NICKEL

By Peter H. Kuck

Known world resources of nickel have grown dramatically as a result of the discovery in 1993 and subsequent delineation of a world class nickel-copper-cobalt deposit at Voisey's Bay, Labrador. The near-surface sulfide deposit has indicated resources of approximately 150 million metric tons, of which 31.7 million tons average 2.83% nickel (Ni), 1.68% copper (Cu), and 0.12% cobalt (Co) and are amenable to open pit mining. An additional 50 million tons containing 1.36% Ni, 0.67% Cu, and 0.09% Co have been identified at depth in another zone of the deposit. The Voisey's Bay project, the modernization of operations at Sudbury, Ontario, and the new Raglan Mine in northern Quebec, should solidify Canada's position as a leading supplier of nickel far into the 21st century. These developments in Canada have encouraged the use of nickel in advanced battery systems for electric vehicles (EV's) and other new applications.

Russia, the world's largest producer of nickel, continued to privatize and restructure all of its nickel mining and smelting operations. In 1995, RAO Norilsk Nickel accounted for 89.2% of total Russian production. Modernization of the company's three smelters has been hampered by the enormous amounts of capital required. Efforts were underway to borrow a significant portion of the necessary funds from potential financial backers in Scandinavia.

Apparent U.S. demand for primary nickel increased 13% between 1994 and 1995. U.S. demand for stainless steel was also up, but to a lesser degree. Almost 35% of U.S. stainless steel demand was being met by imports. U.S. stainless steel producers have begun to increase output after a period of extensive restructuring. U.S. stainless steel production rose 12% between 1994 and 1995.

Stainless steel production remained depressed in Russia because of that country's continuing economic restructuring. In other parts of the world, though, stainless production has been steadily growing. Capacity was being added in the Republic of Korea, South Africa, and Taiwan. By 1997, the combined output of austenitic stainless steel from South Korea and Taiwan is expected to exceed that of North America. Stainless steel now accounts for about 66% of primary nickel demand in the entire world.[1] Another 5% is consumed in the production of alloy steels. Over the last 20 years, stainless steel production in the Western World has been growing at an average rate of 4.5%, down somewhat from the long-term trend of 6%.

Demand for primary nickel by battery manufacturers continues to grow, although the tonnages involved are an order of magnitude smaller than those for stainless steel. Rechargeable nickel-cadmium (Ni-Cd) and nickel-metal hydride (Ni-MH) batteries are in strong competition with one another for hand-held power tools, laptop computers, cellular telephones, and camcorders.

Legislation and Government Programs

Cuban Embargo.—The splitting up of Sherritt Inc. has made an already complicated nickel supply situation between the United States and its principal trading partners even more complex. In December 1994, Sherritt and the Cuban Government formed a joint venture to mine, process, refine, and market nickel and cobalt from the Moa Bay operation in Holguín Province. The joint venture was originally formed to (1) provide a secure source of feed for Sherritt's Fort Saskatchewan refinery in Alberta and (2) accelerate modernization and expansion of the Cuban nickel industry. (*See Cuba section of this review.*) The Cuban Government and Sherritt are equal partners in the Moa Bay venture. The day-to-day interests of the Cuban Government are handled by General Nickel (La Compania General de Niquel S.A.), a parastatal enterprise that also manages the Nicaro, Punta Gorda, and Las Camariocas nickel operations. None of the venture's production can be marketed in the United States because of the U.S. embargo against Cuba.

On June 26, 1995, the Department of the Treasury added General Nickel and its three Cuban joint-venture subsidiaries of Sherritt to the U.S. Government's List of Blocked Persons and Specially Designated Nationals.[2] The Government of Canada immediately expressed concern about Treasury's action to discourage trade with Cuba. Canadian officials pointed out that mining companies from Australia and South Africa also were negotiating joint ventures with the Government of Cuba, and that numerous other countries maintain trading relationships with Cuba.

In response to the U.S. Government action, Sherritt restructured its holdings and divested its metal mining and processing assets into two separate companies: Sherritt International Corp. and Westaim Corp. Sherritt's fertilizer and oil and gas holdings in Canada are now being managed by Viridian Inc. Sherritt International began operations on November 24, 1995, but Westaim, a wholly owned subsidiary of Viridian, was not incorporated until May 1996. Westaim was focusing on advanced materials, such as nickel hydroxide powder for rechargeable batteries and fine cobalt powder for use in cutting tools. The fissioning permitted Sherritt International and Viridian to adopt distinctly different business strategies and objectives.[3]

Environmental Regulations.—On May 11, 1995, the U.S. Environmental Protection Agency (EPA) promulgated

streamlined regulations governing the collection and management of spent Ni-Cd batteries, mercury-containing thermostats, and certain other widely generated hazardous wastes.[4] The new regulations (40 CFR part 273) were designed to encourage environmentally sound recycling of Ni-Cd batteries and keep them out of the municipal waste stream.

In 1994, legislation was introduced in the Congress to make the recycling of consumer batteries (i.e., household batteries and batteries for EV's) more economically feasible and remove regulatory burdens from the battery recycling industry. A modified version of the legislation pertaining specifically to Ni-Cd batteries was taken up again by the 104th Congress, passed, and eventually enacted into law in March 1996.

Defense Stockpile Sales.—The Defense Logistics Agency (DLA) continued to sell nickel from the National Defense Stockpile. The Government had 33,760 tons of nickel in inventory when sales started on March 24, 1993. All 33,760 tons was some form of electrolytic metal except for 399 tons contained in 520 tons of oxide of Cuban origin. By the end of 1994, uncommitted stocks had shrunk to 25,470 tons. An additional 1,287 tons was awaiting pickup on December 31, 1994, for a total physical inventory of 26,757 tons.

DLA warehouses turned over 6,960 tons to purchasers in 1995, leaving uncommitted stocks of 17,010 tons on December 31. Total yearend stocks also included 2,787 tons of committed material, for a grand total of 19,797 tons. All of the oxide was sold in June.

Production

In April 1995, the Glenbrook Nickel Co. restarted its ferronickel smelter near Riddle, OR. The mining and smelting complex had been on standby since August 1993 and had no production in 1994. Glenbrook has cut back on its consumption of local lateritic ores and now imports most of its feed from New Caledonia. The New Caledonian ore imported in 1991-93 typically contained 2.2% to 2.4% Ni on a dry basis and was significantly richer than the 1.0% to 1.25% material being mined on Nickel Mountain. The first 1995 shipment of New Caledonian ore arrived in Coos Bay in March.

The reopening of the smelter was made possible by the gradual recovery of nickel prices in 1994. The company produced about 8,300 tons of Ni in FeNi in 1995 and was expecting production to be at least 14,500 tons in 1996[5]. The recently renovated smelter has a capacity of 16,000 tons per year. The ferronickel contains 48% to 52% Ni and is available in both shot and ingot form. The existing process requires ferrosilicon, but produces ferronickel with a considerably higher Ni content than most competing ferronickel products (19% to 41% Ni).

Glenbrook also reactivated its ferrosilicon furnace, using local quartzite for feed. The company had been buying ferrosilicon on the open market since its takeover of the Riddle operation in 1989, but decided to resume production when domestic ferrosilicon prices began to strengthen. The ferrosilicon is added to the molten nickel ore to promote rapid reduction of the nickel, while still keeping a large part of the iron in oxide form.

The International Metals Reclamation Co., Inc. (INMETCO) continued to produce nickel-chromium-iron remelt alloy at its metals recovery facility in Ellwood City, PA. The facility was set up in 1978 to reclaim chromium and nickel from electric arc furnace dusts and other wastes generated by the stainless steel industry. Over the next 15 years, the plant was extensively modified, permitting waste feed specifications to be broadened. Because of these changes, INMETCO can now accept a spectrum of chromium and nickel wastes, including filter cakes, plating solutions and sludges, catalysts, refractory brick, and Ni-Cd batteries. In 1995, INMETCO produced about 22,000 tons of chromium-nickel-iron alloy from 58,000 tons of solid waste and 710,000 gallons (roughly 3,400 tons) of liquid waste. The 58,000 tons of solids included 2,300 tons of spent consumer and industrial Ni-Cd batteries. INMETCO is a subsidiary of Inco Ltd., the second largest producer of nickel in the world.

In May 1994, INMETCO acquired key cadmium processing technology from Saft Nife AB. That same month, INMETCO awarded Davy International a contract to design and construct a full-scale unit at Ellwood City for recovering cadmium on-site from spent Ni-Cd batteries. Construction was completed in late 1995 and on December 28, INMETCO began feeding spent batteries into the new system. The first heat of cadmium metal was poured on December 30. The $5 million cadmium addition was the only facility of its kind in the world and was capable of processing more than 2,500 tons of spent Ni-Cd batteries annually.[6] The company was also accepting Ni-MH and nickel-iron batteries.

Consumption

Demand for primary nickel in the Western World grew substantially in 1995 and was estimated to be about 900,000 tons—an alltime high.[7] The tonnage was about 15% more than the previous record of 786,000 tons set in 1994 (revised figure). U.S. apparent consumption of primary nickel was 150,000 tons, or about 17% of Western demand. U.S. industry consumed an additional 64,400 tons of nickel in scrap. Both U.S. and world demand continued to be driven by the stainless steel industry, which accounted for 40% of primary nickel demand in the United States and more than 60% of equivalent world demand.

Production of raw stainless and heat-resisting steel in the United States increased substantially to 2.05 million tons and was 12% more than the corresponding figure for 1994—breaking the national record of 1.99 million tons set in 1988.[8] Nickel-bearing grades accounted for 1.33 million tons, or 65% of the total stainless production for 1995. Net shipments of all types of stainless totaled 1.72 million tons.[9] Shipments of sheets and strip rose 15% to 1.20 million tons, breaking the record of 1.13 million tons just set in 1994. The next largest category was plate [flat product 4.8 millimeters (3/16 inch) or more in thickness]. Shipments of plate were 241,000 tons, 30% more than that of 1994. Together, plate and sheet accounted for 84% of total net shipments, the same

percentage as in 1994.

