open pit. In 1995, the Government of Zambia reaffirmed its intention to privatize ZCCM and set up a Government Mining Privatisation Unit to plan when and how privatization would occur.

Colossal Resources Corp. of Vancouver, British Columbia, and Qasim Mining Enterprises Ltd. (QME) of Lusaka, Zambia, continued with a joint-venture project to recover cobalt, copper, and associated metals from smelter slag stockpiled at ZCCM's Nkana division in Kitwe. QME has an agreement with ZCCM to process slag from Nkana over the next 25 years. The agreement gives the joint venture access to approximately 8.6 million tons of stockpiled slag containing an estimated 56,000 tons of cobalt and 80,000 tons of copper based on grades of 0.70% to 0.81% cobalt and 1.15% copper. Colossal planned to process the slag with a pyrometallurgical process. The initial product would be a cobalt-copper-iron "white alloy," although Colossal was considering adding a second processing step at a later date to refine the alloy to cobalt metal or salts. During the year, feasibility studies and process trials were conducted, Colossal purchased and began reconditioning furnaces and other equipment, and began preparation of the plant site at Kabwe. Colossal planned to begin production in 1996, with output forecast at about 500 tons contained cobalt during the first full year of production, increasing annually to approximately 3,000 tons by the fourth year.

Outlook

Cobalt supply is expected to continue increasing in the next few years. African producers Gécamines and ZCCM have reversed the downward trends in their production. In addition, foreign companies are investing or considering investments that would lead to new mine, intermediate product, or metal production from Zaire and Zambia. Forecasts of large increases in nickel demand have resulted in many new proposed mine projects. Nickel projects in the following countries have the potential for byproduct cobalt production: Australia, Brazil, Canada, Cuba, New Caledonia, the Philippines, and Tanzania.

The economic viability of these nickel projects will be influenced by the development of the large low-cost Voisey's Bay project in Labrador, Newfoundland, Canada. Future cobalt production could also come as a byproduct of copper mining in Australia and Mexico, and from uranium tailings in Canada.

Several producers of intermediate products will soon do their own refining. This is expected to add cobalt to the market. Morocco will produce electrolytic cobalt in addition to concentrates currently exported to China. QNI in Australia and Outokumpu in Finland will produce cobalt oxide-hydroxide and cobalt metal powders, respectively. OMG, which currently

refines intermediate products from QNI and Outokumpu, is expected to obtain its feedstock from other sources.

World cobalt demand is also expected to increase. Cobalt consumption by the superalloy industry will rise with the growth in commercial jet aircraft production and production of land-based gas turbines for power generation. Increased cobalt consumption is also expected from the battery, catalyst, and cemented carbide industries.

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³Cobalt Development Institute (Wickford, Essex, United Kingdom). Statistics and Review 1995. Cobalt News, v. 2, Apr. 1996, pp. 8-9.

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⁶Reid, J. G. More Cobalt From Australia. Pres. at New Cobalt News 1995, Toronto, Canada, May 9-10, 1995; available from the Cobalt Development Institute, 22 Riverside House, Wickford, Essex, SS11 8BB, United Kingdom.

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⁹Metal Bulletin. Anaconda Hopes to Push Nickel Output to 46,000 tpy. No. 8030, Nov. 16, 1995, p. 5.

¹⁰_____. Resolute Studies Options for Bulong. No. 8038, Dec. 14, 1995, p. 6.

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¹⁴_____. RTZ Brazilian Nickel Project to Start in 1998. No. 8048, Jan. 25, 1996, p. 5.

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¹⁶Work cited in footnote 15.

¹⁷Work cited in footnote 3.

¹⁸Inco. Ltd. 1995 Annual Report, 60 pp.

¹⁹Canada Newswire. Inco Limited Announces Agreement to Acquire Diamond Fields Resources Inc. Apr. 3, 1996, 2 pp.

²⁰Metal Bulletin. Voisey's Bay Ni Growth will be Market-Led. No. 8031, Nov. 20, 1995, p. 7.

²¹Sherritt International Corp. Management's Discussion and Analysis and Consolidated Financial Statements, 38-Day Period Ended Dec. 31, 1995, 16 pp.

²²Cobalt Development Institute (Wickford, Essex, United Kingdom). Another Source of Cobalt. Cobalt News, v. 1, Jan. 1996, pp. 7.

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²⁴American Metal Market. Cuba Names Gencor New Nickel Comrade. V. 103, No. 77, Apr. 21, 1995, p. 1.

