CHROMIUM

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In 1999, the U.S. chromium supply (measured in contained chromium) was 118,000 metric tons (t) from recycled stainless steel scrap, 476,000 t from imports, and 998,000 t from Government and industry stocks. Supply distribution was 60,300 t to exports, 964,000 t to Government and industry stocks, and 558,000 t to apparent consumption. Chromium apparent consumption increased by 5.08% compared with that of 1998.

The United States exported about 162,000 t, gross weight, of chromium-containing materials that were valued at about $92.5 million and imported about 933,000 t that were valued at about $420 million.

Chromium has a wide range of uses in chemicals, metals, and refractories. Its use in iron, nonferrous alloys, and steel enhances hardenability and resistance to corrosion and oxidation; production of stainless steel and nonferrous alloys are two of its more important applications. Other applications are in alloy steel, catalysts, leather processing, pigments, metal plating, refractories, and surface treatments.

Chromium is an essential trace element for human health. Some chromium compounds, however, are acutely toxic, chronically toxic, and/or carcinogenic. The U.S. Environmental Protection Agency (EPA) regulates chromium releases into the environment. The Occupational Safety and Health Administration regulates workplace exposure.

Because the United States has no chromite ore reserves and a small reserve base, domestic supply has been a concern during every national military emergency since World War I. World chromite resources, mining capacity, and ferrochromium production capacity are concentrated in the Eastern Hemisphere. World chromite ore reserves are more than adequate to meet anticipated world demand. In recognition of the vulnerability of long supply routes during a military emergency, chromium has been held in the National Defense Stockpile in various forms that include chromite ore, chromium ferroalloys, and chromium metal. As a result of improved national security, stockpile goals have been reduced, and inventory is being sold. Recycling is the only domestic supply source of chromium.

The U.S. Geological Survey (USGS) has conducted mineral-resource surveys of the United States to assess the potential for occurrences of chromium and other mineral resources. The National Aeronautics and Space Administration, the National Institute of Standards and Technology, the U.S. Department of Defense, and the U.S. Department of Energy conduct alternative materials research.

Legislation and Government Programs

The Defense Logistics Agency (DLA) disposed of chromium materials under its fiscal year 1999 (October 1, 1998, through September 30, 1999) Annual Materials Plan (AMP). As revised in April 1999, the AMP set maximum disposal goals for chromium materials at 90,700 t of chemical grade chromite ore, 227,000 t of metallurgical grade chromite ore, 90,700 t of refractory grade chromite ore, and 45,400 t of chromium ferroalloys. The DLA also developed its fiscal year 2000 AMP, which set maximum disposal goals of 90,700 t of chemical grade chromite ore, 227,000 t of metallurgical grade chromite ore, 90,700 t of refractory grade chromite ore, 136,000 t of chromium ferroalloys, and 7,720 t of chromium metal. The buyers preference offered to ferroalloy up-graders ended in October (U.S. Department of Defense, 2000, p. 8, 11).

The Defense National Stockpile Center published Solicitation of Offers DLA-Ferrochromium-002 and Amendments 001 and 002 to that solicitation. The solicitation described 57,618 t of high-carbon ferrochromium available for sale that is stored in piles at Charleston, SC. The solicitation contained information about preparation and submission of offers, inspection, payment, removal, shipping, contract administration data, definitions, and submittals.

The EPA proposed to exempt chromite ore mined in the Transvaal Region of South Africa and the unreacted ore component of the chromite-ore-processing residue from this region from reporting requirements under Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) (U.S. Environmental Protection Agency, 1999, p. 8774-8779). EPA criteria to add or delete are in Section 313(d) of EPCRA. To be added, a chemical must meet one of the criteria. To be deleted, a chemical must be shown to meet none of the criteria. Petition to delete a chromium chemical was denied on two previous occasions—a 1990 petition to delist chromium antimony titanium buff rutile and a 1991 petition to delist chromium (III) oxide.

The U.S. Department of Health and Human Services reported on the status of research programs to study chromium as one of seven priority hazardous substances. The Tri-Agency Superfund Applied Research Committee, which comprised the Agency for Toxic Substances and Disease Registry, the National Toxicology Program, and the EPA, conducted a survey to assess Federal agencies' needs for testing chromium. The EPA planned to solicit testing proposals and rules. The Agency for Toxic Substances and Disease Registry selected chromium as 1of 3 primary contaminant from a list of 50 priority hazardous substances for which information on contaminant levels in humans must be obtained. It will obtain this information by exposure and health-effect studies and through establishment and use of substance-specific subregistries of people within the Agency's National Exposure Registry (U.S. Department of Health and Human Services, 1999).

The Superfund Recycling Equity Act of 1999 became law as part of Congress' omnibus spending bill. The Act corrects a misinterpretation of the original Superfund Act's liability provisions. Although unintended by the Act's authors, recyclers had been held accountable for the actions of those who purchase their goods. This new legislation states that recycling is not disposal and that shipping for recycling is not arranging for disposal. As a result, recyclers will no longer be held responsible for cleaning up a contaminated site if the site's owners or operators caused the contamination. This clarification removes an impediment to reaching America's recycling goals while saving many recycling businesses. The law removed disincentives to recycling while not loosening any existing liability laws for polluters (Institute of Scrap Recycling Industries, Inc., 1999).

Production

The major marketplace chromium materials are chromite ore and chromium chemicals, ferroalloys, and metal. In 1999, the United States produced chromium ferroalloys, metal, and chemicals, but no chromite ore. Domestic data for chromium materials are developed by the USGS by means of the "Chromite Ores and Chromium Products" (consumers, monthly) survey.

Elkem ASA (Norway) sold its Elkem Metals Company plant at Marietta, OH, to Eramet (France). Elkem's major activity at Marietta was the production of manganese alloys; chromium metal and low-carbon ferrochromium also were produced. The operation, which was renamed Eramet Marietta, Inc., owned an ore supply and was a vertically integrated ferromanganese producer. Elkem had been pressured to sell when The Broken Hill Pty. Co. Ltd. (Australia), which was the ore supplier for its main product (ferromanganese), was purchased by Billiton Plc. (United Kingdom); Billiton was the owner of Samancor Limited (South Africa), which was a vertically integrated ferromanganese producer and Elkem's competitor (Platt's Metals Week, 1999c, d, f; Ryan's Notes, 1999c, d).

Elementis Chromium LP started construction of a new chromite-ore-roasting kiln at its Corpus Christi, TX, plant site. The first stage of chromium chemical manufacture is roasting chromite ore with soda ash at a temperature of about 2000 °F. The new kiln was expected to cost $30 million, to be completed in June 2000, and to reduce production cost by $2 million per year (Industrial Minerals, 1999e, p. 17).

Health and Nutrition

Chromium is an essential chemical element required for normal human carbohydrate and lipid metabolism. Chromium improves insulin function, insulin receptor number, and insulin sensitivity. Adult safe and adequate daily dietary intake for chromium ranges from 50 to 200 micrograms per day. Normal dietary intake is suboptimal. Anderson (1999) concluded that although the problems associated with occupational exposure to chromium are limited to a small segment of the population, those associated with insufficient dietary chromium are likely to involve a large segment of the population.

Consumption

The domestic chemical and refractory industry consumed chromite ore and concentrate in 1999. Chromium has a wide range of uses in chemical, metallurgical, and refractory industries (table 3). The chemical industry consumed chromite for manufacturing sodium dichromate, chromic acid, and other chromium chemicals and pigments. Sodium dichromate is the material from which a wide range of chromium chemicals is made. In the metallurgical industry, its principal use was in stainless steel. Of the 389,000 t of chromium ferroalloys, metal, and chromium-containing materials reported consumed, stainless steel accounted for 73%; full-alloy steel, 6.5%; carbon steel, 3.3%; superalloys, 2.4%; high-strength, low-alloy, and electric, 1.1%; cast irons, 0.44%; and other end uses, 13%. The primary use of chromium in the refractory industry was in the form of chromite to make refractory bricks to line metallurgical furnaces.

Stocks

Reported domestic consumer stocks of chromite ore at consumers' plants were 130,000 t in 1999. Consumer stocks of chromium ferroalloys, chromium metal, and other chromium materials were 24,300 t in 1999. At the 1999 annual rates of consumption of chromium ferroalloy, chromium metal, and other chromium material, producer-plus-consumer stocks represented 0.75 month of supply. Government inventories declined as the DLA disposed of stocks.

Prices

Chromium materials are not openly traded. Although purchase contracts are confidential information between buyer and seller, trade journals report composite prices based on interviews with buyers and sellers, and traders declare the value of materials they import or export. Thus, industry publications and U.S. trade data are sources of chromium material prices and values, respectively. The value of chromium materials was reviewed through 1998 in Papp (1999).

Foreign Trade

Chromium material exports from and imports to the United States included chromite ore and chromium chemicals, ferroalloys, metal, and pigments. The value of foreign trade in 1999 was $92.5 million for exports and $420 million for imports (tables 8 through 11).

World Review

Industry Structure.—The chromium industry comprises primarily chromite ore, ferrochromium, and stainless steel producers. Other industry components are chromite refractory and chromium chemical and metal producers. The trend toward vertical integration was evident within and across national boundaries. Brazil, Finland, India, Japan, Kazakhstan, South Africa, Turkey, and Zimbabwe had chromium industries that were "vertically integrated." As used here, vertically integrated means that at least two of the three major industry sectors—chromite ore mining; chromium chemical or metal, chromite refractory, or ferrochromium production; and stainless steel production—are owned or controlled by a single company.