In 1995, U.S. consumption of primary nickel in superalloys increased 14%, despite problems in the aerospace industry. Jet engine manufacturers [e.g., General Electric Co., Pratt & Whitney Co., Inc. (subsidiary of United Technologies Corp.), and Rolls-Royce PLC] are significant consumers of nickel-chromium-cobalt and nickel-chromium-iron alloys. Sales by the U.S. aerospace industry fell 4% to $106 billion—the lowest level since 1986.[10] Combined aircraft and missile purchases by the U.S. Department of Defense declined for the eighth consecutive year. Purchases of civil aircraft, engines, and parts by commercial airlines and foreign governments were down 1%, as a result of the protracted recession in the airline industry.

Between 1991 and 1994, the backlog of orders held by Boeing Co. and McDonnell Douglas Corp. for civil jet transport steadily shrank due to fewer new orders. However, in 1995, orders began to increase—again building up the backlog. A total of 421 net orders for large civil jet transports were received in 1995, compared with only 79 in 1994. Actual shipments declined between 1994 and 1995, dropping from 309 aircraft to 256. On December 31, 1995, the two companies had a combined backlog of 1,291 aircraft, up from 1,126 at yearend 1994.

Stocks

In recent years, stocks stored by the London Metal Exchange (LME) have far exceeded U.S. consumer stocks. However, this gap sharply narrowed in 1995. On December 28, 1995, LME warehouses held 44,892 tons of nickel metal, of which 44,820 tons or 99.8% was in the form of cut cathodes. The remaining 0.2% consisted of 60 tons of briquets and 12 tons of pellets. The total, 44,892 tons, represented a drop of 70 % from the alltime record high of 151,254 tons reached on November 24, 1994. Although the LME now has 25 warehouse sites scattered around the world that are authorized to hold nickel, most of the material continues to be stored in Rotterdam.

Prices

Prices for nickel metal on the LME were relatively stable throughout most of 1995 after recovering from a 6-year low in September 1993. In 1993, nickel supply in the Western World exceeded demand by approximately 64,000 tons. However, by 1995, the situation had reversed, with demand exceeding supply by about 60,000 tons. Prices peaked in January 1995 following this major market swing and then gradually leveled off. Further price increases were kept in check by massive exports of cathode and carbonyl pellets from Norilsk Nickel in Russia. Internal demands within Russia for hard currency and the depressed state of the Russian stainless steel industry encouraged Norilsk to export the bulk of its production to the West.

In January 1995, the monthly LME cash price reached $9,593 per ton ($4.351 per pound), only to drop to $7,232 per ton ($3.280 per pound) in May. Prices slowly improved during the summer of 1995, returning to $8,945 per ton ($4.057 per pound) in August. During the second half of 1995, prices weakened slightly and continued to slowly decline through the first half of 1996.

The last weekly price (for the week ending December 29, 1995) was $8,018 per ton ($3.637 per pound). The average annual price for 1995 was $8,228 per ton ($3.732 per pound). The annual price was almost 30% higher than the 1994 average of $6,340 per ton ($2.876 per pound).

Foreign Trade

U.S. net import reliance as a percentage of apparent consumption was 59% in 1995. The figure was slightly lower than the 1994 percentage because Glenbrook Nickel resumed production of ferronickel. Canada, as usual, supplied most of the imported material. The second largest source was Norway, which has limited mine production and a single refinery—Falconbridge Ltd.'s Nikkelverk operation at Kristiansand. The Norwegian refinery uses Canadian and Botswanan mattes as its principal feedstocks. U.S. imports of Russian cathode (including pellets) jumped by almost a factor of 7 between 1994 and 1995. In 1995, the United States imported 32,000 tons of cathode and 1,290 tons of powder and/or flake directly from Russia. Importers also brought in 1,270 tons of Russian nickel contained in ferronickel and 1 ton contained in nickel sulfate.

Increased demand for stainless steel in the Far East and Western Europe caused prices for both primary nickel and nickel-bearing scrap to rise worldwide. As a result, U.S. exports of stainless steel scrap rose 23% between 1994 and 1995. Most of the additional tonnage went to meltshops in Belgium, the Republic of Korea, Taiwan, and Ukraine. Exported stainless scrap contained an estimated 27,600 tons of Ni, up from 22,400 tons in 1994.

On September 8, 1994, the U.S. International Trade Commission (ITC) launched an investigation of Japanese-made Ni-MH anode materials and batteries. In August 1994, the Ovonic Battery Co., Inc., and Energy Conversion Devices, Inc., petitioned the ITC to bar the importation and sale of Ni-MH batteries from Japan, claiming that major Japanese battery manufacturers were infringing on Ovonic Battery's patent (U.S. Letters Patent 4,623,597)—violating section 337 of the Tariff Act of 1930. Ovonic Battery is a subsidiary of Energy Conversion Devices, which owns 93.5% of the former's stock; both companies are in Troy, MI. Three prominent Japanese companies were named in the complaint together with their U.S. subsidiaries: Sanyo Electric Co. Ltd. of Hyogo, Toshiba Battery Co. Ltd. of Tokyo, and Yuasa Corp. of Tokyo. On February 6, 1995, the ITC abruptly terminated its investigation after Sanyo, Toshiba, and Yuasa signed separate licensing agreements with Ovonic Battery. Energy Conversion Devices received $10.5 million as part of the settlement.

World Review

Australia.—Western Mining Corp. Holdings Ltd. (WMC) continued to expand production capacity. The company started up its new Mount Keith Mine in late 1994. The open pit operation is in the Greenstone Belt of Western Australia, about 55 kilometers north-northwest of Leinster. The $320 million complex is now one of the larger metal mines in Australia. The first primary ore was crushed in September 1994, and by January 1995 the concentrator was operating above design capacity.[11] The concentrate was being dried at Leinster and then shipped either to WMC's smelter at Kalgoorlie or the Harjavalta smelter of Outokumpu Oy in Finland. The first regular shipments of Mount Keith concentrate began arriving at Harjavalta in March 1995. The Harjavalta smelter was to receive 14,000 tons of Ni in concentrate each year for 10 years as part of a long-term agreement.

The Mount Keith mining complex was officially opened by the Premier of Western Australia on May 30, 1995. In fiscal year ending June 30, 1996, the Mount Keith concentrator treated 7.97 million tons of ore grading 0.60% Ni and produced 29,677 tons of Ni in concentrate.[12]

During the same 12-month period, WMC's other two mining operations—Kambalda and Leinster—produced 37,460 tons and 27,668 tons of Ni in concentrate, respectively. As a result, WMC's total production of concentrate was a record 94,805 tons of Ni. The recently upgraded and expanded Kalgoorlie smelter and Kwinana refinery also set new production records. The smelter produced 77,316 tons of Ni in matte, but was handicapped by air quality control restrictions. A new $128 million acid plant, scheduled for completion in July 1996, was expected to reduce sulfur dioxide emissions by 90%, permitting the smelter to operate at full capacity. WMC's nickel refinery at Kwinana produced a record 46,712 tons of metal in fiscal year 1995-96, up 10.3% from that of 1994-95.

Several other mining projects were in various stages of development in Western Australia. Anaconda Nickel NL has begun infill drilling at its Murrin Murrin deposit in Western Australia.[13] The lateritic nickel-cobalt deposit is about 60 kilometers east of Leonora and about 150 kilometers southeast of Agnew. Bulk samples have been sent to Sherritt International's facilities at Fort Saskatchewan, Alberta, for pilot-plant evaluation. According to Anaconda officials, the deposit has at least 66 million tons of ore grading about 1.14% Ni and 0.07% Co. A pressure acid-leaching plant would be built on-site to extract the nickel and cobalt directly from the ore. The proposed plant would process about 3.75 million tons of ore per year, producing 31,500 tons per year of Ni in briquets, 13,500 tons per year of Ni in concentrate, and 2,500 tons per year of cobalt. Anaconda was actively seeking minority investors at the end of 1995.

Centaur Mining & Exploration Ltd. was seeking investors to help finance its Cawse project, 50 kilometers northwest of Kalgoorlie. The nickel-cobalt laterite deposit reportedly has 52.8 million tons of limonitic clay averaging 1.0% Ni and 0.07% Co.[14] Preliminary tests indicate that the nickel content of the clay can be upgraded to 1.5% Ni by screening. The upgraded clay would be acid leached and the nickel captured by solvent extraction.

Resolute Samantha Ltd. also was considering using pressure acid leach technology to recover nickel from lateritic ores. In 1987, the company acquired the Bulong deposit, 30 kilometers east of Kalgoorlie, from WMC. Since then, pilot-plant studies have shown that nickel and cobalt can be economically recovered from the Bulong laterites by pressure acid leaching, reviving WMC's interest in the deposit. Sulfuric acid for the leach would come from WMC's new acid plant at the Kalgoorlie smelter. The nickel would be separated from the cobalt by solvent extraction and upgraded to marketable metal by electrowinning. Some 6,000 drill holes have delineated a resource of 140 million tons of laterite containing up to 1.4% Ni and 0.1% Co.[15]

In March 1994, the Government of Western Australia approved the construction of a 1,380-kilometer-long natural gas pipeline from Yarraloola on the northwest coast through the Pilbara to the nickel smelter at Kalgoorlie. The pipeline would go through the Goldfields region and pass close to Wiluna, Mount Keith, and Leinster, providing gas to many mines along the way for mineral processing and extraction. Cheaper energy could spur development of Bulong, Murrin Murrin, and several other nickel laterite deposits.[16] Construction of the pipeline started in July 1995 and was well underway at the end of the year. The pipeline was being financed by the Goldfields Gas Transmission Joint Venture (GGTJV). GGTJV is composed of WMC (62.7%), BHP Minerals Pty. Ltd. (11.8%), and Normandy Poseidon Ltd. (25.5%). Most of the gas will come from fields in the offshore Canarvon Basin. Delivery of gas to Leinster and Mount Keith was to begin in August 1996. Kalgoorlie would be hooked up a month later.

On November 20, 1995, Outokumpu Metals and Resources Oy (OMR) and its joint-venture partner, Mining Project Investors Pty. Ltd., announced the discovery of high-grade nickel sulfide mineralization about 45 kilometers northeast of Kalgoorlie. The deposit has been named the Silver Swan and is near the previously explored Black Swan deposit.