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²⁶International Curator Resources Ltd. 1995 Annual Report, 20 pp.

²⁷Hurst, D. and M. McInnis. Boleo Project: A New North American Source of Copper/Cobalt. Pres. at Cobalt 95 Managing for Profits in an Era of Potential Shortages and Price Volatility, Washington, DC, Sept. 26-28, 1995; available from Gorham/Intertech Consulting, P.O. Box 250, Gorham, ME 04038.

²⁸Cobalt Development Institute (Wickford, Essex, United Kingdom). Sources of Cobalt. Cobalt News, v. 4, Oct. 1995, pp. 6-8.

²⁹Work cited in footnote 18.

³⁰Work cited in footnote 15.

³¹Metal Bulletin. New Buyers Take Closer Look at Nonoc. No. 8035, Dec. 4, 1995, p. 6.

Platt's Metals Week. Nonoc Sale Approved. V. 66, No. 47, Nov. 20, 1995, p. 7.

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³⁵Tshofu, S. Cobalt in Zaire: Old and New Products. Pres. at The Cobalt Conference 1996, London, U.K., May 22-23, 1996; available from the Cobalt Development Institute, 22 Riverside House, Wickford, Essex, SS11 8BB, United Kingdom.

³⁶Work cited in footnote 3.

TABLE 1
SALIENT COBALT STATISTICS 1/

(Metric tons cobalt content unless otherwise specified)

	1991	1992	1993	1994	1995
United States:					
Consumption:					
Reported	7,200 r/	6,380 r/	6,430 r/	6,990 r/	7,000
Apparent	7,790	6,590	7,310	8,470 r/	8,660
Imports for consumption	6,920	5,760	5,950	6,780	6,440
Exports	1,540	1,420	795	1,360	1,300
Stocks, December 31 2/	1,620	835 r/	814 r/	914 r/	802
Price: Metal, per pound					
Average U.S. spot cathode 3/	\$16.92	\$22.93	\$13.79	\$24.66	\$29.21
Yearend producer 4/	\$11.00	\$18.00	\$18.00	\$25.00	\$27.50
World production:					
Mine	33,300 r/	27,800 r/	21,600 r/	17,600 r/	22,100 e/
Refinery	25,200 r/	21,900	16,800	18,600 r/	21,900 e/

e/ Estimated. r/ Revised.

1/ Data are rounded to three significant digits, except prices.

2/ Stocks held by cobalt processors and consumers.

3/ Prices for 1991-92 are weighted averages of weekly prices reported by Metals Week; prices for 1993-95 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)

	1994	1995
Consumption by end use:		
Steel:		
Stainless and heat resisting	41 r/	38
Tool	84 r/	146
Superalloys	2,810 r/	2,940
Alloys (excludes steels and superalloys):		
Magnetic alloys	698 r/	757
Welding materials (structural and hard-facing) 3/	312 r/	287
Other alloys 4/	97 r/	80
Cemented carbides 5/	723	748
Chemical and ceramic uses:		
Catalysts	871	732
Driers in paints or related usage	809	770
Ground coat frit	W	172
Pigments	198	172
Miscellaneous and unspecified 6/	347 r/	163
Total	6,990 r/	7,000
Consumption by form:		
Chemical compounds (organic and inorganic) 7/	2,030 r/	1,800
Metal	3,390 r/	3,660
Purchased scrap	1,570 r/	1,540
Total	6,990 r/	7,000
Stocks, December 31: 8/		
Chemical compounds (organic and inorganic) 7/	292	309
Metal	474 r/	390
Purchased scrap	149 r/	103
Total	914 r/	802

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Data are rounded 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, mill products made from metal powder, and data indicated by the symbol "W."

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)

	1994	1995
Metal: 2/		
Gross weight	5,890	5,530
Cobalt content 3/	5,890	5,530
Value	thousands \$248,000	\$325,000
Oxides and hydroxides:		
Gross weight	763	808
Cobalt content 3/	549	582
Value	thousands \$26,100	\$34,300
Other forms:		
Acetates:		
Gross weight	157	129
Cobalt content 3/	38	31
Value	thousands \$1,760	\$1,650
Carbonates:		
Gross weight	93	80
Cobalt content 3/	43	37
Value	thousands \$2,010	\$2,310
Chlorides:		
Gross weight	89	24
Cobalt content 3/	22	6
Value	thousands \$815	\$361
Sulfates:		
Gross weight	906	940
Cobalt content 3/	245	254
Value	thousands \$7,560	\$11,500
Total:		
Gross weight	7,890	7,510
Cobalt content 3/	6,780	6,440
Value	thousands \$286,000	\$376,000

1/ Data are rounded to three significant digits, may not add to totals shown.