Jones (1999) reviewed the major chromium-producing countries for ferroalloy production potential, and identified four supply factors that are required for efficient ferrochromium production—chromite ore, labor, power, and reductant. Most of the countries considered (Brazil, China, Kazakhstan, and India) had two of these supply factors available. South Africa, however, had all four factors available, which explains why South Africa accounted for about 40% of world chromite ore and ferrochromium production in 1999. Although South African ore is not the highest quality, it is the least costly to mine at $10 to $20 per metric ton, minimum. Reserves are near the surface. Yield at the smelter has been 65% to 75% owing to the high proportion of fines, a situation that is being improved by process technology changes. About 0.6 to 0.7 t of reductant (carbonaceous material, like coke, charcoal, or coal) is required per metric ton of charge-grade ferrochromium produced. Depending on the process, ferrochromium production requires between 2,800 and 4,800 kilowatt-hours per ton (kWh/t) of product. Worker productivity has been low in South Africa; it, however, is improving.

Capacity.—"Rated capacity" is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate on the basis of the physical equipment of the plant and given acceptable routine operating procedures, which involve energy, labor, maintenance, and materials. Capacity includes operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Because not all countries or companies make production capacity information available, historical chromium trade data have been used to estimate production capacity. Production capacity changes result from changes in facilities and in knowledge about facilities. Countries have been rated for production capacities of chromite ore, chromium chemical, chromium metal, and ferrochromium industries.[1]

Reserves.—The United States has no chromite ore reserves, but it does have a reserve base and resources that could be exploited. The U.S. reserve base, measured in shipping grade chromite ore (45% Cr_2O_3), was estimated to be about 10 million metric tons (Mt), the world reserves were about 3.6 billion metric tons (Gt), and the world reserve base was about 7.5 Gt. More than 80% of world reserves and more than 70% of the world reserve base were located in South Africa (Papp, 2000).

Production.—World chromite ore production was about 14.0 Mt, which is a 3.5% increase compared with that of 1998. World ferrochromium production was estimated to be about 5.03 Mt, which is a 5.3% increase compared with that of 1998. World production of chromium chemicals and metal, chromite refractories, and ferrochromium-silicon was small compared with that of ferrochromium.

Afghanistan.—The Ministry of Mines and Industries produced from 10,000 to 15,000 t of chromite ore from a mine in Lowgar Province. The mine had 6.5 Mt of chromite ore reserves. Other deposits in Afghanistan had chromite ore reserves of 40 Mt. The chromite ore product had a typical chromic oxide content of 58.2% and was traded by Afjet Co. (Industrial Minerals, 1999d).

Albania.—The Government of Albania contracted Hayri Ögelman Madencilik (Turkey) to operate chromite mines at Kalimash, Perollay, and Vlahna and the chromite beneficiation plant at Kukes (Ryan's Notes, 1999j).

Australia.—Danelagh Resources Pty. Ltd. produced chromite ore at the Coobina chromite deposit, which is 57 kilometers (km) east-southeast of Newman, Western Australia. The Coobina Range consists of a central core of serpentine. An associated gabbro was formed by the serpentinization of layered peridotite, which contains minor amounts of carbonate, chlorite, chromite, magnetite, and talc. As of December 1997, resources were (listed in order of certainty of recovery) measured, 39,000 t graded at 38.5% chromic oxide; indicated, 86,200 t graded at 39.7% chromic oxide; and inferred, 400,000 t of similar grade. Mining process is open cut, and run-of-mine ore is crushed and screened. Danelagh exercised its option to take ownership of the mine leaving Consolidated Minerals Ltd. interest to that of collecting a royalty. Chromite ore production was, listed in order of time progression—6,000 t in 1996, 31,000 t in 1997, and 130,000 t in 1998 (Resource Information Unit, 1999, p. 297-298).

Dragon Mining NL studied the Range Well Deposit, which is 67 km northwest of Cue, Western Australia. Chromium occurs predominantly in the iron oxide minerals hematite and goethite. The Range Well laterite resource lies directly over part of a 5.5-km-thick funnel-shaped layered ultramafic complex. Inferred resource was estimated to be 31 Mt graded at 3.60% chromium (2% cut-off grade) (Resource Information Unit, 1999, p. 298).

Brazil.—In 1998, Brazil produced chromite ore and high- and low-carbon ferrochromium. Chromite ore production of 360,000 t contained 136,000 t of Cr_2O_3, of which 98% was used for ferrochromium production and 2% was used for refractory production. Ferrochromium production was 65,683 t. Chromite ore (measured in contained Cr_2O_3) exports were 70,000 t, and imports were 4,400 t. Ferrochromium exports were 3,790 t, and imports were 2,556 t (Associação Brasileira dos Produtores de Ferroligas e de Silício Metálico, 1999; Cesar, 1999, p. 40-41). On the basis of production and trade of chromite ore and trade of ferrochromium, Brazilian chromium apparent consumption, measured in contained chromium, was 49,400 t.

Cia. de Ferro Ligas da Bahia S.A. reported production of 70,000 t of high-carbon ferrochromium and 8,000 t of low-carbon ferrochromium from an annual capacity of 150,000 t of high-carbon ferrochromium and 19,000 t of low-carbon ferrochromium. Production was for the domestic market (Ryan's Notes, 1999q).

Canada.—SNC-Lavalin Company, which was an engineering company, found Allican Resources Company's low-carbon ferrochromium smelter project in Quebec to be economically viable. The project was estimated to cost about $44.6 for a 19,000-metric-tons-per-year (t/yr) smelter. SNC estimated that the project could return 15.9% on the equity portion of the financing. Chromite ore would be supplied from

[1] Ferrochromium production capacity was revised to match more closely maximum reported national production during the past 5 years.

imports initially, followed by development of chromite ore deposits in the Thetford area. At this capacity, the plant could supply about one-half of the North American low-carbon ferrochromium demand. Construction could begin after detailed engineering studies are completed in April or May 2000, and production could start in 2001 (Metal Bulletin, 1999a; Platt's Metals Week, 1999a, g; Ryan's Notes, 2000c).

China.—China reported its national chromium-material trade statistics for 1998. Chromite ore imports were 764,147 t in 1996, 893,987 t in 1997, and 711,539 t in 1998. Over this time, the average value measured in U.S. dollars per metric ton gross weight of chromite ore in China dropped from $163.90 in 1996 to $123.90 in 1997 to $110.00 in 1998. Chinese ferroalloy plants, which comprised mostly small electric furnaces at plants that did not have chromite ore presmelting treatment facilities, stockpiled or converted this material to ferrochromium mostly for export. China reported high-carbon ferrochromium exports of 65,538 t valued at $40.7 per ton in 1998 compared with 70,848 t valued at $43.6 per ton in 1997. China reported low-carbon ferrochromium exports of 36,487 t valued at $69.4 per ton in 1998 compared with 27,222 t valued at $79.6 per ton in 1997 (TEX Report 1999i, j, p).

BOHAI Chemical Group Co. contracted with Solucorp Industries, Ltd. (USA), to install a slag remediation system at BOHAI's Tong Sheng Chemical Plant in Tianjin City where sodium chromate was produced. The project was to remediate existing slag, which was estimated to total from 170,000 to 800,000 t, and slag production (PointCast Network, 1999).

Owing to excess demand for stainless steel compared with domestic production, China identified stainless steel as a commodity for domestic development. Consequently, China planned to renovate its chromium industry by rationalizing its ferrochromium industry. Chinese stainless steel consumption was about 700,000 t and growing rapidly. Stainless steel consumption was forecast to grow to 1 Mt in 2000 and 2 Mt in 2010. To meet this demand, Shanghai Krupp Stainless Company was constructing a stainless steel plant with an annual capacity of 490,000 t of raw stainless steel. Other stainless steel projects were being planned as joint ventures between Chinese and Japanese, U.S., or other Chinese steel companies (Karpel, 1999a). The Chinese ferrochromium industry comprised a large number of manufacturers that operated small furnaces and a small number of manufacturers that operated large furnaces. Small furnace operations are less cost efficient and lack adequate environmental controls. China planned to increase productivity without increasing production capacity, to control the production of ferrochromium, and to increase the production of chromium metal (Metal Bulletin Monthly, 1999).

European Union.—The European Union (EU) permitted duty-free importation of ferrochromium from non-EU countries on a specified amount of material from all non-EU sources. Import duties were applied to imported materials in excess of the specified amount of material. In 1999, duty-free ferrochromium imports were 765,000 t with subsequent imports subject to an import duty of 4% to 5%. The duty-free amount was reached in June 1999, which was 3 or 4 months earlier in the year than in previous years. In July, the Council of Ministers and the European Commission (EC) increased the duty-free amount to 925,000 t (Metal Bulletin, 1999n; Ryan's Notes, 1999f, t). The EC subsequently retroactively raised the ferrochromium duty-free import amount to 1.035 Mt for 1999 (Metal Bulletin, 2000a).

The EU signed a 12-year free-trade agreement with South Africa that is to be implemented in 2003. From 2003 until 2006, duties will be reduced (Metal Bulletin, 1999o).

European stainless steel application development focused on building and construction and automotive applications. Growth was encouraged through substitution and end-product growth. European applications that are important stainless steel markets included pots and pans, kitchen sinks, chimneys, motor cars, and kegs. Applications that have been growing included white goods, flue gas desulfurization, and waste-water treatment. The stainless steel industry encouraged growth in other applications that included fasteners, roofing, exterior applications, structural applications, heating and plumbing, rebar, and automotive applications. The high strength-to-weight properties of stainless steel permit a small amount of stainless steel to perform the same structural function as a greater weight of another metal. In this sense, stainless steel may be viewed as a light metal (Pauly, 2000).