Preliminary drilling indicates that the Silver Swan has at least 440,000 tons of ore reportedly averaging 14% Ni. The incredibly rich, deeply plunging ore body lies at depths of 200 to 500 meters below the highly weathered surface. Although the resource is not particularly large, the nickel grade of the ore is the richest discovered to date in Western Australia. The proposed $35 million underground operation would produce about 10,000 tons of Ni per year in concentrate.[17]

Brazil.—Inco and the Korea Zinc Co. have joined forces to assess and possibly develop the Barro Alto laterite deposit, 150 kilometers northwest of Brasília. The deposit, which is in the State of Goiás, contains 36 million tons of proven and probable reserves averaging 1.94% Ni. Inco controls the property, but Korea Zinc had an option to acquire up to a 49% interest in the project.[18]

RTZ Corp. has begun developing the Fortaleza sulfide deposit in the State of Minas Gerais.[19] RTZ's Brazilian

subsidiary, RTZ Mineracao Ltda., was managing the project. The deposit reportedly contains 10.3 million tons of minable material, averaging 1.89% Ni, 0.36% Cu, 0.2% Co, and 1.7 grams per ton of platinum-group metals and gold. An open pit mine was to be constructed during the first phase of the project and reportedly was 90% completed in December 1995. Production of sulfide concentrates could begin as early as 1998. The sulfides would be smelted and refined on-site. An underground mine would be constructed sometime after 2003 to recover the deeper ores. The complete project was expected to cost $233 million, of which $50 million was allocated for the underground operation.

Canada.—In September 1993, Albert Chislett and Chris Verbiski—partners in a small exploration company called Archean Resources Ltd.—discovered significant nickel-copper-cobalt mineralization in a remote area of the Labrador coast at a point west of Voisey's Bay. At the time, Archean Resources was under contract to Diamond Fields Resources Inc. and was prospecting for diamonds as well as sulfides. In mid-1994, Diamond Fields agreed to finance further exploration of the discovery site—a large iron-stained hill of gossan. Initial core drilling of the gossan later that year revealed a massive sulfide ore body more than 100 meters thick. The Voisey's Bay deposit is the largest base metal discovery in Canada in more than 30 years. The deposit is 35 kilometers southwest of the town of Nain and only 10 kilometers from a natural deep-water harbor.[20]

In 1994 and 1995, airborne geophysical surveys were conducted over 1,800 square kilometers of claims staked by Archean Resources and Diamond Fields. Drill crews initially focused on a large, strongly conductive anomaly located in an area riddled with sills and dikes. The anomaly is at least 7 kilometers in length. The four discovery holes (VB-94-01 to 04) penetrated a thick east-west trending gabbroic dike containing disseminated, semi-massive, and massive sulfide mineralization. The best of the four holes (VB-94-02) intersected 71 meters of ore assaying 2.23% Ni, 1.47% Cu, and 0.123% Co.[21]

Geophysical surveying in late 1994 revealed that the Voisey's Bay anomaly widens to the east, where it takes on an ovoid shape. In January 1995, crews began drilling the ovoid feature and again intercepted massive sulfide. The mineralization at this point lies immediately below the overburden, permitting open pit mining. The principal ore minerals are pentlandite, chalcopyrite, and pyrrhotite. The second drill hole (VB-95-07) to test the feature penetrated 104 meters of massive sulfide grading 3.93% Ni, 2.84% Cu, and 0.14% Co.

More than 340 holes have been drilled on the property since the original discovery and several high-priority targets still have not been evaluated. The ore body has a wine-glass shape in section and is roughly 450 meters in length. In plan view, it is 300 meters wide at its thickest point. Three separate zones have been identified to date: the Ovoid, the Eastern Deeps, and the Western Extension. The Ovoid zone has an estimated 31.7 million tons of ore averaging 2.83% Ni, 1.68% Cu, and 0.12% Co that is amenable to open pit mining.[22] Preliminary drilling of the Eastern Deeps zone along a 1-kilometer traverse has identified an additional 50 million tons of resources at depth averaging 1.36% Ni, 0.67% Cu, and 0.09% Co. Limited drilling also delineated a new zone of high-grade mineralization in the Western Extension, but much more work was needed before this third resource could be satisfactorily estimated. Two other targets were being seriously investigated—the Sarah prospect 4 kilometers north of the discovery site and the Ashley prospect, 8 kilometers southwest of the Ovoid. *(For additional information and detailed assay results, see references cited in footnotes 23 through 26.)*

In June 1995, Inco acquired 7% of Diamond Fields' common stock for $111 million. At the same time, Inco also acquired a 25% interest in the Voisey's Bay deposit from Diamond Fields as part of a related but separate transaction.[27] The Voisey's Bay Nickel Co. Ltd., a subsidiary of Diamond Fields at the time, held exploration and development rights to the deposit along with 2,000 square kilometers of other land in Labrador. In exchange, Diamond Fields received $387 million worth of 6.5% preferred stock in Inco. Inco also put up $18 million in cash for a feasibility study and additional exploration work. If the feasibility study is positive, production of concentrate could begin as early as July 1999.

Inco also agreed to acquire 2 million common shares of Diamond Fields from three existing shareholders. The three shareholders received a total of 1.4 million shares of Inco common stock and $68 million in cash. Inco was to be responsible for marketing all of the nickel and cobalt under a long-term agreement. The Voisey's Bay project was expected to generate roughly 122,000 tons of nickel and 91,000 tons of copper per year by the year 2001.

In late 1995, Falconbridge approached Diamond Fields and offered to acquire the 75% of Voisey's Bay Nickel Co. not held by Inco. Under the terms of the proposal, Diamond Fields would have merged with Falconbridge. Diamond Fields shareholders were to have received Falconbridge stock and corporate notes plus a limited amount of cash in exchange for their common share holdings. At yearend 1995, Diamond Fields was still weighing the merger proposal from Falconbridge. The proposal had the support of Noranda Inc., the largest shareholder in Falconbridge (46.3% interest). The merger also reportedly was supported by Teck Corp. which owned 10.4% of Diamond Fields at the time.

Under the terms of the June 1995 agreement with Diamond Fields, Inco had the right to submit a counterproposal. Inco's management immediately began evaluating a variety of possible responses and postponed commenting on the entire matter for more than 3 months. Falconbridge's offer indicated that discovery of the Voisey's Bay deposit had transformed Diamond Fields into a company worth at least $4 billion.

A world-class smelting and refining complex will have to be built in North America before the year 2002 to handle the large amounts of concentrate scheduled to be generated by the Voisey's Bay operation. At yearend 1995, the Voisey's Bay Nickel Co. was considering several sites in southern Newfoundland for the proposed smelter. The Newfoundland sites have access to abundant, inexpensive hydroelectric power

as well as deep-sea harbors that are open year round. The smelting and refining project also had the support of the Provincial Government of Newfoundland and Labrador.

In early 1995, Falconbridge began constructing its $354-million Raglan Mine on the Ungava Peninsula of northern Quebec.[28] The company spent $55.5 million on development work in 1995 and was planning to spend an additional $300 million to bring the mine into production by the end of 1997. Followup drilling at Raglan during 1994 led to the discovery of a 400,000-ton ore body at Katinniq containing 2.94% Ni and 0.89% Cu. The ore body was discovered at a depth of 100 meters. Another ore body was found 4 kilometers east of Katinniq. This second ore body contains 814,000 tons of material averaging 3.36% Ni and 0.83% Cu. According to Falconbridge officials, the Raglan deposit now has 19.3 million tons of proven or possible reserves. Of the 19.3 million tons, 13.3 million are proven or probable, averaging 3.18% Ni and 0.87% Cu. Falconbridge was planning to produce 20,000 tons per year of Ni in concentrate over the first 15 years of operation.[29] The Raglan concentrates were to be converted to matte at the company's smelter in Sudbury.

In the Sudbury Basin, Falconbridge commissioned its new Craig Mine and resumed production at the previously idled Lockerby Mine. If all goes well, ore production at Lockerby should reach 8,000 tons of contained Ni and 3,500 tons of contained Cu by 1998. Falconbridge has spent over $220 million to date developing the Craig Mine and recently discovered additional resources down-dip from the Craig. New resources have also been found down-dip from the neighboring Onaping Mine. The company's smelter on the opposite side of the basin was gearing up to treat concentrates from the new Raglan Mine in northern Quebec. The smelter expansion will cost Falconbridge $27 million.

Inco's new McCreedy East Mine was scheduled to come on-line in 1996 and should be one of the company's lower-cost mines to operate in Canada. Inco also has begun sinking a shaft at its Victor deposit on the northeastern edge of the basin. The $53 million shaft will enable Inco to extract high-grade ore from depths of 1,400 to 1,800 meters.[30]

At the end of 1995, Inco's Canadian mines had 340 million tons of ore reserves. The reserves contained 4.87 million tons of Ni and 3.26 million tons of Cu, which equated to an average grade of 1.43% Ni and 0.96% Cu. The total does not include additional resources associated with the Victor Deep deposit near Sudbury and recent discoveries in the Pipe area of Manitoba.

Colombia.—In the fall of 1994, Gencor Ltd.—a leading South African mining company—acquired Billiton BV from the Royal Dutch/Shell Group, and with it, Billiton's original 46.9% interest in the Cerro Matoso ferronickel operation. The transaction also included the 5.4% interest formerly held by Cia. de Niquel Colombiano S.A., giving Gencor a majority interest of 52.3% in Cerro Matoso S.A. The remaining 47.7% was held by an agency of the Colombian Government— Instituto de Fomento Industrial (IFI). Since 1993, Gencor has become increasingly involved with nickel because of its ties to the Columbus Stainless Steel Project and Impala Platinum Holdings Ltd. *(See section on South Africa.)*

The Government of Colombia has been planning to privatize Cerro Matoso for some time.[31] However, at yearend 1995, the Colombian Cabinet had still not approved the sale of IFI's interest. IFI's shares would be offered first to Cerro Matoso's employees and various state-employee funds, and only then to the public. Gencor was prepared to buy all of IFI's shares—valued at more than $100 million—but was concerned about the long-term prospects for Cerro Matoso's mining concession. The South African company has postponed building a second electric furnace until the proposed extension of the mining lease to the year 2005 is clarified. Cerro Matoso's reserves are expected to be exhausted that year.

In 1995, Cerro Matoso produced 24,565 tons of nickel contained in ferronickel bars and granules—a new record. Gencor has made several processing improvements to the operation which has increased productivity and improved the quality of the ferronickel. The latest statistics released by the International Nickel Study Group indicate that the company exported 24,491 tons on a contained basis in 1995, 87% of which went to Europe.