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

3/ Estimated from gross weight.

Source: Bureau of the Census, minor adjustments by the U.S. Geological Survey.

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 (thousands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)
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	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
1995:												
Belgium	189	189	13,500	217	156	10,600	35	8	552	441	354	24,600
Brazil	30	30	1,660	--	--	--	--	--	--	30	30	1,660
Canada	993	993	60,700	66	47	3,070	18	8	486	1,080	1,050	64,300
China	18	18	1,090	12	8	149	--	--	--	30	27	1,240
Finland	658	658	41,300	266	192	10,900	898	241	11,100	1,820	1,090	63,300
France	34	34	2,970	19	14	1,600	(5/)	(5/)	3	54	48	4,580
Germany	147	147	9,430	2	1	83	--	--	--	149	148	9,520
Japan	14	14	841	10	7	280	(5/)	(5/)	8	24	21	1,130
Norway	1,510	1,510	93,700	--	--	--	--	--	--	1,510	1,510	93,700
Russia	649	649	30,900	90	65	2,450	177	59	3,260	915	772	36,600
South Africa	33	33	1,980	14	10	606	1	(5/)	14	48	43	2,600
United Kingdom	22	22	1,240	79	57	3,920	40	10	340	141	88	5,500
Zaire	656	656	34,800	--	--	--	--	--	--	656	656	34,800
Zambia	569	569	31,300	--	--	--	--	--	--	569	569	31,300
Other	3	3	146	33	24	623	3	1	16	39	27	786
Total	5,530	5,530	325,000	808	582	34,300	1,170	327	15,800	7,510	6,440	376,000

1/ Data are rounded 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 weight.

5/ Less than 1/2 unit.

Source: Bureau of the Census, minor adjustments by the U.S. Geological Survey.

TABLE 5
U.S. EXPORTS OF COBALT IN 1995, 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	6	\$279	12	\$535	177	\$483	--	--	57	\$1,300
Belgium	249	21,400	3	120	--	--	--	--	252	21,500
Brazil	14	511	17	721	22	375	6	\$94	33	1,700
Canada	166	5,590	27	633	3	65	2	24	187	6,310
China	--	--	2	88	--	--	6	28	3	116
Colombia	--	--	10	325	(6/)	12	--	--	7	337
France	10	505	15	583	290	689	1	17	90	1,790
Germany	60	2,750	(6/)	3	--	--	--	--	60	2,750
Hong Kong	2	77	10	474	--	--	--	--	10	551
Indonesia	31	1,460	--	--	--	--	--	--	31	1,460
Japan	71	4,260	60	1,810	5	153	17	262	120	6,490
Korea, Republic of	32	1,790	5	155	2	47	1	29	36	2,020
Mexico	10	578	51	1,360	183	2,520	--	--	91	4,460
Netherlands	95	4,810	3	99	26	63	--	--	104	4,970
Spain	(6/)	23	--	--	19	285	--	--	5	308
Switzerland	7	362	9	189	(6/)	3	--	--	14	553
Taiwan	44	486	21	720	23	386	6	94	66	1,690
Thailand	2	83	--	--	16	263	--	--	6	346
Turkey	--	--	--	--	30	459	--	--	7	459
United Kingdom	78	3,030	10	341	15	506	--	--	88	3,880
Other	22	985	15	685	10	224	--	--	35	1,890
Total	898	49,000	271	8,850	820	6,530	39	548	1,300	64,900

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ In addition to the materials listed, the United States exports 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 weight.

6/ Less than 1/2 unit.

Source: Bureau of the Census. minor adjustments by the U.S. Geological Survey.

TABLE 6
WORLD ANNUAL COBALT
REFINERY CAPACITY
DECEMBER 31, 1995 1/

(Metric tons, cobalt content)

Country	
Belgium 2/	1,200
Brazil	300
Canada 2/	4,200
China e/	500
Finland e/ 2/	4,000
France 3/	600
Japan 2/	480
Norway	2,900
Russia e/	8,000
South Africa e/ 4/	750
United States 5/	900
Zaire	18,000
Zambia	5,000
Total	46,800

e/ Estimated.

1/ Data are rounded to three significant digits; may not add to total shown.

2/ Includes oxide and salts.

3/ Cobalt chloride.

4/ Includes sulfates.

5/ Standby capacity.