Finland.—Outokumpu Oy planned to increase its stainless steel production capacity. The company invested in its stainless steel production facility to increase the annual production capacity to between 1 and 1.2 million metric tons per year (Mt/yr) by 2004 (Buchanan, 1999a; TEX Report, 1999k).

India.—The Ministry of Commerce imposed antidumping duties on low-carbon ferrochromium from China and Macedonia. The duty was $22.80 per ton on Chinese material and $162.80 per ton on Macedonian material. These were in addition to antidumping duties already imposed on low-carbon ferrochromium from Kazakhstan and Russia (TEX Report, 1999h).

The Indian Stainless Steel Development Association reported 1998 stainless steel consumption to have been 595,000 t, of which 76% was for utensils and the remainder, for industrial and other uses. From 1980 to 1995, compound annual growth in stainless steel production was 18%. In 1996 and 1997, growth was about 8%. Still, Indian stainless steel consumption was 0.66 kilogram (kg) per capita compared with 18 kg per capita in developed Western countries. Jindal Strips Ltd. and Shah Alloys Company, which were the two major stainless producers, made mostly 200 series stainless for kitchenware and utensils. India can produce cold-rolled 200 series stainless for US$0.84 per kilogram compared with US$1.52 for utensil-grade aluminum and US$1.98 for utensil-grade brass. Production growth was anticipated to continue at about 10% per year (Lobo, 2000).

Ferro Alloys Corp. Ltd. (Facor) reported production of 287,000 t of high-carbon ferrochromium in 1997 (Platt's Metals Week, 1999b).

The State of Orissa, which accounted for most of the Indian chromite ore mining and ferrochromium production, was struck by a cyclone in October. The storm-caused wind and flood damage included the downing of power lines. Also part of the wind and flood damage were the export facilities at Paradip port. The storm disrupted production at Facor's plant in Orissa. Other plants and chromite mines were not damaged, although, transportation was disrupted (Metal Bulletin, 1999b; Platt's Metals Week, 1999b; Ryan's Notes, 1999b; TEX Report, 1999e).

Indian Charge Chrome Ltd., which had an annual capacity of 62,500 t, produced high-carbon ferrochromium. The ferrochromium plant had a captive powerplant that comprised two turbine electrical power generators and five boilers with an electrical power capacity of 108 megawatts (MW). One of the turbines was damaged by fire (Ryan's Notes, 1999a; TEX Report, 1999t).

The Tata Iron and Steel Company Ltd. reported reduced ferrochromium production at its Bamnipal plant. Annual production capacity at the plant was 60,000 t of high-carbon ferrochromium. Cyclone-caused flooding interrupted chromite ore supply to the plant. Tata negotiated with Industrial Development Corp. (IDC) to purchase its Dhankanal plant. Annual production capacity at IDC's Dhankanal plant was 20,000 t of ferrochromium from a 5- and a 9-megavolt-ampere (MVA) electric furnaces (TEX Report, 1999u).

Italy.—Italian stainless steel flat product demand has grown to about 1 Mt in 1999 from about 500,000 t in the early 1990's, which was an increase of about 9% per year. This demand growth for stainless steel flat products exceeded average Italian economic growth and EU apparent demand growth for those products. From 1990 through 1999, Italian cold-rolled stainless steel demand grew by 9.1% per year compared with European growth of 6.3% per year. Italian per capita stainless steel flat product consumption was 13.5 kg compared with the European average of 8 kg. Italian market uses for stainless steel flat products included household electric appliances, welded tubes, and exports. Good functional, hygienic, and aesthetic properties at an inexpensive price were the reasons for stainless growth in the Italian market (Borghesi, 2000).

Stainless steel was an important restoration material in Italy. The "flesh and bones" of buildings are stone and steel. Atmospheric agents, pollution, war, and vandalism are the conditions that contributed to the degradation of architectural treasures. Historically, carbon steel was used. When carbon steel corrodes, it expands, which causes stone to crack. Stainless steel does not have this property. These architectural treasures are refurbished or restored by using stainless steel because it resists degradation under these conditions. Italian application of stainless steel in restoration projects started in the 1960's and has been used in Florence, Rome, Venice, and other cities. Austenitic and duplex stainless steel grades are the most popular for restorations (Capelli and Boneschi, 2000).

Japan.—Showa Denko K.K., which produced low-carbon ferrochromium at its Chichibu plant and high-carbon ferrochromium at its Shunan plant, has phased out low-carbon ferrochromium production and identified the Shunan plant as a noncore division, thus making it available for sale. This decision was made when Showa Denko and Samancor established Middelburg Technochrome Pty Ltd., which was a joint venture to replace Japanese low-carbon ferrochromium production.

Shunan Denko K.K., which was a joint venture between Showa Denko and Nisshin Steel Co., Ltd., produced high-carbon ferrochromium via the SRC process, which includes agglomeration, kiln roasting, then electric-furnace smelting. The Shunan plant is located at the Shunan steel plant of Nisshin Steel. Nisshin Steel used molten ferrochromium supplied by the Shunan Denko plant and cold ferrochromium from other sources. In 1998, Shunan Denko produced about 81,000 t of high-carbon ferrochromium for Nisshin Steel to make from 600,000 to 636,000 t of stainless steel. Loss of molten ferrochromium supply would lower the productivity of stainless steel production. Showa Denko may also sell its 21.5% share of Technochrome (Platt's Metals Week, 1999e; Ryan's Notes, 1999q; TEX Report, 1999o).

Japan Metals and Chemicals Co. Ltd. stopped low- and high-carbon ferrochromium production in Japan. High-carbon ferrochromium production was stopped after the company signed a joint-venture agreement with Zimasco (Pvt.) Ltd. (Zimbabwe). This left NKK Corporation as the sole low-carbon ferrochromium producer in Japan. NKK and Nippon Denko Co., Ltd. continued to produce high-carbon ferrochromium. NKK planned to produce specialty grades of low-carbon ferrochromium directed at the domestic and export aviation and electronics industries. In 1998, NKK produced about 34,000 t of high-carbon ferrochromium and 11,000 t of low-carbon ferrochromium from an annual capacity of 49,800 t of high-carbon ferrochromium and 12,300 t of low-carbon ferrochromium. In 1998, Nippon Denko produced 7,705 t of high-carbon ferrochromium from an annual capacity of 18,500 t (Ryan's Notes, 1999l, q).

Japan levied a 5.8% ad-valorem import duty on ferrochromium in 1998 but planned to lower that duty to 5.3% in 1999 in accordance with the Uruguay Round of tariff agreements made in 1995. In 1998, Japan imported, in order of increasing amount of material processing, 416,665 t of chromite ore, 628,260 t of ferrochromium, and 2,327 t of chromium metal. Domestically, the Japan Ferroalloy Association reported that the ferroalloy industry produced 105,634 t of ferrochromium, which was a decrease of 47% compared with that of 1997. Stainless steel production was 3.102 Mt; hot-rolled stainless steel, 2.767 Mt; and heat-resisting stainless steel, 334,150 t. Ferrochromium imports represented 86% of market share. Japan exported 700 t of ferrochromium and 1.140 Mt of stainless steel, which represented 37% of production. Japan imported 144,143 t of stainless steel scrap and exported 22,943 t. On the basis of chromite ore, ferrochromium, and chromium metal trade, apparent consumption, measured in contained chromium, in Japan was 473,000 t. (TEX Report, 2000b, c, d, e, f, g, h, i)

Kazakhstan.—The Kazakhstani chromium industry included the Donskoy Ore Dressing Complex, the Aksusky Ferroalloy Plant (Aksu), the Aktyubinsk Ferroalloy Plant, and a chemical plant. Donskoy completed a new shaft that would increase chromite ore production capacity from 2 to 2.5 Mt/yr (Metal Bulletin, 1999e). Donskoy's mining plan called for chromite ore production of 1.9 Mt to be increased to 2.6 Mt in 2000. In addition to finishing the new Central Mine, Donskoy installed briquetting facilities and planned to modify the preparation plant. In 1998, Kazakhstan produced 500,000 t of high-carbon ferrochromium and 30,000 t of low-carbon ferrochromium (TEX Report, 1999l). In 1999, Kazakhstan produced 732,200 t of chromium ferroalloys of which 466,000 t was high-carbon ferrochromium from Aksu and 265,800 t was ferrochromium from Aktyubinsk (CRU International, 2000). Aksu was constructing a furnace supplied by Mannesmann Demag Company (Germany). The new furnace had electrical power capacity of 62 to 65 MW and an annual production capacity of

90,000 to 100,000 t of high-carbon ferrochromium. Aksu planned to complete the furnace in 2000. Aktyubinsk planned increased recovery from slag. Aksu and Aktyubinsk each planned new crushing and screening equipment. Production in 1999 was projected to have been 620,000 t of high-carbon ferrochromium, and 40,000 t of medium-carbon and low-carbon ferrochromium (Metal Bulletin, 2000b; Ryan's Notes, 1999v; TEX Report, 1999a, n).

Norway.—Elkem reported production of 157,000 t of high-carbon ferrochromium in 1999 compared with 170,000 t in 1998 at its plant in Mo i Rana (Elkem, 2000, p. 28-29). Elkem produced high-carbon ferrochromium that contained 60% to 65% chromium from two closed furnaces. Elkem also reported 1998 high-carbon ferrochromium production of 170,000 t and raised its capacity to 180,000 t in 1999 (Ryan's Notes, 1999x).