Cuba.—In late 1994, General Nickel, a parastatal enterprise, and Sherritt formed a joint venture to recover nickel and cobalt from lateritic ores at Moa Bay and refine the two metals in Canada. Cuba's two other mining operations—Nicaro and Punta Gorda—were not part of the joint venture.[32] Sulfide precipitate was being shipped from Moa Bay via Halifax, Nova Scotia, to the joint venture's nickel-cobalt refinery at Fort Saskatchewan. The Fort Saskatchewan refinery can produce up to 25,000 tons per year of nickel in metal powder and briquets.

The Sherritt-Cuban joint venture will spend approximately $165 million rehabilitating and upgrading the Moa facilities over the next 4 years. The Cuban plant was built for the Freeport Nickel Co. between 1957 and 1959 at a cost of $61.5 million and has been in almost continuous production since then. In 1995, the Moa Bay facility produced sulfide precipitates with a combined nickel and cobalt content of 20,652 tons, or approximately 19,000 tons of Ni and 1,700 tons of Co.[33] By 1999, Moa Bay will be able to produce about 27,000 tons of contained nickel plus cobalt per year.

The goethite-gibbsite ore averages 1.32% Ni and 0.108% Co, and comes from two ore bodies—Moa Occidental and Moa Oriental—on opposite sides of the Moa River. The nickel and cobalt do not form discrete minerals phases, but are associated instead with the goethite and, to a lesser extent, spinels. A pressurized leach process is used to extract the two metals from the goethite. The process is relatively efficient, recovering more than 90% of the nickel, but consumes large amounts of sulfuric acid. Almost one-third of the modernization money would be used to replace the three existing acid plants with a single modern unit capable of producing 1,500 tons of acid per day. One of the three plants was permanently closed in September 1995 because of high maintenance costs. New materials handling equipment was also needed.[34] The Sherritt-Cuban joint venture (now called the Metals Enterprise) reportedly was

prospering, having earned $41.2 million on sales of $211 million during the first half of 1996. Sherritt International was planning to eventually raise the output of the operation to 46,000 tons per year. The expansion would cost an additional $173 million.

Cuba has the largest reserve base of nickel-bearing laterites in the world.[35] At least two other prominent nickel producers, besides Sherritt, have entered into agreements with Cuban parastatal organizations since 1993. Gencor recently began evaluating a lateritic deposit in the San Felipe area of Camaguey Province. In September 1994, WMC signed a memorandum of understanding with Commercial Caribbean Nickel S.A. to evaluate and develop the Pinares de Mayari West lateritic deposit in Holguín Province. The details of the WMC joint venture were still being negotiated in mid-1996. The Pinares deposit reportedly contains more than 200 million tons of ore exceeding 1% nickel and 0.1% cobalt.[36]

Dominican Republic.—In 1995, Falconbridge Dominicana, C. por A. (Falcondo) produced 30,900 tons of Ni in ferronickel. More than 90% of the ferronickel was in the form of ferrocones, a product resembling a large metallic gumdrop and weighing about 125 grams. The company will no longer make ingot. Customers prefer the ferrocones over ingot because (1) the ferrocones are easier to handle with bulk loaders and (2) the ferrocones melt more efficiently in the electric furnace.

Falcondo has been reforesting much of the Bonao area for some time and was planting at least 10 trees for every 1 cut down during mining. The company also was working on a novel laterite upgrading process that would permit it to economically mine ore with a cutoff grade of less than 1.40% Ni. If successful, this upgrading process could significantly increase Falcondo's ore reserves and raise production by 5,000 tons per year of contained Ni. At the end of 1995, the company had 30.3 million tons of proven and probable reserves averaging 1.73% Ni plus 22.1 million tons of possible reserves averaging 1.72% Ni.

European Union.—Union Minière (UM), a world leader in the nonferrous metals sector, launched a major restructuring program in 1995 to restore competitiveness and improve profitability. The conglomerate's nickel salts operations are now part of the UM Cobalt and Energy Products business unit. Much of the efforts of the newly expanded unit will focus on developing and producing new materials for battery manufacturers, the catalyst industry, and coatings.

UM Cobalt produces nickel sulfate crystals and other nickel salts from cobalt-bearing scrap at Olen, Belgium, about 40 kilometers east of Antwerp. Various types of cobalt-nickel scrap are leached in strong acids, dissolving the two metals. The dissolved nickel is then separated from the cobalt in a complex series of purification steps and transformed into nickel sulfate. The Olen plant can produce up to 2,500 tons per year of Ni as nickel sulfate. In mid-1995, UM Cobalt formed a joint venture with two Japanese companies—Mitsui & Co. and the Nikko Rica Group—to produce spherical nickel hydroxide for rechargeable batteries. The joint venture, Battery Materials Corp., was to begin producing the hydroxide in April 1996 at Tatebayashi in Gunma Prefecture, Japan.[37]

OMR completed a major expansion of its Harjavalta smelter and refinery in Turku-Pori Province, Finland. The expansion raised the production capacity of the complex to 32,000 tons per year of nickel briquets and cathode and 160,000 tons per year of blister copper. In 1995, Harjavalta produced 18,400 tons of nickel and 88,300 tons of blister copper, despite a 6-week interruption in the spring because of the expansion. The complex should be operating at its new full capacity of 32,000 tons per year by the end of 1996.[38]

OMR has only one nickel mine still operating in Finland—the Hitura Mine near Ainastalo. Because of declining ore reserves, the Enonkoski Mine was closed in December 1994 and the Vammala Mine in January 1995. Since March 1995, the Harjavalta smelter has been relying mainly on concentrate from WMC's new Mount Keith Mine and OMR's own Forrestania Mine, both in Western Australia. In 1995, the Hitura Mine produced 3,100 tons of Ni in concentrate. An additional 500 tons of Ni in concentrate was made from the last of the Vammala ores. According to company records, the Hitura Mine had 0.7 million tons of proven and probable reserves, averaging 0.7% Ni, at the end of 1995. The mine had an additional 6.9 million tons of measured, indicated, and inferred resources containing 0.8% to 0.9% Ni.

At the beginning of 1995, the Government of Finland solicited bids to develop the Kevitsa nickel-copper deposit in Lapland. The first round of bidding took place on February 2, with Falconbridge, Inco, and OMR all participating. The Kevitsa deposit was discovered by the Finnish Geological Survey about 1991 near the town of Sodankylä. More than 300 exploratory holes have been drilled to date. The deposit covers at least 10 hectares (25 acres) and occurs in a ultramafic layered intrusion (mostly olivine pyroxenites) of Early Proterozoic Age. The Ni/Cu ratio ranges from about 0.6 to 0.9. In December, the Government awarded the concession to OMR. OMR has launched a 3-year exploration program and agreed to submit a feasibility study before the end of 2001.[39]

Greenland.—The discovery of the Voisey's Bay deposit in Labrador encouraged several mining companies to explore for massive sulfide ore bodies across the Davis Strait in Greenland. Several ultramafic intrusives believed to be similar in geologic age and petrology to those in Labrador have been identified on the western coast of the Danish island. In early 1994, before the magnitude of the Voisey's Bay discovery was fully realized, Falconbridge drilled several structures in the Disko Bay area near Qeqertarssuaq (*Danish*— Godhavn), but reportedly did not find any economically significant mineralization. The project was part of a joint exploration venture with Platinova A/S, a Greenlandic mineral development company. Platinova currently has a 32% interest in the Disko Bay project, with Falconbridge holding the remaining 68%.[40]

In July 1995, Cartaway Containers Ltd. and Platinova formed a joint venture to explore three of Platinova's concessions in the southern part of the West Coast. The northernmost concession adjoins a 4,332-square kilometer concession held by Cominco Ltd., the owner of Glenbrook Nickel. Diamond Fields also has

two concessions, totaling 2,541 square kilometers, in the region. The central concession held by the Platinova-Cartaway venture contains a belt of anorthositic intrusions with several prominent, untested gossans.

Indonesia.—In late 1995, P. T. International Nickel Indonesia (P. T. Inco) began a major expansion of its mining and smelting complex on the island of Sulawesi. The $580 million expansion will take 4 years to complete and raise the production capacity of the Soroako smelter from 45,000 tons per year of Ni in matte to 68,000 tons per year. The expansion would involve installation of a fourth smelting line at Soroako and construction of a second hydroelectric power station on the Larona River. The new $130 million power station was being built at Balambano, 5 kilometers downstream from the existing facility, and will have an average output of 93 megawatts.

The fourth smelting line would consist of a new ore dryer, reduction kiln, electric arc furnace (EAF), and converter. The new smelting line would employ the same processing technology as the existing three lines, but some of the equipment would have greater capacity, increasing the operational flexibility of the entire smelter.[41] P. T. Inco decided to move ahead with the expansion after the Government of Indonesia agreed to extend P. T. Inco's contract of work to the year 2025. The previous contract was to have expired in 2008. The new agreement was formally signed in Jakarta on January 15, 1996.

At the end of 1995, ore reserves in the Soroako project area consisted of 108 million tons of nickeliferous laterite averaging 1.85% Ni. Exploration since 1990 has identified additional resources some 150 kilometers south-southeast of Soroako, between Pomalaa and Torobulu. The Pomalaa East area contains at least 50 million tons of ore, averaging 1.9% Ni, and may constitute a possible resource of 147 million tons. Another sizable resource exists at Bahodopi, on the Gulf of Tolo, 80 kilometers southeast of Soroako. A test pit exploration program carried out in 1994-95 suggests that the Bahodopi area has 180 million tons of material averaging 1.77% Ni.

P. T. Inco produced a record 45,463 tons of nickel in matte in 1995, up slightly from the previous high of 45,325 tons set in 1994. The granulated matte averaged 78% Ni and was being shipped to the Tokyo Nickel Co., Ltd. at Matsuzaka, Japan, for conversion into oxide sinter and utility nickel.

New Caledonia.—In May 1994, Société Métallurgique Le Nickel (SLN) commissioned its new Kopéto 2 Mine near Népoui, some 230 kilometers northwest of the capital of Nouméa. The open pit mine is in a massif about 15 kilometers northeast of the coastal town of Pouembout. The mine and its associated washing plant, slurry transfer system, and coastal loading facility form the Népoui-Kopéto mining center. The new mining center experienced some start-up problems, but, by the end of 1995, was recovering lateritic ore at a rate of 600,000 tons per year.[42] The Kopéto Mine has a design capacity of 830,000 tons per year of ore and was expected to provide one-third of the feed material required by the company's Doniambo smelter in Nouméa. The garnierite-rich saprolitic ore assays about 2.1% Ni.