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

(Metric tons, cobalt content)

Country 3/	1991	1992	1993	1994	1995 e/
Albania e/ 4/	600	20	10	10	--
Australia e/ 5/	1,400	1,600	1,800 r/	2,200 r/	2,500
Botswana 6/	208	208	205	225 r/	280 7/
Brazil e/	400	400	400	400	400
Canada 8/	5,274	5,102	5,108	4,265 r/	5,266 7/
Cuba e/ 9/	1,100 r/	1,150	1,060 r/	972 r/	1,561 7/
Kazakstan e/ 10/ 11/	XX	1,000	600	300	300
Morocco 12/	325	461	397	440	450
New Caledonia e/ 13/	800	800	800	800	800
Russia e/ 10/	XX	4,000	3,500 r/	3,000 r/	3,500
South Africa e/	350	350	350	345 r/	280
U.S.S.R. e/ 10/ 14/	5,800 r/	XX	XX	XX	XX
Zaire 12/ 15/	9,900	5,700	2,459	826 r/ e/	1,650
Zambia 12/ 16/	6,994	6,910	4,840 r/	3,711 r/	5,000
Zimbabwe e/ 17/	105	80	90	100	100
Total	33,300 r/	27,800 r/	21,600 r/	17,600 r/	22,100

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

1/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through July 19, 1996. 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, nickel concentrate, 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: 1991--1,670; 1992--1,270; 1993--1,320; 1994--1,270; and 1995--1,500.

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

7/ Reported figure.

8/ 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: 1991--2,171; 1992--2,223; 1993--2,150; 1994--1,846 (revised); and 1995--2,148.

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

10/ All production in the U.S.S.R. for 1991 came from Kazakstan and Russia.

11/ Figures represent estimated cobalt content of only those ores from which it is assumed cobalt is recovered. Cobalt content of total ores mined is assumed to be as follows, in metric tons: 1992-93--not available; 1994--1,394; and 1995--1,400.

12/ Cobalt content of concentrates.

13/ Series represents estimated recoverable content of ores and intermediate metallurgical products exported from New Caledonia to France. Estimated cobalt content of total ores mined is as follows, in metric tons: 1991--6,000; 1992--6,000; 1993-6,000; 1994--6,000; and 1995--6,000.

14/ Dissolved in Dec. 1991.

15/ In addition to concentrates, cobalt hydrates and scrap are used as feed to the refineries. Estimated cobalt content of these materials was as follows, in metric tons: Hydrates: 1991--5,483 (reported); 1992--4,106 (reported); 1993--860 (revised); 1994--3,190 (revised); and 1995--4,340. Scrap: 1991--517 (reported); 1992--1,113 (reported); 1993--320 (revised); 1994-95--not available.

16/ Fiscal years beginning Apr. 1 of that stated. Cobalt content of ore milled was as follows, in metric tons: 1991--10,976; 1992--11,370; 1993--9,480; 1994--6,747 (revised); and 1995--8,500 (estimated).

17/ Estimated cobalt content of ore.

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

(Metric tons, cobalt content)

Country 3/	1991	1992	1993	1994	1995
Albania: Oxide e/	15	3	1	--	--
Brazil: Metal e/	240	240	240	240	180
Canada: Metal (including metal powder and oxide)	2,248	2,210	2,695	2,971 r/	3,092
China: Metal e/	300	220	190	200	210
Finland (metal powder and salts)	1,503	2,100	2,200	3,000	3,610
France: Chloride	123	120	144	146 r/	161
Japan: Metal	185	105	191	161	227
Norway: Metal	1,983	2,293	2,414	2,823	2,804
Russia: Unspecified e/ 4/	XX	4,500	4,000	4,000	4,400
South Africa:					
Metal (powder) e/	60	65	50	42 r/	32 5/
Sulfate e/	149	169	122	204 r/	158 5/
Total	209	234	172	246 r/	190
U.S.S.R.: Unspecified e/ 4/ 6/	5,500 r/	XX	XX	XX	XX
Zaire: Metal 7/	8,114	5,049	831	2,329 r/	3,441
Zambia: Metal 8/	4,741	4,797	3,705	2,482 r/	3,577
Grand total	25,200 r/	21,900	16,800	18,600 r/	21,900
Of which:					
Metal	17,900	15,000	10,300	11,200 r/	13,600
Salts 9/	287	292	267	350 r/	319
Unspecified	7,000 r/	6,600	6,200	7,000	8,010

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

1/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data through July 19, 1996. 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/ All production in the U.S.S.R. for 1991 came from Russia.

5/ Reported figure.

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.