Oman.—The chromite resources of Oman amount to 2 Mt and are distributed among more than 600 deposits, which range in size from a few hundred to a few thousand metric tons each. Although Oman started chromite mining in 1982, mining has been continuous only since 1993 after the formation of the Oman Chromite Company SAOG by royal decree in 1991. Oman produced metallurgical- and refractory-grade chromite ore, which was exported to China, India, Japan, Taiwan, and the United Kingdom (Humaid, 1999).

According to the feasibility study on producing ferrochromium in Oman, from 3,800 to 4,800 kilowatt-hours of electrical power would be required to produce 1 t of high-carbon ferrochromium. Competitively priced electrical power was available from Oman's natural gas reserves. Domestic chromite ore blended with imported high-grade ore would feed the plant planned for Sohar. This plant, which could cost $80 million, would be constructed after a gas pipeline to the area and a port facility in Sohar are built; construction was projected to start in 2000 and to be completed in 2001. The annual capacity of the plant will range from 50,000 to 52,000 t (Casey, 1999; Humaid, 1999; Metal Bulletin, 1999l).

Philippines.—Benguet Corporation mined foundry and refractory grades of chromite ore. Mine annual production has dropped from 269,000 t in 1989 to 114,000 t in 1997. Having developed a stockpile equivalent to 15 to 18 months of demand, Benguet temporarily suspended production so that it could reduce stocks (Industrial Minerals, 1999b).

Heritage Resources Mining Corporation produced chemical-grade chromite ore on Homonhon Island. Production was estimated to be more than 13,000 t/yr (Industrial Minerals, 1999g).

Russia.—Severonickel Combine, which was a subsidiary of RAO Norilsk Nickel, planned to develop the Sopcheozersk chromite deposits. Norilsk sought a partner to develop the mine during the next 2 years to an annual chromite ore production capacity of 250,000 to 750,000 t and to develop a ferrochromium smelter at or near the mine site. Norilsk started surface mining the Sopcheozersk chromite deposits in September 1998. The first chromite ore product came in May 1999. Continued prospecting, testing of samples, and processing techniques were estimated to cost about $6 million. Ferrochromium production was planned to start at 20,000 t/yr of high-carbon ferrochromium and 15,000 t/yr of low-carbon ferrochromium and to reach 70,000 t/yr of high-carbon ferrochromium and 45,000 t/yr of low-carbon ferrochromium. Eventually, Norilsk could combine its nickel and chromium resources in a stainless steel production plant (Ryan's Notes, 1999b, j; Norilsk Nickel, 1999, Into the new millennium—Norilsk Nickel today, accessed June 6, 2000, at URL http://www.nornik.ru/index.html/english/product/persp.htm).

Chelyabinsk Electrometallurgical Integrated Plant produced low-carbon ferrochromium (Ryan's Notes, 1999cc; TEX Report, 1999b). Klutchevsk Ferroalloy Plant produced aluminothermic chromium metal and low-carbon ferrochromium. Chromium metal production capacity was about 6,000 t/yr; low-carbon ferrochromium, 15,000 t/yr (Metal Bulletin, 1999f; Metal Bulletin Plc., 2000; Ryan's Notes, 1999i). Serov Ferroalloys Plant reported production of high- and low-carbon ferrochromium (Ryan's Notes, 1999aa). Polema Corporation, which had an annual production capacity of less than 1,000 t, reported production of electrolytic chromium metal (Buchanan, 1999b, p. 45; Metal Bulletin, 1999g; Ryan's Notes, 1999q). ZAO SDM, which had an annual production capacity of about 2,000 t, produced aluminothermic chromium metal. In 1999, ferrochromium production was 243,000 t—120,000 t from Chelyabinsk and 123,000 t from Serov (CRU International, 2000, p. 10).

South Africa.—The Minerals Bureau reported chromite ore production of 5.893 Mt. Of the 5.897 Mt sold, 85% was local, and 15% was exported. South African ferrochromium production cost was estimated to have been in the range of $0.28 to $0.34 per pound of chromium (Ryan's Notes, 1999s; South African Minerals Bureau, 2000).

ASA Metals (Pty.) Ltd. started production at the new ferrochromium plant that it constructed in Northern Province near Steelpoort at a cost of $25 million (130 million Rand). Annual ferrochromium production capacity was 60,000 t, and electrical capacity, 33 MVA; a second furnace was planned. The new furnace was supplied with chromite ore from the Dilokong chromite ore mine, which was wholly owned by ASA. Chromite ore production capacity at Dilokong was 300,000 t/yr run-of-mine. Chromite ore furnace feed was about 60% lump and 40% fines. Chromite ore reserves at the mine were estimated to be 12 Mt. ASA was a joint venture between East Asian Metals Investment Co. Ltd. (60%) and Northern Province Development Corporation (40%); East Asian Metals Investment comprised China Iron and Steel Industry and Trade Group Corporation (80%) and Jilin Ferroalloy Works (20%) (Robinson, 1999; Ryan's Notes, 1999h; TEX Report, 1999r, s).

Associated Manganese Mines of South Africa Ltd. (Assmang) purchased the Dwarsriver chromite ore mine from Gold Fields Ltd. for about $25 million. The mine was being developed initially as an open pit operation that will produce about 350,000 t in 2000; production will increase to 1 Mt/yr run-of-mine. A beneficiation plant will be located at the mine site. Mine development cost was estimated to be about $32 million. After 2 or 3 years, the mine will exploit chromite ore reserves by underground mining as well. The mine will supply chromite ore to Assmang's ferrochromium smelter at Machadodorp where Feralloys Ltd. operated three furnaces. Two of the furnaces had an electrical capacity of 24 MVA each. The company increased its ferrochromium production capacity at the third furnace, which was upgraded to 30 MVA; capacity went to 105,000 t/yr from 120,000 t/yr in 1998. After the other two furnaces are modified, which was planned for completion in 2000, capacity will be further increased to 175,000 t/yr. Feralloys started a feasibility study to add a fourth furnace; the study was to be completed in 2000. If the results are favorable, then the additional furnace will be completed in 2004. The new furnace would have an annual ferrochromium production capacity of 100,000 t (Buchanan, 1999a; Industrial Minerals, 1999a; Ryan's Notes, 1999m; TEX Report, 1999d, m).

Chrome International Pty., Ltd., which was a joint venture between Bayer (Pty.) Ltd., which was a subsidiary of Bayer AG (Germany), and Dow Chemical Co., started production at its new chromium chemical plant at Newcastle, KwaZulu-Natal Province. The plant was expected to require about 100,000 t/yr of chromite ore from Bayer's chromite mine near Rustenburg. Annual production capacity of sodium dichromate was expected to reach 70,000 t; chromium tanning salts, 45,000 t; and chromic acid, 10,000 t. Chromite ore was supplied to the chemical plant by Chrome Chemicals (Pty.) Ltd., which operated a 1-Mt/yr capacity mine near Rustenburg (Industrial Minerals, 1999c).

Columbus Stainless, which was a division of Columbus Joint Venture, produced 371,000 t of stainless steel, of which 90,000 t was used domestically. Columbus planned to increase production to 400,000 t in 1999 (Billiton Plc., 1999, p. 52-59; Ryan's Notes, 1999o).

Hernic (Pty.) Ltd. operated the Ilitha, the Maroelabult, and the Mooinooi chromite ore mines and started mining the Stellite deposit. The Mooinooi Mine was to be phased out in 1999, thus joining Kaffersdraal and Kroondal as mines with depleted reserves. As stocks were consumed at the Mooinooi beneficiation plant to produce foundry- and chemical-grade chromite, Hernic was developing a new plant for the same products at the Stellite deposit. The Maroelabult Mine produced about 900,000 t of ore with a recovery rate of 70% to 75%. The Ilitha Mine started production in 1999. Hernic sold a 40% share to Itochu Corporation (Japan) for $14 million. Itochu supplied Kawasaki Steel Co. with the chromite ore it uses as a feed material to produce stainless steel. At Ilitha, chromite ore was mined from the LG6 seam, which had reserves of 10.8 Mt, of which 3.6 Mt was accessible by opencast mining; the remaining 7.2 Mt will be accessed via underground mining. In 1999, production capacity was 200,000 t of chromite ore that was distributed among foundry, chemical, and metallurgical grades (O'Driscoll, 1999; Ryan's Notes, 1999bb; TEX Report, 1999g, m).

Hernic operated a ferrochromium smelter near Brits, North West Province. Hernic, along with Outokumpu and Titaco Projects (Pty.) Ltd., installed and started production with new pelletizing and preheating equipment and a new closed furnace at a cost of about $130 million. The new equipment will boost Hernic's annual high-carbon ferrochromium production capacity to 260,000 t from 130,000 t in 1998. The process technology, which was from Outokumpu, was the second such process equipment installed in South Africa; the first had been at Ferrometals' plant at Witbank. Titaco provided the furnace, which was rated at 54 MVA and used pelletizing, sintering, and preheating equipment, and had an annual ferrochromium production capacity of 110,000 t. The annual production capacity of the sintered pellets equipment was 350,000 t, which was more than the new furnace could smelt. Pellet production in excess of that required by the new furnace will be used to supplement the feed to the original two furnaces, thereby increasing their annual combined production capacity to 150,000 t from 130,000 t in1998 while reducing energy consumption. Off gases from the new closed furnace were used to preheat the pelletized feed to the new furnace. The two existing semiclosed furnaces, which were rated at 37 MVA each, will take cold pellets. The new furnace will have a chromium recovery rate of 83% and energy consumption of 3,200 kWh/t of product. The semiclosed furnaces will consume about 3,900 kWh/t of product (Mining Journal, 1999b; Robinson, 1999, p. 28-29, 31).