SLN, a subsidiary of the Eramet Group, had three other nickel mines in operation—Thio, Kouaoua, and Kaala-Gomen. Each mine normally screens its ores on-site before shipping them to Doniambo. In 1995, the Doniambo smelter produced 42,200 tons of Ni in ferronickel and 10,143 tons of Ni in matte. The combined output was a new record for Doniambo.

In July 1995, Inco initiated a feasibility study of its Goro holdings at the southeastern tip of the island. Drilling to date has delineated a resource of 150 million tons of lateritic material grading 1.6% Ni and 0.16% Co.[43] The feasibility study was being sponsored by Goro Nickel S.A., a joint venture between Inco (85% interest) and France's Bureau de Recherches Géologiques et Minières (15%). The nickel and cobalt would be recovered using a pressure acid leaching process combined with solvent extraction.

Norway.—Falconbridge Nikkelverk A/S produced 53,200 tons of refined nickel, down 22% from 68,000 tons in 1994. The drop was due primarily to a shortfall of feed during the first half of the year. Shipments of matte were down from both Falconbridge's smelter at Sudbury, ON, and BCL Ltd.'s smelter at Selebi Phikwe in Botswana. In addition, there were no shipments at all in 1995 from Norilsk Nickel.

The Nikkelverk refinery was upgraded in 1994 and is now capable of producing 69,000 tons per year. A second expansion was in progress which should raise refining capacity even further to 85,000 tons by 1998. The additional capacity is needed to process matte made from Raglan's concentrates. The matte from this new source should begin arriving in 1998.

In December 1995, OMR acquired a 70% interest in Nikkel og Olivin A/S. The remaining 30% was held by Nordlandsbanken AS, a Norwegian Bank. Nikkel og Olivin mines nickel sulfides at Ballangen, about 30 kilometers southwest of the iron ore port of Narvik in Nordland. The entire annual output of the underground mine—some 2,600 tons of Ni in concentrate—has been going to OMR's Harjavalta smelter in Finland. The concentrate typically assays 12.5% Ni, 3.2% Cu, and 0.5% Co.

Russia.—RAO Norilsk Nickel produced 180,100 tons of nickel metal in 1995, along with 338,700 tons of copper metal, and 3,650 tons of cobalt in metal or oxide.[44] Nickel production was up 10.9% from that of 1994, when the company's output was 162,400 tons. This increase came at a time when the company was in a difficult financial situation.

According to company officials, Norilsk Nickel controls 90.4% of Russia's nickel reserves. About 84.7% of the company's reserves are on the Taimyr Peninsula of north-central Siberia; the other 15.3% are on the Kola Peninsula near the Finnish border. The Norilsk complex on the Taimyr Peninsula had two new underground mines under development—the Skalisty and the Gluboky. These would supplement the one large open pit and five underground mines that the Siberian complex has had in operation for some time.

Norilsk Nickel was partially privatized in April 1994 and has since undergone a major restructuring of its management. The new organization is composed of six, largely independent joint-stock companies. The Russian government still remains the principal shareholder in Norilsk Nickel and has put the

Oneximbank in charge of its interests. In November 1995, Oneximbank bought 51% of Norilsk Nickel's voting stock from the Government under a controversial loans-for-shares program. The purchase was later approved by the Duma—the Russian parliament—effectively giving Oneximbank a 39% interest in the company.

Norilsk Nickel was behind in its tax payments and, like several other companies with Arctic operations, was heavily in debt to its natural gas supplier. Continuing cash flow problems made it difficult for the company to meet its payroll and purchase foodstuffs for its workers and essential supplies. Norilsk Nickel also was under pressure from both foreign and domestic environmental groups to drastically reduce sulfur dioxide emissions from its three smelters. The company was actively seeking loans from the Russian government to modernize all three facilities and correct the pollution problem.

TOO Tyazhzvetmet also increased production, in spite of the country's extensive economic problems. The parastatal organization has three nickel operations in the Ural Mountains —the Ufaleynikel Joint Stock Co., the Yuzhuralnikel Combine Stock Co., and the Rezh Nickel Plant. The two stock companies mined lateritic ores grading 0.7% to 1.0% Ni. All three ventures reportedly had sizable debts and were struggling with sharply rising production costs, especially for purchases of electricity and fuel. Together, they produced 21,800 tons of contained Ni, up from 18,500 tons in 1994. Products included metal granules, cathode, ferronickel, and nickel salts.

Ufaleynikel operates several open pit mines in the Chelyabinsk and Sverdlovsk regions. Minimally processed ores are shipped to the company's smelters at Ufaley and Rezh. Some of the ores are smelted with pyrite in shaft furnaces to make a nickel-cobalt matte. Nickel-cobalt scrap and wastes are mixed with part of the ore to enrich the matte. Other ores are smelted in electric furnaces and converted into ferronickel.

The Yuzhuralnikel Combine has mines in the Orenburg and Chelyabinsk regions and also receives ore from the adjoining Aktubinsk region of Kazakstan. The various ores are processed at the company's smelting and refining complex in Orsk. The Orsk smelting operation is similar to the ones at Ufaley and Rezh, but has a much larger production capacity (46,000 tons per year of contained Ni versus 17,000 tons per year and 5,000 tons per year, respectively).

South Africa.—The first stage of the Columbus Project was completed in late 1995 and was formally commissioned in February 1996. The huge stainless steelmaking complex has been under construction since December 1992 and was being built around the existing Southern Cross stainless steel plant at Middelburg in Mpumalanga Province.

The new facility raised the production capacity of the Middelburg plant from 140,000 tons per year of crude stainless to 240,000 tons per year. The existing Southern Cross melt shop was still operational, but has been largely replaced by a totally new melt shop designed to produce up to 600,000 tons of continuous cast slab.[45] Molten ferrochromium was being taken directly from Samancor Ltd.'s adjoining ferroalloy plant and charged to either the new 100-ton, 90-megavolt-ampere EAF or one of two new Creusot-Loire Uddeholm converters. The plant has a single strand caster which can handle slabs up to 1,600 millimeters in width and 250 millimeters in thickness. When fully operational, Columbus will be the largest single site producer of stainless and related chromium-bearing steels in the world.

Columbus is a joint venture of Samancor, Highveld Steel and Vanadium Ltd., and the State-owned Industrial Development Corp., each holding a one-third share. The project will cost the partnership 3.5 billion Rand *(approximately US$880 million at R4=$1.00)*.

A second expansion phase was launched in early 1996 which will raise the complex's output further to 430,000 tons per year. Products would include hot-rolled coil and band, cold-rolled band, cold-rolled plate of varying sizes, and slab.[46] When the Middelburg facility reaches its final goal of 600,000 tons per year, planned for the end of 1997, it is expected to consume approximately 30,000 tons per year of nickel units.

Iscor Ltd. began converting part of its carbon steel operations at Pretoria to stainless steel production as part of a major corporate restructuring. This conversion took advantage of spare melting and casting capacity at the steelworks. The first stainless slabs were to come off the line in April 1996 and were to be shipped from Pretoria to the company's Vanderbijlpark facility in Gauteng Province for hot rolling. Some slabs also were to be sent to Columbus for cold rolling tests or shipped abroad for further evaluation. The less costly Pretoria project—approximately $50 million vs. $880 million for Columbus—would require between 20,000 and 35,000 tons per year of nickel units, bringing total South African nickel consumption for the year 2000 to more than 60,000 tons.

The rapid expansion of South Africa's stainless steel industry is transforming the country from a net exporter of nickel into a net importer. To date, almost all of the nickel produced has been a byproduct of the country's platinum mines in the Bushveld Complex. Limited amounts of nickel are recovered as nickel sulfate from the Palabora copper plant.

Only two of the four platinum producers in South Africa currently produce nickel in a refined form suitable for austenitic stainless steel production. The two nickel refiners are Rustenburg Platinum Holdings Ltd. (RPH) and Impala Platinum Holdings Ltd. (IMPLATS). Together, the two have been supplying most of the primary nickel consumed by the Columbus Joint Venture. There is industry concern that the two refiners will be unable to meet local nickel demand and that additional nickel will have to be obtained either from South African-owned operations in Latin America or from the open market. In 1995, South Africa produced about 29,000 tons of nickel as a byproduct of its platinum mines. However, by 1997, Columbus alone will require at least 48,000 tons per year of nickel. South Africa may have to import even more nickel when the Iscor plant is in full production.[47]

To reduce this projected import dependence, Anglo American Corp. (AAC), a major shareholder in RPH, teamed up with the Anglovaal Group in mid-1995 to further evaluate nickel-cobalt-copper-platinum mineralization in the Uitkomst

Complex in Mpumalanga Province. The 2-billion-year-old intrusive complex is spatially related to the Bushveld Igneous Complex. Exploration of the Uitkomst complex had been carried out intermittently since 1972—first by an AAC joint venture with Inco and later by Anglovaal. The various drilling programs have focused on two adjoining farms, Uitkomst and Slaaihoek.

In August 1993, two Anglovaal subsidiaries, Eastern Transvaal Consolidated Mines Ltd. and Middle Witwatersrand (Western Areas) Ltd., formed the Nico Joint Venture to evaluate the Slaaihoek deposit. At that time, AAC held the mineral rights to the neighboring Uitkomst farm. When it became apparent that development costs could be reduced significantly by integrating the Slaaihoek and Uitkomst programs, Nico linked up with Kaffrarian Metal Holdings (Pty.) Ltd., an AAC subsidiary, to form the Nkomati Joint Venture.

The Uitkomst Complex is a layered intrusive made up of gabbro, norite, pyroxenite, and massive chromitite. The complex has been explored by drilling more than 550 holes since 1972. Four distinct zones of sulfide mineralization have been identified to date in the 12-kilometer by 0.5-to-1.5-kilometer complex. The principal ore minerals are pentlandite and chalcopyrite.