SA Chrome and Alloys (Pty.) Ltd. (formerly Southern Witwatersrand Exploration Co.) purchased two chromite ore mines—the Horizon for $3.7 million and the Chromeden for $1.2 million. Both mines are in North West Province. In addition, it purchased the beneficiation plant at Chromeden for $1.7 million. The combined chromite ore reserves of the two mines were 27 Mt. During the next 4 years, SA Chrome planned to sink three shafts and increase production to 40,000 metric tons per month. When Southern Witwatersrand changed its name in 1999, it also changed its listing status on the Johannesburg stock exchange from an exploration company to a metals and minerals sector company. SA Chrome planned to construct a 150,000-t/yr ferrochromium plant near its mining operations, which it estimated would cost $50 million (Graulich, 1999; Metal Bulletin, 1999i, j; Ryan's Notes, 1999y).

Samancor, which operated chromite ore mines and ferrochromium smelters, reported production of 904,000 t of ferrochromium in 1998. Samancor reported fiscal year 1999 ferrochromium production (year ending June 30) of 947,000 t, compared with 959,000 t in fiscal year 1998, and marketable chromite ore production of 3.16 Mt, compared with 3.07 Mt in fiscal year 1998. During the same time period, Samancor reduced chromite ore production cost by 22%, ferrochromium production cost by 19%, and ferrochromium price by 20% and planned further cost reductions by replacing high-unit-cost-of-production furnaces (Billiton Plc., 1999, p. 52-59; Metal Bulletin, 1999h; Ryan's Notes, 1999z; Sguazzin, 1999).

The location and production capacities of Samancor's chromite ore mines were as follows. In the eastern Bushveld Igneous Complex, which totaled 1.98 Mt/yr, Tweefontein Mine produced 780,000 t/yr; Lannex Joint Venture Mine, 480,000 t/yr; and Steelpoort Mine, 360,000 t/yr. In the western Bushveld Igneous Complex, which totaled 1.78 Mt/yr, Mooinooi Mine produced 720,000 t/yr; Elandsdrift Mine, 400,000 t/yr; Millsell Mine, 360,000 t/yr; and Elandsdraal Mine, 300,000 t/yr. Thus, Samancor's marketable chromite ore production capacity from the Bushveld Complex in 1999 was 3.76 Mt. The Doornbush and the Montrose sections were closed owing to the high cost of production (Billiton Plc., 1999, p. 52-59; Mining Journal, 1999a).

The distribution of Samancor's smelting operations and ferrochromium production capacity was as follows: Ferrometals (435,000 t/yr), Tubatse Ferrochrome (340,000 t/yr), Middelburg Ferrochrome (235,000 t/yr), and Palmiet Ferrochrome (120,000 t/yr). Ferrometals' closure of two furnaces reduced its annual production capacity by 150,000 t (Mining Journal, 1999a). Samancor planned to meet new ferrochromium demand and improve its cost structure by simultaneously closing or renovating high-cost-of-production furnaces and constructing new low-cost-of-production facilities. Samancor renovated production at Ferrometals by installing metal-from-slag recovery and introducing Outokumpu's pelletizing and preheating technology. Tubatse was next in line to adopt the pelletizing and preheating technology. Samancor now planned to lower production cost by moving to larger volume operations, including larger mines (that is, mines with 1 Mt/yr of output) and larger furnaces (electrical capacity of 60 megawatt-amperes). Samancor planned to construct a smelter at its Mooinooi Mine. The smelter was to include pelletizing and preheating and to start out with two furnaces, each capable of 150,000 t/yr of production. The plant was planned to reach a production capacity of 800,000 t/yr. Production at the new plant could start as soon as 2002. Should development of the new plant's production capacity exceed market demand, Samancor will close higher-cost-of-production furnaces to keep its average production cost low (Metal Bulletin, 1999k; Ryan's Notes, 2000c, d).

Xstrata S.A. (Pty.) Ltd., which was formerly known as Suedelectra S.A., operated chromite ore mines near its ferrochromium plants. Xstrata chromite ore mines included the Purity and the new Thorncliffe, which increased annual production to 1 Mt. Xstrata planned to develop the Townlands chromite deposit located under its Rustenburg smelter complex and near the Wonderkop smelter. The deposit was purchased by Xstrata in 1997 and was accessible via its Purity Mine. Eventually, a separate mine will be developed to exploit the Townlands deposit. Chromite ore resources of the Townlands deposit were estimated to be 100 Mt (Ryan's Notes, 1999n). In addition to using chromite ore from its own mines, Xstrata purchased byproduct UG2 seam chromite ore for its Wonderkop smelter from platinum operations.

Xstrata operated ferrochromium plants at Lydenburg and Wonderkop and a plant complex at Rustenburg. The company reported 980,000 t of ferrochromium production in 1998. It expanded its product line by renting the unused stainless steel plant at Durban to refine ferrochromium from Lydenburg. At Durban, Xstrata applied the refining furnaces to the production of medium-carbon ferrochromium from high-carbon material at an annual rate of 10,000 to 15,000 t. The company planned to increase annual production to 40,000 t and, possibly, to add low-carbon ferrochromium to its product line (Ryan's Notes, 1999k). At Lydenburg, it increased production capacity by improving power delivery, substituting anthracite for bituminous coal, and improving the pelletizing process. Adding metal recovery from slag at the plant could increase annual production by 12,000 t. At Wonderkop, Xstrata planned to expand production facilities by adding two furnaces. Annual production capacity would then be increased by 160,000 t (Ryan's Notes, 1999u, 2000a).

Sweden.—Vargön Alloys AB reported production of high-carbon ferrochromium (Ryan's Notes, 1999g).

Taiwan.—Tang Eng Iron Works planned to increase stainless steel production capacity by 30,000 t/yr. In 1999, annual production capacity was 260,000 t. Production in 1999 was 250,000 t compared with 220,000 t in 1998 (Platt's Metals Week, 2000a).

Turkey.—Pinarbasi Madencilik Sanayi ve Ticaret Ltd. reported chromite ore production capacity of 160,000 t/yr. Pinarbasi planned to increase its chromite ore production capacity to 200,000 t/yr during the next 5 years. Production was about 110,000 t of chromite ore grading from 36% to 42% Cr_2O_3 and 50,000 t of concentrate grading in excess of 48% Cr_2O_3 (Metal Bulletin, 1999m; Ryan's Notes, 1999v; TEX Report, 1999c).

Birlik Madencilik Dis Tic. Insaat San. ve Tic. A.S., which was established in 1981, produced more than 2.6 Mt of chromite ore and products during the past 5 years. The company produced from its own mines and managed production under contract to Eti Krom A.S. Birlik's mines are in the Kopdag area, where reserves were about 32 Mt. The area has produced more than 7.5 Mt of ore in the past decade from open pit mines to a depth of 200 meters. The company invested $25 million in the Kopdag Ore Processing Complex, which processed 600,000 t/yr of raw chromite ore. It produced chromite ore briquettes at a plant in Mersin at the rate of 180,000 t/yr; the briquetting plant was completed in 1997. The Kopdag concentrator used the Dyna Whirlpool and Spiral Concentrator Processes to beneficiate chromite ore. Birlik planned to add a Multi Gravity Separator in 2000. Birlik's goal was to produce a consistently high quality chromite ore product by using a broad range of chromite ore feed material grades (Ersavci, 1999).

Eti Holdings reported high- and low-carbon ferrochromium production after it was privatized in March 1999. Low-carbon ferrochromium production was, listed in order of time progression, 9,450 t in 1996, 10,820 t in 1997, and 10,155 t in 1998. High-carbon ferrochromium production was, listed in order of time progression, 92,000 t in 1996, 97,500 t in 1997, and 100,000 t in 1998 (Karpel, 1999b, p. 24-25).

Eti Krom produced at about 70% of its capacity, which was 150,000 t/yr of high-carbon ferrochromium. Eti Krom estimated that its production in 2000 would drop to range from 50% to 60% of capacity owing to production problems and the need to shut down to perform furnace repairs (Metal Bulletin, 1999c; Platt's Metals Week, 2000b; Ryan's Notes, 2000e).

United Kingdom.—Elementis Chromium started production of chromic acid at its new $17 million plant at Eaglescliff, Stockton-on-Tees. The new plant had an annual chromic acid production capacity of 25,000 t; production capacity of the old plant was 12,000 t/yr of chromic acid. The chromic acid plant feed was sodium dichromate produced at the same site with an annual production capacity of 125,000 t. Elementis also produced sodium sulfate, which is a byproduct of sodium dichromate production, at $14 million[2] plant at the same location. The chromium chemicals sector in the United Kingdom was estimated to be growing at a rate of about 1% or 2% per year (Industrial Minerals, 1999f).

Zimbabwe.— Maranatha Ferrochrome (Pvt.) Ltd. in Eiffel Flat, Kadoma, started high-carbon ferrochromium production in March. Maranatha was being developed by Gurta Trading Company (Switzerland); Gurta also owned Amble Mines (Pvt.) Ltd., which started production of chromite ore at the rate of 80,000 t/yr by surface mining from a reserve of 5 Mt. Six underground shafts will be developed at the mine. Used furnaces were imported from Italy. Maranatha's annual production capacity was 30,000 t of high-carbon ferrochromium. The company planned to double that capacity by acquiring additional furnaces (Buchanan, 1999a; Metal Bulletin, 1999d; Ryan's Notes, 1999e, o, p).

Zimasco received a shaking ladle used in the production of low-sulfur and low-phosphorus grades of high-carbon ferrochromium from Japan Metal and Chemicals Company Minami-Iwata plant as part of its joint venture. Zimasco reported production of 210,000 t of high-carbon ferrochromium in 1999 from 540,000 t of chromite ore, and production capacity of 50,000 t/yr of special-grade high-carbon ferrochromium (TEX Report, 1999f, 2000a).

Zimbabwe Alloys Ltd. recovered, listed in order of time progression, 7,400 t of low-carbon ferrochromium and ferrochromium silicon from slag in 1997, 11,000 t in 1998, and anticipated recovery of 11,000 t again in 1999 (Ryan's Notes, 1999w). Zimbabwe Alloys was the sole low-carbon ferrochromium producer in Zimbabwe and had an annual capacity of 40,000 t (Ryan's Notes, 1999y ; TEX Report, 1999q).

The ownership structure of Zimbabwe's ferrochromium industry changed. Zimbabwe Alloys was owned by Anglo American Corp. (58%), Radar Holdings Company (14.6%), and JB Africa Investments (16.6%) (Rushmere, 1999, p. 7). Zimasco was privately owned. First Anglo American bought Radar Holdings' share of Zimbabwe Alloys and then proceeded to acquire Zimasco, although at yearend, the purchase had not been completed because the Government of Zimbabwe had not approved the sale (Africa Energy & Mining, 2000).

Environment

Arthrobacter oxydans, which is a bacteria, was found to convert hexavalent chromium to trivalent chromium in a geological setting. Hexavalent chromium is used as a wood preservative and rust inhibitor. It is highly water soluble and mobile but is toxic and a pernicious environmental contaminant. Trivalent chromium is relatively insoluble, immobile, and less harmful. Thus, this conversion process is a potential tool for environmental remediation (Wilson, 1999).

The perception that refractory-grade chromite ore is environmentally hazardous was challenged in a letter on use of refractory-grade chromite (McCracken, 1999). The refractory production process itself does not cause the conversion of trivalent chromium found in chromite ore into hexavalent chromium, which is the environmentally unfriendly form of chromium. Hexavalent chromium compounds are formed under high-temperature refractory furnace conditions when chromite is exposed to alkali-bearing materials. The resulting hexavalent chromium, which is not stable and is converted to trivalent chromium, can be dissolved and mobilized in the environment. Chromite use in refractories improves the refractory materials resistance to spalling and slag and promotes volume stability and structural strength.

Current Research and Technology

Mineral Processing and Industrial Applications.—Industry conducts research to develop new, more-efficient processes and to improve the efficiency of currently (1999) used processes. The Council for Mineral Technology of South Africa conducts Government-sponsored, commercially sponsored, and cosponsored research and development on chromite ore and ferrochromium.

Chromite Ore.—The UG2 reef of the Bushveld Igneous Complex in South Africa is mined for its platinum-group metal (PGM) content; the reef, however, contains chromite, which is detrimental to the smelting operations used to recover PGM. An oxide mineral, chromite is separated by flotation, a process in which metal sulfides are separated from spinel minerals. Chromite is hydrophilic, and the concentrate in the flotation process is hydrophobic. Wesseldijk and others (1999) found that chromite was activated by the flotation reagents resulting in chromite reporting to the concentrate. The activation of chromite was attributed to the adsorption of copper chemicals by chromite under certain chemical conditions.

Ferrochromium.—The thermodynamic properties of chromium-bearing slags were reviewed by Reuter and Xiao (1999, p. 95). Thermodynamic properties include thermodynamic activity, phase relations, metal recovery from slag, viscosity, and electrical conductivity. Divalent and trivalent chromium has been found to coexist in ferrochromium slags. Increasing slag basicity effectively increases chromium recovery.

Stainless Steel.—When electric-arc furnaces (EAF) are used in the production of stainless steel, chromium is found in the dust. The role of the EAF in the making of stainless steel is to melt the charge mix producing molten steel of appropriate temperature and chemistry for subsequent refining. Because chromium is chemically active and an expensive constituent of stainless steel, improving yield is important. Sun and others (1998) targeted the EAF for improved yield when they discovered that 97% of chromium losses were there. They found that chromium losses could be controlled by minimizing chromium oxidation during charge meltdown, oxygen blow, and furnace tapping and by effective reduction of furnace slag.

Outlook

The outlook for chromium consumption in the United States and the rest of the world is about the same as that for stainless steel, which is the major end use for chromium worldwide. Thus, stainless steel industry performance largely determines chromium industry demand worldwide. (See the following section on stainless steel.)

The trend to supply chromium in the form of ferrochromium by countries that mine chromite ore is expected to continue. With new efficient ferrochromium production facilities and excess capacity in chromite-producing countries, ferrochromium production and capacity are expected to diminish in countries that produce ferrochromium, but not chromite ore, and in countries with small, less efficient producers, except where domestic industries are protected by quotas and tariffs. Further vertical integration of the chromium industry is expected as chromite-producing countries expand ferrochromium or stainless steel production capacity.

Chromite Ore.—Chromite ore production capacity is in balance with average consumption. Consumption capacity by ferrochromium plants, however, exceeds production capacity, which can lead to short supply when demand surges, thus preventing ferrochromium producers from meeting surge demand. To improve chromite ore availability and to stabilize feed material price, ferrochromium producers invest in chromite-ore-producing mines. Indeed, most chromite ore is produced under vertically integrated mine-smelter ownership. South African chromite ore production in 1999 was about one-half of world production. Redistribution of chromite ore reserves by the courts in India may result in development of those resources, thereby increasing its position as a world supplier of chromite ore. Resolution of the ownership dispute in Kazakhstan and selection of a development plan in Albania may have the same effect in these countries.

The 1998 end-use distribution of chromite ore production was estimated to have been as follows: 82% to ferrochromium smelters, 10% to chemical plants, and 8% to refractories, including foundries. About 2.5 t of chromite ore, 0.6 t of reductant, and 4.0 megawatt-hours of electrical energy were required to produce 1 t of ferrochromium that contains from 50% to 65% chromium and 1.9 t of slag. Ferrochromium was estimated to have accounted for 58% of the chromium units supplied to produce 16.4 Mt of stainless steel that averaged 18% chromium content; scrap accounted for the remaining 42%. Ferrochromium represented about 20% of the cost of stainless steel raw materials. The cost distribution of ferrochromium delivered to the consumer was 30% raw materials, 24% power, 23% distribution, 10% labor, and 13% other. The compound annual growth rate of world stainless steel production from 1963 to 1998 was 3.9% compared while that of the gross domestic product was 3.8%. The primary factor that encourages the increased use of stainless steel was identified as life cycle cost. From 1972 through 1999, the adjusted-for-inflation price trend of ferrochromium showed a decrease of 3.5% per year. This trend was consistent with the changing industry cost structure. From 1982 through 1998, ferrochromium industry production capacity increased, and cost of production decreased (Kobus van Dyk, 1999, Chrome, accessed June 17, 1999, at URL http:// www.billion.com/ newsite/index.html).

Ferrochromium.—Ferrochromium production is electrical energy intensive. Charge-grade ferrochromium requires from 2,900 to 4,100 kWh/t of product, with efficiency varying with ore grade, operating conditions, and production process. Thus, ferrochromium plant location reflects a cost balance between raw materials and electrical energy supply. South African ferrochromium production in 1999 was about 45% of world production. A situation similar to that between chromite ore and ferrochromium producers exists between ferrochromium and stainless steel producers. Stainless steel producers have been investing in ferrochromium production plants (Papp, 1994, p. 22-26).

Stainless Steel.—U.S. stainless steel production showed an average annual compound growth of 1.9% from 1995 through 1999 and 2.2% from 1950 through 1999. World stainless steel production showed growth of 1.7% from 1995 through 1999 and 5.9% from 1950 through 1999.

Stainless steel demand is price sensitive, and an important part of stainless steel cost is nickel cost (about 70% of stainless steel production requires nickel). Nickel availability and cost have been viewed as potential limitations to increased stainless steel production. The discovery and development of new nickel deposits projected to produce at nearly one-half the cost of current production mitigates this potential limitation to stainless steel production growth. Salamon (1999) reported that the cost of production of nickel and chromium has decreased. Nickel cost of production decreased by about one-half from 1990 to 1998. Chromium cost of production decreased by about one-half from 1986 to 1998. The inflation-adjusted price of high-carbon ferrochromium shows an average decline from of about 3.5% from 1972 to 1999.

Anticipating the effect of stainless steel market growth on chromium demand is complicated by stainless steel scrap use. Stainless steel scrap use displaces demand for ferrochromium and the chromite ore needed to make ferrochromium. Some scrap is blended with ferrochromium making the secondary supply industry a consumer of ferrochromium.