In March 1996, AAC and Anglovaal announced that they would begin developing one of the zones—the so-called Massive Sulfide Body, beneath the Slaaihoek farm. According to an article in Geobulletin[48], the Massive Sulfide Body has 3 million tons of indicated resources averaging 2.04% Ni, 1.13% Cu, and 0.09% Co, with significant palladium, platinum, and other precious metal credits. A pilot plant is now in operation at Slaaihoek. The Nkomati project would be South Africa's only active primary nickel mine and was scheduled to begin milling ore in early 1997 at the rate of 10,000 tons per month. The initial concentrates would be toll smelted and refined.

Venezuela.—Anglo-American Corp. of South America (AMSA) has completed its feasibility study of the Loma de Hierro nickel deposit and has decided to exercise its option to develop the property.[49] At the beginning of 1995, the company renegotiated its buy-in agreement with Jordex Resources Inc. and has since increased its equity in the project from 10% to 85%. The Venezuelan laterite deposit was being developed jointly by AMSA, Corporación Caracas, and Jordex. The partnership originally was incorporated in Venezuela under the name Corporación Federal de Minas.

Loma de Hierro is about 85 kilometers southwest of Caracas in the States of Miranda and Aragua. The site has been under investigation since the 1960's. Recent sampling of test pits and additional drilling have confirmed a resource of about 38 million tons of ore averaging 1.57% Ni, or roughly 590,000 tons of contained nickel. The resource estimate assumes a cutoff grade of 0.8% Ni. Mining could begin as early as late 1998. The proposed $330 million mining and smelting complex was expected to produce between 16,000 and 19,000 tons per year of Ni in ferronickel over the 25- to 30-year life of the operation. The ferronickel smelter would have a feedstock capacity of 1.2 million tons per year of ore.

A significant portion of the ferronickel from Loma de Hierro was expected to go to the Columbus stainless steel plant in South Africa. AMSA has been involved with ferronickel production in Brazil for over 15 years through its financial ties to Cia. de Desenvolvimento de Recursos Minerais SA and Mineraçâo Morro do Niquel SA. Jordex and Corporación Caracas received a total of $33 million for their two 37.5% equity shares. Each retained a 7.5% interest in the venture.

Current Research and Technology

At the end of 1995, increasing numbers of EV's began to emerge from assembly plants in Western Europe. U.S. and Japanese automobile manufacturers were expected to follow suit in late 1996 and early 1997. Five different battery chemistries were being used: Ni-Cd, Ni-MH, valve-regulated lead-acid, lithium-ion (Li-ion), and zinc-air. If one of the two nickel-based batteries wins out in the current competition, demand for nickel could increase significantly. According to Toyota officials, a Ni-MH battery pack offers 1.5 times the energy storage capacity of lead-acid batteries while being more than 10% lighter.

PSA Peugeot-Citroën and Renault were gearing up to produce Ni-Cd powered EV's on an extended basis. The new vehicles were being powered by Ni-Cd batteries made by SAFT S.A. In October 1995, Peugeot released detailed technical information on its new *106 Electrique* automobile to the news media.[50] The two-door hatchback has three battery packs composed of 6-volt Ni-Cd monoblocks. The three packs (a total of 20 monoblocks in series) provide 120 volts to the direct current motor. All the monoblocks together weigh 342 kilograms. The Ni-Cd battery packs will be rented by the EV buyer and serviced by SAFT under a comprehensive agreement that extends over the life of the vehicle. In October 1995, SAFT inaugurated a Ni-Cd EV battery plant in Bordeaux, France, that will initially produce batteries for 5,000 vehicles per year. The other two major producers of Ni-Cd batteries for EV's are: DAUG-HOPPECKE Gesellschaft Für Batteriesysteme mbH in Germany and the Acme Electric Corp. in the United States.

In June 1994, General Motors Corp. (GM) entered into a joint venture with Ovonic Battery to manufacture EV batteries utilizing proprietary Ni-MH technology. The venture, GM Ovonic L.L.C., has been purchasing both negative electrodes and battery packs from Ovonic Battery. GM has a 60% interest in the venture; Ovonic Battery, 40%. GM was conducting scale-up engineering activities at a manufacturing facility in Troy, MI, and reportedly was to begin limited production of Ovonic Ni-MH battery packs for its EV1 in 1997. Honda Motor Co. Ltd., which owns 6.5% of Ovonic Battery, and Hyundai Motor Co. Ltd. were planning to use Ovonic Ni-MH batteries in their EV test fleets, starting in 1997.

Outlook

Demand for austenitic stainless steel will continue to drive the world nickel market for at least another 20 years. World consumption of stainless steel is expected to grow between 3%

and 9% annually from 1997 to the year 2005. This growth rate should increase substantially at some point when the Russian economy inevitably turns around. Demand for stainless steel has already resumed its upward growth in Japan, the United States, and several EU countries following the global recession of 1991-93. Stainless steel production capacity is being expanded in some of the newly industrialized countries of the Far East that successfully weathered the recession. Since 1990, production of austenitic stainless steel has been increasing in South Korea and Taiwan by more than 10% per year.

Demand for superalloys is expected to grow despite projected cutbacks in the defense programs of the United States, the EU, and Russia. Total U.S. aerospace sales for 1996 will reportedly rise for the first time in 5 years. Sales in 1997 are expected to be even better because of increased orders for commercial jet transport.

Although still relatively small, demand for nickel in rechargeable batteries is growing at more than 10% per year. The nationwide recycling system for nickel-based batteries being established in the United States should lessen environmental concerns. It also helps that INMETCO now has an on-site facility for recovering the cadmium in Ni-Cd batteries. The Rechargeable Battery Recycling Corp. and the Portable Rechargeable Battery Association have been working with a broad spectrum of manufacturers, domestic retailers, and Government agencies to improve Ni-Cd and Ni-MH battery recycling rates. The organization expects to have 6,000 retailers in 30 States participating in its program by the beginning of 1997.

The development of the Voisey's Bay deposit is expected to have a major impact on the world nickel supply, sharply reducing concerns about future shortages of the metal. Recent drilling has delineated additional resources at depth in the immediate area of the discovery site and changed long-range thinking about future exploration targets elsewhere in the Northern Hemisphere. Development plans for the Voisey's Bay deposit have gone through several gyrations since the end of 1995, pitting Falconbridge against Inco. In August 1996, Inco acquired Diamond Fields for $3.1 billion and, with it, control of the deposit. Inco has set up a special executive team to oversee and accelerate construction of the proposed mine and concentrator. The executive team has since recommended that a new smelter and refinery complex be built on the island of Newfoundland to process the concentrate. The most attractive site to date is at Argentia, 130 kilometers west of St. John's. It will take about 36 months to build the complex.

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TABLE 1
SALIENT NICKEL STATISTICS 1/

(Metric tons of contained nickel unless otherwise specified)

	1991	1992	1993	1994	1995
United States:					
Mine production	5,520	6,670	2,460	--	1,560 e/
Plant production	7,070	8,960	4,880	--	8,290 p/
Secondary recovery from purchased scrap:					
From ferrous scrap	44,800	47,700	46,600	48,900	54,400
From nonferrous scrap	8,700	8,140	7,460	9,690	10,000
Exports:					
Primary	9,100	8,560	7,180	7,420 r/	9,750
Secondary	27,800	25,300	26,000	34,500	41,800
Imports for consumption:					
Ore	371	3,580	2,970	--	8,200 p/
Primary	132,000	119,000	126,000	127,000	149,000
Secondary	6,210	9,510	6,710	6,060	7,930
Consumption:					
Reported:					
Primary	109,000	101,000	105,000	107,000	124,000
Secondary (purchased scrap) 2/	53,500	55,900	54,000	58,600	64,400
Total	162,000	157,000	159,000	166,000	188,000
Apparent:					
Primary	125,000	119,000	122,000	133,000 r/	150,000
Secondary (purchased scrap)	31,400	40,300 r/	36,600	30,500	29,400
Total	157,000	159,000	158,000	164,000	180,000
Stocks, yearend:					
Government	33,800	33,800	31,600	26,800	19,800
Producer and traders	11,800	10,100	15,700	10,200	14,100
Consumer:					
Primary	10,500	12,300	11,100	8,000 r/	8,130
Secondary	5,460 r/	5,240 r/	3,360 r/	3,010 r/	4,150
Employment, yearend:					
Mine	8	10	2	1	15 p/
Smelter	277	250	33	22	250 p/
Port facility	--	23	5	3	25 p/
Price, cash, London Metal Exchange:					
Per metric ton	$8,156	$7,001	$5,293	$6,340	$8,228
Per pound	$3.699	$3.176	$2.401	$2.876	$3.732
World: Mine production	1,010,000 r/	996,000 r/	918,000 r/	924,000 r/	1,040,000 e/

e/ Estimated. p/ Preliminary. r/ Revised.

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

2/ More nearly represents amount consumed than does apparent secondary consumption; internal evaluation indicates that apparent secondary consumption is considerably understated.

TABLE 2
NICKEL RECOVERED FROM PURCHASED SCRAP IN THE
UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons of contained nickel)

	1994	1995
Kind of scrap:		
Aluminum-base 2/	3,150	3,280
Copper-base	2,970	2,720
Ferrous-base 3/	48,900	54,400
Nickel-base	3,580 r/	4,050
Total	58,600	64,400
Form of recovery:		
Aluminum-base alloys 4/	3,150	3,280
Copper-base alloys	4,830	4,660
Ferrous alloys	48,900	54,400
Nickel-base alloys	1,620	2,060
Miscellaneous and unspecified	41	--
Total	58,600	64,400

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Primarily used beverage cans and foundry borings and turnings.
3/ Primarily stainless and alloy steel scrap consumed at steel mills and foundries.
4/ Includes can scrap converted to ingot by toll smelters for sale on open market.