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TABLE 1
SALIENT CHROMIUM STATISTICS 1/

(Metric tons, contained chromium unless otherwise specified)

	1995	1996	1997	1998	1999
World production:					
Chromite ore (mine) 2/	4,230,000 r/	3,480,000 r/	4,110,000 r/	4,070,000 r/	4,210,000 e/
Ferrochromium (smelter) 3/	2,690,000 r/	2,250,000 r/	2,760,000 r/	2,720,000 r/	2,870,000 e/
Stainless steel 4/	2,750,000 r/	2,750,000 r/	2,960,000 r/	2,920,000 r/	2,940,000 e/
U.S. supply:					
Components of U.S. supply:					
Domestic mines	--	--	--	--	--
Secondary	112,000	98,400	120,000	104,000 r/	118,000
Imports:					
Chromite ore	81,400	79,200	96,600	117,000 r/	85,000
Chromium chemicals	8,360	7,060	6,430	9,070	10,400
Chromium ferroalloys	319,000	267,000	237,000	249,000 r/	371,000
Chromium metal	7,040	8,730	9,800	9,520 r/	9,030
Stocks, January 1:					
Government	1,170,000	1,120,000	1,070,000	1,020,000	928,000
Industry 5/	101,000	80,100	74,400 r/	71,400 r/	59,700
Total U.S. supply	1,790,000	1,660,000	1,610,000	1,580,000	1,580,000
Distribution of U.S. supply:					
Exports:					
Chromite ore	5,740	21,900	5,890	39,900	37,200
Chromium chemicals	14,700	18,200	16,700	17,500	17,300
Chromium ferroalloys and metal	6,260	10,800	7,710	5,000	5,790
Stocks, December 31:					
Government	1,120,000	1,070,000 r/	1,020,000	928,000	909,000
Industry 5/	80,100 r/	74,400 r/	71,400 r/	59,700 r/	54,100
Total U.S. distribution	1,230,000	1,190,000	1,120,000	1,050,000	1,020,000
Apparent consumption	565,000 r/	467,000 r/	490,000 r/	531,000 r/	558,000
Reported production: 6/					
Chromium ferroalloy and metal net production:					
Gross weight	72,500	36,800	60,700	W	W
Chromium content	49,500	26,400	40,900	W	W
Net shipments	72,100	38,800	56,300	W	W
Reported consumption:					
Chromite ore and concentrates (gross weight)	351,000	282,000	350,000	269,000	W
Chromite ore average Cr_2O_3 (percentage)	43.8	45.2	45.1	45.4	45.0
Chromium ferroalloys (gross weight)	334,000	329,000 r/	385,000 r/	332,000 r/	384,000
Chromium metal (gross weight)	4,600	4,520 r/	4,970 r/	4,640 r/	4,690
Stocks, December 31 (gross weight):					
Government:					
Chromite ore	1,320,000	1,190,000 r/	1,090,000	885,000	820,000
Chromium ferroalloys	1,070,000	1,050,000 r/	1,020,000	974,000	973,000
Chromium metal	7,690	7,720	7,720	7,720	7,720
Industry, producer	8,430	6,450	10,900	W	W
Industry, consumer:					
Chromite ore	205,000	173,000	175,000	159,000	130,000
Chromium ferroalloys	22,500	27,400 r/	16,700 r/	17,300 r/	24,000
Chromium metal	264	215 r/	227 r/	193 r/	245
Prices, average annual:					
Chromite ore, per ton gross weight 7/	$61 r/	$75	$73	$68	$63
Ferrochromium, per pound chromium content 8/	$0.704 r/	$0.510 r/	$0.480 r/	$0.467 r/	$0.366
Chromium metal, per pound gross weight 9/	$3.97	$4.15	$4.15	$4.15	$4.33
Value of trade: 10/					
Exports thousands	$83,200	$111,000	$107,000	$102,000	$92,500
Imports do.	$545,000	$463,000	$450,000	$421,000	$420,000
Net exports 11/ do.	($461,000)	($352,000)	($343,000)	($319,000)	($327,000)

See footnotes at end of table.

TABLE 1--Continued
SALIENT CHROMIUM STATISTICS 1/

(Metric tons, contained chromium unless otherwise specified)

		1995		1996		1997		1998		1999
Stainless steel (gross weight):										
Production 12/		2,060,000	r/	1,870,000	r/	2,160,000		2,010,000	r/	2,190,000
Shipments 13/		1,720,000		1,730,000		1,880,000		1,850,000		1,890,000
Exports		180,000		162,000		199,000		206,000		216,000
Imports		732,000		781,000		774,000		862,000		941,000
Scrap:										
Receipts		658,000		579,000		706,000		611,000	r/	696,000
Consumption		1,110,000		1,040,000		1,140,000		1,040,000	r/	1,140,000
Exports		368,000		303,000		370,000		298,000		260,000
Imports		42,500	r/	50,500	r/	64,100	r/	57,200	r/	66,100
Value of trade:										
Exports	thousands	$615,000		$583,000		$653,000		$622,000		$628,000
Imports	do.	$1,810,000		$1,880,000		$1,720,000		$1,680,000		$1,560,000
Scrap exports	do.	$325,000		$234,000		$231,000		$176,000		$151,000
Scrap imports	do.	$33,800		$28,500		$33,700		$21,600		$27,700
Net exports 11/ 14/	do.	($902,000)	r/	($1,090,000)	r/	($870,000)	r/	($903,000)	r/	($811,000)

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Calculated assuming chromite ore to average 44% Cr_2O_3, which is 68.42% chromium.
3/ Calculated assuming chromium content of ferrochromium to average 57%.
4/ Calculated assuming chromium content of stainless steel to average 17%.
5/ Industry stocks include chromium ferroalloy and metal producer stocks before 1998.
6/ Includes chromium ferroalloys and metal and other chromium materials in the United States.
7/ Time-weighted average price of South African chromite ore, as reported in Platt's Metals Week.
8/ Time-weighted average price of imported high-carbon chromium that contains 50% to 55% chromium, as reported in Platt's Metals Week.
9/ Time-weighted average price of electrolytic chromium metal, as reported in Platt's Metals Week.
10/ Includes chromite ore and chromium ferroalloys, metal, and chemicals.
11/ A number in parentheses indicates that imports are greater than exports.
12/ Data on stainless steel production from American Iron and Steel Institute, quarterly production of stainless and heat-resisting raw steel.
13/ Data on stainless steel shipments from American Iron and Steel Institute Annual Reports.
14/ Includes stainless steel and stainless steel scrap.

TABLE 2
PRINCIPAL U.S. PRODUCERS OF CHROMIUM PRODUCTS IN 1999, BY INDUSTRY

Industry and company	Plant
Metallurgical:	
Eramet Marietta, Inc.	Marietta, OH.
JMC (USA), Inc.	Research Triangle Park, NC.
Refractory:	
Harbison-Walker Refractories, a subsidiary of Global Industrial Technologies	Hammond, IN.
National Refractories & Minerals Corp.	Moss Landing, CA, and Columbiana, OH.
North American Refractories Co. Ltd.	Womelsdorf, PA.
Chemical:	
Elementis Chromium LP	Corpus Christi, TX.
Occidental Chemical Corp.	Castle Hayne, NC.

TABLE 3
U.S. CONSUMPTION OF CHROMIUM FERROALLOYS AND METAL, BY END USE 1/

(Metric tons, gross weight unless noted)

End use	Ferrochromium Low-carbon 2/	Ferrochromium High-carbon 3/	Ferro-chromium-silicon	Other	Total
1997:					
Steel:					
Carbon	4,330 r/	9,580	149 r/	W	14,100 r/
Stainless and heat-resisting	8,620 r/	253,000 r/	W	155 r/	262,000 r/
Full-alloy	4,370 r'	26,800	1,580	42 r/	32,800
High-strength, low-alloy, electric	2,280 r/	W	7,480 r/	W	9,760 r/
Tool	W	3,620 r/	W	W	3,620 r/
Cast irons	723 r/	3,590 r/	W	W	4,320 r/
Superalloys	2,530 r/	W	W	4,370	6,890 r/
Welding materials 4/	W	274 r/	5 r/	378 r/	658 r/
Other alloys 5/	445 r/	W	--	1,410 r/	1,850 r/
Miscellaneous and unspecified	1,650 r/	8,380 r/	43,600 r/	743 r/	54,400 r/
Total 6/	25,000 r/	305,000 r/	52,800	7,090 r/ 7/	390,000 r/
Chromium content	17,000 r/	183,000 r/	18,800	5,790 r/	225,000 r/
Stocks, December 31, 1997	1,940 r/	13,800	699 r/	441 r/ 8/	16,900 r/
1998:					
Steel:					
Carbon	4,440	7,950	138	W	12,500 r/
Stainless and heat-resisting	7,230	226,000	W	W	233,000 r/
Full-alloy	4,050	22,300	1,530	35	28,000 r/
High-strength, low-alloy, electric	2,170	1,790	7,170	W	11,100 r/
Tool	(9/)	W	W	W	W
Cast irons	(9/)	2,510	W	W	2,510 r/
Superalloys	2,470	W	W	4,050	6,520 r/
Welding materials 4/	161	249	W	W	410 r/
Other alloys 5/	480	W	--	1,310	1,790 r/
Miscellaneous and unspecified	(9/)	7,750	29,500	3,160	40,400 r/
Total 6/	21,000	268,000	38,300	8,550 10/	336,000 r/
Chromium content	14,200	157,000	13,800	6,410	192,000
Stocks, December 31, 1998	2,460	13,900	730	459 11/	17,500 r/
1999:					
Steel:					
Carbon	4,100	6,330	165	W	10,600
Stainless and heat-resisting	9,920	274,000	W	W	284,000
Full-alloy	3,830	19,900	1,410	W	25,200
High-strength, low-alloy, electric	2,130	2,300	W	W	4,430
Tool	(9/)	W	--	W	W
Cast irons	(9/)	1,710	W	W	1,710
Superalloys	1,730	3,820	W	3,720	9,280
Welding materials 4/	219	232	1	363	815
Other alloys 5/	412	W	--	1,710	2,130
Miscellaneous and unspecified	(9/)	2,010	44,800	3,240	50,000
Total 6/	22,300	311,000	46,300	9,040 12/	389,000
Chromium content	15,000	178,000	16,300	6,720	216,000
Stocks, December 31, 1999	2,160	20,900	733	545 13/	24,300

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified." -- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Contains less than 3% carbon.
3/ Contains 3% or more carbon.
4/ Includes structural and hard-facing welding material.
5/ Includes cutting materials and magnetic, aluminum, copper, nickel, and other alloys.
6/ Includes estimates.
7/ Includes 4,970 tons of chromium metal.
8/ Includes 227 tons of chromium metal.
9/ Withheld to avoid disclosing company proprietary data.
10/ Includes 4,640 tons of chromium metal.
11/ Includes 193 tons of chromium metal.
12/ Includes 4,690 tons of chromium metal.
13/ Includes 245 tons of chromium metal.