TABLE 3
REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM 1/

(Metric tons of contained nickel)

Form	1994	1995
Primary:		
Metal	80,200 r/	93,200
Ferronickel	18,900	21,700
Oxide and oxide sinter 2/	3,690	3,250
Chemicals	1,730	4,310
Other	3,010 r/	1,440
Total primary	107,000	124,000
Secondary (scrap) 3/	58,600	64,400
Grand total	166,000	188,000

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Includes chemical-grade oxide.
3/ Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4
U.S. CONSUMPTION OF NICKEL IN 1995, BY USE 1/

(Metric tons of contained nickel)

Use	Metal	Ferro-nickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)	Grand total 1995	Grand total 1994 r/
Cast irons	185	W	(2/)	W	28	213	267	480	501
Chemicals and chemical uses	1,340	--	W	3,860	--	5,200	--	5,200	2,680
Electric, magnet, expansion alloys	W	--	--	--	--	W	W	W	599
Electroplating (sales to platers)	15,600	(2/)	W	56	W	15,600	--	15,600	15,800
Nickel-copper and copper-nickel alloys	4,420	W	W	W	W	4,420	3,880	8,300	8,210
Other nickel and nickel alloys	19,300	W	W	--	W	19,300	1,820	21,100	20,800
Steel:									
Stainless and heat-resistant	26,700	20,300	2,180	--	W	49,200	53,100	102,000	88,800
Alloys (excludes stainless)	6,800	W	W	--	(2/)	6,800	1,040	7,840	7,400
Superalloys	13,400	--	W	W	W	13,400	W	13,400	12,200
Other 3/	5,520	1,410	1,070	391	1,410	9,800	4,350	14,100	9,110
Total reported	93,200	21,700	3,250	4,310	1,440	124,000	64,400	188,000	166,000
Total all companies, apparent	XX	XX	XX	XX	XX	150,000	29,400	180,000	164,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.

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

2/ Less than 1/2 unit.

3/ Includes batteries, catalysts, ceramics, coinage, and other alloys containing nickel, and data represented by symbol "W."

TABLE 5
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES, BY FORM 1/

(Metric tons of contained nickel)

Form	1994	1995
Primary:		
Metal	4,910 r/	6,200
Ferronickel	544 r/	674
Oxide and oxide sinter	1,230	324
Chemicals	1,060 r/	808
Other	261 r/	129
Total primary	8,000 r/	8,130
Secondary (scrap)	3,010 r/	4,150
Grand total	11,000 r/	12,300

r/ Revised.

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

TABLE 6
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS 1/

(Metric tons of contained nickel unless otherwise specified)

Class	1994 Quantity	1994 Value (thousands)	1995 Quantity	1995 Value (thousands)
Unwrought primary:				
Cathodes, pellets, briquets, and shot	564	$4,040	1,310	$11,400
Ferronickel	35	96	807	6,590
Powder and flakes	1,090	10,000	1,230	13,900
Metallurgical-grade oxide 2/	3,630 r/	7,370	3,490	7,730
Chemicals: 3/				
Catalysts	1,630	60,400	2,210	83,900
Salts	480	7,430	714	10,100
Total	7,420 r/	89,300	9,750	134,000
Unwrought secondary : 4/				
Stainless steel scrap	22,400	190,000	27,600	325,000
Waste and scrap	12,100	45,200	14,200	58,600
Total	34,500	235,000	41,800	384,000
Grand total	41,900	325,000	51,500	517,000
Wrought:				
Bars, rods, profiles and wire	257	3,280	205	2,150
Sheets, strip and foil	121	2,060	117	2,180
Tubes and pipes	49	573	154	1,420
Total	427	5,920	476	5,750
Alloyed (gross weight):				
Unwrought alloyed ingot	2,830	21,000	4,170	41,000
Bars, rods, profiles and wire	4,290	59,600	4,920	79,900
Sheets, strip and foil	6,180	86,500	6,380	104,000
Tubes and pipes	1,160	22,300	1,240	28,000
Other alloyed articles	2,580	36,400	2,150	36,500
Total	17,000	226,000	18,900	289,000

r/ Revised.

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

2/ Chemical-grade oxide is included with the "Salts" category.

3/ For the different salts, the nickel contents are assumed to be as follows: chlorides, 25%; sulfates, 22%; other salts, 22%; and oxide, sesquioxide and hydroxide, 65%. The typical catalyst is assumed to have a nickel content of 22%.

4/ The nickel content of waste and scrap is assumed to be 50%, while that of stainless steel scrap has been shown to be about 7.5%.

Sources: Bureau of the Census and Journal of Commerce.

TABLE 7
U.S. EXPORTS OF NICKEL PRODUCTS IN 1995 , BY COUNTRY 1/

(Metric tons of contained nickel 2/)

Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferro-nickel	Metal-lurgical grade oxide 3/	Waste and scrap	Stainless steel scrap	Chemicals	Total 1995	Total 1994	Wrought nickel 4/
Australia	--	8	--	45	109	1	1	164	178 r/	26
Belgium	1	44	--	--	548	1,720	207	2,520	942	3
Canada	1,020	694	--	3,300	8,760	4,340	443	18,600	15,800	41
China	--	--	--	--	11	306	55	372	270	4
Colombia	17	5	--	2	--	--	10	34	67	5
Finland	--	--	--	--	30	--	7	37	85	--
France	160	11	--	--	70	10	29	280	169	31
Germany	6	19	--	1	646	32	26	730	700	3
India	--	5	--	(5/)	91	252	6	354	387	--
Italy	--	2	--	--	--	27	10	39	25	1
Japan	--	32	641	60	1,470	2,090	1,010	5,300	3,750	5
Korea, Republic of	8	24	--	1	--	7,950	26	8,010	6,150	6
Mexico	66	61	28	1	(5/)	18	350	524	502	87
Netherlands	--	38	--	--	254	1,100	11	1,400	1,470	16
Spain	--	1	--	--	8	5,150	5	5,160	5,490	(5/)
Sweden	--	4	(5/)	--	1,850	515	5	2,380	2,650	1
Taiwan	--	12	138	15	23	1,280	59	1,520	701	1
United Kingdom	22	39	--	8	116	240	26	451	875	62
Other	9	227	--	61	181	2,590	638	3,710	1,730 r/	183
Total	1,310	1,230	807	3,490	14,200	27,600	2,920	51,500	41,900	476

r/ Revised.

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

2/ The nickel contents are assumed to be as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The chemical category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; and sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.

3/ Chemical-grade oxide is included in the "Chemicals" category.

4/ Not included in "Total."

5/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY CLASS 1/

(Metric tons of contained nickel 2/ unless otherwise specified)

	1994		1995	
Class	Quantity	Value (thousands)	Quantity	Value (thousands)
Unwrought primary:				
Cathodes, pellets, briquets, and shot	95,700	$552,000	118,000	$959,000
Ferronickel	15,300	85,500	16,700	129,000
Flakes	275	2,020	790	4,690
Powder	8,800	78,400	8,720	89,100
Metallurgical-grade oxide	3,070	18,700	530	5,110
Chemicals: 3/				
Catalysts	2,330	36,700	2,420	34,200
Salts	1,620	16,700	1,780	22,100
Total	127,000	790,000	149,000	1,240,000
Unwrought secondary:				
Stainless steel scrap	3,190	20,200	3,190	33,800
Waste and scrap	2,880	21,700	4,740	47,100
Total	6,060	41,900	7,930	80,900
Grand total	133,000	832,000	157,000	1,320,000
Wrought:				
Bars, rods, profiles and wire	238	3,100	170	2,540
Sheets, strip and foil	352	4,440	1,980	17,200
Tubes and pipes	45	1,200	94	2,020
Total	634	8,740	2,240	21,800
Alloyed (gross weight):				
Unwrought alloyed ingot	2,720	20,300	3,000	28,200
Bars, rods, profiles and wire	2,470	28,000	3,210	39,900
Sheets, strip and foil	1,310	15,300	1,510	22,200
Tubes and pipes	801	19,900	1,040	21,000
Other alloyed articles	380	10,200	377	11,500
Total	7,680	93,800	9,140	123,000

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

2/ The nickel contents are as follows: metallurgical-grade oxide from Australia 90%; elsewhere 77%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

Sources: Bureau of the Census and Journal of Commerce.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY 1/

(Metric tons of contained nickel 2/)

Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferro-nickel	Metal-lurgical grade oxide 3/	Waste and scrap	Stainless steel scrap	Chemicals	Total 1995	Total 1994	Wrought nickel 4/
Australia	12,100	1,580	--	130	--	--	17	13,800	17,300	(5/)
Austria	--	12	127	--	--	--	--	139	158 r/	--
Belgium	--	1	--	--	7	--	546	554	289	--
Brazil	2,080	4	710	--	3	--	--	2,800	5,150	--
Canada	42,600	6,410	--	394	1,490	1,650	1,850	54,400	49,600	108
China	196	(5/)	--	--	38	1	(5/)	235	960	(5/)
Colombia	--	--	2,320	--	--	13	--	2,330	2,130	4
Dominican Republic	--	--	8,100	--	171	4	--	8,270	8,170	--
Finland	2,320	--	--	--	--	--	545	2,870	2,520	--
France	1,270	1	--	--	600	--	141	2,010	1,770	34
Germany	--	20	--	--	302	--	203	525	575	467
Japan	1	3	--	--	140	39	276	459	654	4
Mexico	--	--	--	--	54	1,360	149	1,560	1,100 r/	(5/)
New Caledonia	--	--	4,200	--	--	--	--	4,200	3,760	--
Norway	19,100	--	--	--	19	--	--	19,200	22,300	--
Russia	32,000	1,290	1,270	--	6	2	1	34,600	6,130	1,560
South Africa	2,500	38	7	--	21	--	9	2,570	5,260	--
United Kingdom	1,750	102	(5/)	6	863	--	17	2,740	1,700	17
Zimbabwe	1,900	--	--	--	--	--	--	1,900	2,640	--
Other	59	44	--	--	1,030	125	454	1,710	987 r/	45
Total	118,000	9,510	16,700	530	4,740	3,190	4,210	157,000	133,000	2,240

r/ Revised.

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

2/ The nickel contents are assumed to be as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The chemicals category contains the following: chemical-grade oxide, sesquioxide and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts which are assumed to be 22% nickel. The typical catalyst is assumed to have a content of 22%.

3/ Primarily oxide rondelles and sinter.

4/ Not included in "Total."

5/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of nickel content)

Country	1991	1992	1993	1994	1995
Albania (content of ore)e/	7,500	150	75	--	--
Australia (content of concentrate)	69,000	57,683	64,717	78,962 r/	101,000 e/
Botswana (content of ore milled)	23,500	23,000	23,000	19,041 r/	18,672
Brazil (content of ore)	26,376	29,372	32,154	32,663 r/	32,700 e/
Burma (content of ore)	15	9	67	50 e/	50 e/
Canada (content of concentrate)	192,259	186,384	188,080	149,886	180,984
China (content of concentrate) e/	30,400	32,800	30,700	36,900 r/	37,000
Colombia (content of laterite ore)	23,048 r/	23,347 r/	22,831 r/	26,141 r/	24,194
Cuba (content of oxide, oxide sinter, sulfide) 3/	33,349	32,190	30,227	26,926 r/	42,696
Dominican Republic (content of laterite ore) 4/	44,661	42,641	37,423	48,000 e/	49,000 e/
Finland (content of concentrate)	9,900	9,270 r/	8,287	7,652 r/	4,382
Greece (content of laterite ore)	19,300	17,000	12,940	18,821 r/	19,947
Indonesia (content of ore)	71,681	77,600	65,757	81,175 r/	88,183
New Caledonia (content of ore)	114,492	113,000	97,092	97,323 r/	121,457
Norway (content of concentrate)	1,958 r/	3,398	3,462	2,938 r/	3,000 e/
Philippines	13,658	13,022	7,663	9,895 r/	15,075
Russiae/ 5/	XX	280,000	244,000 r/ 6/	240,000	251,000
Serbia and Montenegro (content of ferronickel produced) 7/	XX	1,857	443	603 r/	962
South Africa (content of concentrate)	27,700	28,400	29,868 r/	30,751 r/	29,803
Ukraine (content of ferronickel produced) e/ 5/	XX	5,900 6/	3,500 r/	2,500 r/	2,500
U.S.S.R. (content of ore) e/ 8/	280,000	XX	XX	XX	XX
United States (content of local ore processed)	5,520	6,670	2,460	--	1,560 e/
Yugoslavia (content of ferronickel produced) e/ 9/ 10/	2,500 r/	XX	XX	XX	XX
Zimbabwe (content of concentrate)	12,371	12,378	12,769	13,836 r/	11,721
Total	1,010,000 r/	996,000 r/	918,000 r/	924,000 r/	1,040,000

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

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

2/ Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output and this is noted parenthetically. Between 1992 and 1995, the Republic of Korea, the United States, and five members of the European Union reported receiving ferronickel originating from Macedonia, but definitive information on the output of the Kavadarci operation was not available. Kazakstan and North Korea may also have active nickel mines, but again information is inadequate to make reliable estimates of output levels. Table includes data available through Oct. 1996.

3/ Data represent nickel plus cobalt content in the ratio of roughly 80 to 1.

4/ Revised series represents nickel content of ore. The previously published series represented content of ferronickel produced. See table 11.

5/ Formerly part of the U.S.S.R.; data were not reported separately until 1992.

6/ Reported figure.

7/ Formerly part of Yugoslavia; data were not reported separately until 1992.

8/ Dissolved in Dec. 1991.

9/ All production in Yugoslavia for 1991 came from Serbia and Montenegro.

10/ Dissolved in Apr. 1992.

TABLE 11
NICKEL: WORLD PLANT PRODUCTION BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons of nickel content)

Country 3/ and product	1991	1992	1993	1994	1995e/
Albania: Metal e/	2,200	50	50	50	50
Australia: Unspecified	49,400	57,000 r/	55,000 r/	67,000 r/	82,000
Austria: Ferronickel	3,500	3,900	3,200	2,100 e/	2,500
Brazil: 4/					
Ferronickel	8,620	8,742	8,683	8,815 r/	8,497 5/
Metal	5,220	5,926	7,022	7,795 r/	7,179 5/
Total	13,840	14,668	15,705	16,610 r/	15,676 5/
Canada: Unspecified 6/	131,500	135,200	123,140	105,144	121,523 5/
China: Metal e/	28,900	30,800	30,500	31,300 r/	38,000
Colombia: Ferronickel	20,194	20,195	20,181 r/	20,833	24,565 5/
Cuba: Oxide sinter 7/	18,531 r/	16,717 r/	15,999 r/	13,930 r/	21,388 5/
Czechoslovakia: 8/ Metal 9/	2,400 e/	1,621	XX	XX	XX
Dominican Republic: Ferronickel	29,063	27,530	23,859	30,766 r/	30,893 5/
Finland:					
Chemicals	2,163	2,890	3,126	4,192	4,000
Metal	13,850	14,781	14,800	16,902 r/	16,000
Total	16,013	17,671	17,926	21,094 r/	20,000

See footnotes at end of table.

TABLE 11--Continued
NICKEL: WORLD PLANT PRODUCTION BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons of nickel content)

Country 3/ and product	1991	1992	1993	1994	1995e/
France:					
Chemicals e/	1,000 5/	1,200	1,200	1,200	1,200
Metal	7,410 r/	6,750 r/	9,120 r/	10,041	10,306 5/
Total e/	8,410 r/ 5/	7,950 r/	10,300 r/	11,200	11,500
Germany: Metal	850	--	--	--	--
Greece: Ferronickel	16,005	15,420	10,934	16,197	17,164 5/
Indonesia: Ferronickel	5,318	5,506	5,266	5,745 r/	10,735 5/
Japan:					
Ferronickel	68,045	57,447	51,120	50,186 r/	63,600 5/
Metal	23,658	22,038	23,108 r/	25,311	26,824 5/
Oxide sinter	22,473	27,520	28,812 r/	34,711 r/	36,800 5/
Chemicals	2,383	2,427	2,258	2,400	2,297 5/
Total	116,559 r/	109,432 r/	105,298 r/	112,608 r/	129,521 5/
Korea, Republic of: Metal e/	(10/)	(10/)	(10/)	(10/)	(10/)
New Caledonia: Ferronickel	34,411	31,895	36,850	39,488	42,200 5/
Norway: Metal	58,730	55,686	56,817	67,955	53,237 5/
Russia: e/ 11/ 12/					
Ferronickel	XX	6,000 r/	6,800 r/	9,800 r/	14,000
Metal	XX	221,000 r/	167,000 r/	165,000 r/	181,000
Oxide sinter	XX	15,000 r/	10,200 r/	4,600 r/	4,500
Chemicals	XX	3,000	2,000	2,000	2,000
Total	XX	245,000 r/	186,000 r/	181,000 r/	202,000
Serbia and Montenegro: 13/ Ferronickel	XX	1,857	443	603 r/	962 5/
South Africa: Metal	26,863	27,621	29,868	30,751 r/	29,803 5/
Sweden: Metal e/	490 5/	500	500	500	500
Taiwan: Metal e/	(10/)	(10/)	(10/)	(10/)	(10/)
Ukraine: 11/ Ferronickel e/	XX	5,900 r/ 5/	3,500	2,500 r/	2,500
U.S.S.R.: e/ 12/ 14/					
Ferronickel	12,600 r/	XX	XX	XX	XX
Metal	259,400 r/	XX	XX	XX	XX
Oxide sinter	15,000 r/	XX	XX	XX	XX
Chemicals	3,000	XX	XX	XX	XX
Total	290,000 r/	XX	XX	XX	XX
United Kingdom: Metal	29,030	28,000 e/	28,000 e/	28,400 r/	31,800
United States: Ferronickel	7,070	8,960	4,880	--	8,290 5/
Yugoslavia: 15/ Ferronickel e/	2,500	XX	XX	XX	XX
Zimbabwe: Metal 16/	11,297	10,349	11,097	13,516 r/	10,862 5/
Grand total	923,000 r/	879,000 r/	795,000 r/	819,000 r/	908,000
Of which:					
Ferronickel	207,000 r/	193,000 r/	176,000 r/	187,000 r/	226,000
Metal	470,000 r/	425,000 r/	378,000 r/	397,000 r/	406,000
Oxide sinter	56,000 r/	59,200 r/	55,000 r/	53,200 r/	62,700
Chemicals	8,550 r/	9,520 r/	8,580 r/	9,790 r/	9,500
Unspecified	181,000	192,000 r/	178,000 r/	172,000 r/	204,000

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

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

2/ Table includes data available through Aug. 22, 1996.

3/ In addition to the countries listed, North Korea is believed to have produced metallic nickel and/or ferronickel, but information is inadequate to make reliable estimates of output levels. Between 1992 and 1995, the Republic of Korea, the United States, and five members of the European Union reported receiving ferronickel originating from Macedonia, but definitive information on the output of the Kavadarci operation, was not available. Data supplied by the International Nickel Study Group suggest that, since 1991, Macedonian ferronickel production has ranged from 2,000 to 4,500 metric tons per year of contained nickel. Several countries produce nickel-containing matte, but output of nickel in such materials has been excluded from this table in order to avoid double counting. Countries producing matte include the following, with output indicated in metric tons of contained nickel: Australia (estimated): 1991-95--45,000; Botswana: 1991--19,280; 1992--18,918; 1993--19,619 (revised); 1994--19,042 (revised); and 1995--18,089; Canada (estimated): 1991-95--40,000; Indonesia: 1991--27,400; 1992--39,300; 1993--37,000; 1994--48,400 (revised); and 1995--49,300; New Caledonia: 1991--9,041; 1992--7,475; 1993--10,883; 1994--10,641; and 1995--10,143.

4/ Brazil is believed to also produce nickel oxide, but information is not available on which to base estimates.

5/ Reported figure.

6/ Nickel contained in products of smelters and refineries in forms which are ready for use by consumers.

7/ Cuba also produces nickel sulfide but, because it is used as feed material elsewhere, it is not included to avoid double counting. Output of processed sulfide was as follows, in metric tons of contained nickel: 1991--13,490 (revised); 1992--14,116 (revised); 1993--12,973 (revised); 1994--11,857 (revised); and 1995--19,456.

8/ Dissolved Dec. 31, 1992.

9/ All production for Czechoslovakia in 1991-92 came from Slovakia. Production for 1993-95 is estimated to be zero.

10/ Nickel metal production figures for the Republic of Korea and Taiwan are not included because the production is derived wholly from imported metallurgical oxides and to include them would result in double counting. Metal estimates are as follows in metric tons: the Republic of Korea: 1991--11,300; and 1992-95--10,000; Taiwan: 1991--11,200; 1992--10,000; 1993--9,000; and 1994-95--10,000.

11/ Formerly part of the U.S.S.R.; data were not reported separately until 1992.

12/ Includes production from sulfidized concentrates shipped from Cuba for toll refining.

13/ Formerly part of Yugoslavia; data were not reported separately until 1992.

14/ Dissolved in Dec. 1991.

15/ Dissolved in Apr. 1992.

16/ Excludes production from matte shipped from Botswana for toll refining.