TABLE 4
U.S. CONSUMER STOCKS OF CHROMITE ORE, CHROMIUM FERROALLOYS, AND METAL, DECEMBER 31 1/

(Metric tons, gross weight)

Industry	1998	1999
Chromite ore 2/	159,000	130,000
Chromium ferroalloy and metal:		
Low-carbon ferrochromium	2,460	2,160
High-carbon ferrochromium	13,900	20,900
Ferrochromium-silicon	730	733
Other 3/	459	545
Total	17,500 r/	24,300

r/ Revised.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Includes chemical, metallurgical, and refractory industry use.
3/ Includes chromium metals stocks of 193 tons in 1998 and 245 tons in 1999.

TABLE 5
U.S. GOVERNMENT STOCKPILE YEAREND INVENTORIES AND CHANGE FOR CHROMIUM 1/ 2/

(Metric tons, gross weight)

			Change 3/	
Material	1998	1999	Quantity	Percentage 4/
Chromite ore:				
Chemical	211,000	205,000	(5,250)	(2)
Metallurgical	387,000	340,000	(47,300)	(12)
Refractory	287,000	274,000	(13,000)	(5)
Chromium ferroalloys:				
Ferrochromium-silicon	51,200	50,700	(510)	(1)
High-carbon ferrochromium	645,000	645,000	(572)	(5/)
Low-carbon ferrochromium	278,000	278,000	(309)	(5/)
Chromium metal:				
Aluminothermic	2,670	2,670	--	--
Electrolytic	5,050	5,050	--	--

-- Zero.
1/ Includes specification- and nonspecification-grade materials.
2/ Data are rounded to no more than three significant digits.
3/ A number in parentheses indicates decrease.
4/ Quantity change as a percentage of stocks in earlier year.
5/ Less than 1/2%.

Source: Defense Logistics Agency.

TABLE 6
TIME-VALUE RELATIONS FOR CHROMITE ORE, FERROCHROMIUM, AND CHROMIUM METAL 1/ 2/

(Annual average value, dollars per metric ton)

Material	1998		1999	
	Contained chromium	Gross weight	Contained chromium	Gross weight
Chromite ore:				
Not more than 40% chromic oxide	402	110	215	65
More than 40% but less than 46% chromic oxide	462	142	866	266
46% or more chromic oxide	221 r/	73	181	62
Average 3/	223 r/	73 r/	184	62
Ferrochromium:				
High-carbon 4/	882 r/	497 r/	658	387
Medium-carbon 5/	716	448	572	372
Low-carbon 6/	1,750	1,150 r/	1,560	1,040
Average 3/	1,010 r/	581 r/	723	429
Chromium metal	XX	7,570 r/	XX	6,270

r/ Revised. XX Not applicable.
1/ Based on Customs value of chromium contained in imported material.
2/ Data are rounded to no more than three significant digits; may not add to totals shown.
3/ Mass-weighted average.
4/ More than 4% carbon.
5/ More than 3%, but not more than 4% carbon.
6/ Not more than 3% carbon.

TABLE 7
PRICE QUOTATIONS FOR CHROMIUM MATERIALS AT BEGINNING AND END OF 1999

Material	January	December	Year average 1/
Dollars per metric ton of product:			
Chromite ore:			
South Africa	60-65	60-65	63
Turkey	140-150	140-150	145
Cents per pound of chromium:			
High-carbon ferrochromium:			
Imported:			
50% to 55% chromium	35.00-38.00	37.00-40.00	36.61
60% to 65% chromium	35.00-40.00	38.00-41.00	36.63
Low-carbon ferrochromium:			
Imported:			
0.05% carbon	77-79	67-70	71
0.10% carbon	61-63	53-55	56
Cents per pound of product:			
Chromium metal (domestic):			
Electrolytic	415	450	433
Elchrome	450	575	516

1/ Time-weighted average.

Source: Platt's Metals Week.

TABLE 8
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE 1/

HTSUSA 2/	Type	1998 Quantity (kilograms)	1998 Value (thousands)	1999 Quantity (kilograms)	1999 Value (thousands)	Destinations, 1999
2610.00.0000	Chromite ore and concentrate, gross weight	121,000,000	$9,230	110,000,000	$8,580	Sweden (72%); Norway (20%); Canada (4%); Egypt (2%); Mexico (1%).
	Metal and alloys:					
8112.20.0000	Chromium metal, gross weight 3/	1,040,000	13,000	2,370,000	17,100	Belgium (32%); Japan (22%); Canada (18%); Brazil (16%); Germany (3%); Mexico (3%); France (2%); Australia (1%); Netherlands (1%); Saudi Arabia (1%); United Kingdom (1%).
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium, gross weight 4/	4,840,000	4,210	4,250,000	3,180	Mexico (60%); Canada (39%); Brazil (1%).
7202.41.0000	High-carbon ferrochromium, contained weight 4/	2,980,000	--	2,550,000	--	
7202.49.0000	Low-carbon ferrochromium, gross weight 5/	1,380,000	2,100	1,290,000	1,560	Mexico (51%); Canada (41%); Australia (1%); France (1%); India (1%); Korea, Republic of (1%); United Kingdom (1%).
7202.49.0000	Low-carbon ferrochromium, contained weight 5/	841,000	--	776,000	--	
7202.50.0000	Ferrochromium-silicon, gross weight	387,000	402	250,000	243	Canada (80%); Mexico (15%); United Kingdom (3%); Hong Kong (1%); Lebanon (1%).
7202.50.0000	Ferrochromium-silicon, contained weight	135,000	--	87,700	--	
	Total ferroalloys, gross weight	6,610,000	6,710	5,790,000	4,980	
	Total ferroalloys, contained weight	3,960,000	--	3,420,000	--	
	Chemicals: (gross weight)					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	10,100,000	19,600	11,100,000	21,800	Canada (32%); Brazil (12%); Australia (10%); New Zealand (8%); Korea, Republic of (7%); Chile (5%); Mexico (5%); Taiwan (5%); Japan (4%); Germany (3%); Hong Kong (2%); China (1%); Indonesia (1%); Malaysia (1%); Singapore (1%); South Africa (1%); Thailand (1%); Venezuela (1%).
2819.90.0000	Other	4,980,000	21,700	3,310,000	13,400	Germany (30%); Canada (23%); Netherlands (9%); South Africa (6%); Mexico (4%); Japan (4%); Taiwan (4%); Domincan Republic (3%); Russia (3%); Australia (2%); Belgium (2%); China (2%); United Kingdom (2%); Hong Kong (1%); Korea, Republic of (1%); Philippines (1%).
2833.23.0000	Chromium sulfates	11,100	145	14,000	69	Mexico (74%); Japan (21%); Taiwan (5%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Zinc and lead chromate	267,000	943	523,000	1,830	India (46%); Mexico (23%); Canada (19%); Dominican Republic (7%); Belgium (1%); Haiti (1%); Jamaica (1%); Netherlands (1%).
2841.30.0000	Sodium dichromate	25,200,000	21,000	26,500,000	17,500	Mexico (48%); Thailand (16%); Colombia (7%); Guatamala (4%); Germany (3%); Spain (3%); Taiwan (3%); Belgium (2%); Ecuador (2%); Panama (2%); Peru (2%); Argentina (1%); Brazil (1%); Canada (1%); China (1%); Hong Kong (1%); Indonesia (1%); Korea, Republic of (1%); Philippines (1%); South Africa (1%).
2841.40.0000	Potassium dichromate	137,000	439	82,600	151	Ireland (39%); Brazil (35%); France (8%); Canada (7%); Taiwan (6%); Netherlands (4%); Japan (1%); Panama (1%).
2841.50.0000	Other chromates, dichromates, and peroxochromates	323,000	1,060	297,000	893	Canada (85%); Mexico (11%); Saudi Arabia (2%); France (1%); United Kingdom (1%).
3206.20.0000	Pigments and preparations, gross weight	2,310,000	8,170	1,470,000	6,200	Mexico (46%); Canada (15%); Australia (11%); Switzerland (6%); Japan (5%); Jamaica (2%); Korea, Republic of (2%); New Zealand (2%); Thailand (2%); Argentina (1%); Costa Rica (1%); Germany (1%); Philippines (1%); Singapore (1%); South Africa (1%); Trinidad and Tobago (1%); Venezuela (1%).

See footnotes at end of table.

TABLE 8--Continued
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE 1/

-- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States of America code.
3/ Articles thereof and waste and scrap.
4/ More than 4% carbon.
5/ Not more than 4% carbon.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF CHROMITE ORE, BY COUNTRY 1/

	Not more than 40% Cr_2O_3 (HTSUSA 2/ 2610.00.0020)			More than 40% but less than 46% Cr_2O_3 (HTSUSA 2/ 2610.00.0040)			46% or more Cr_2O_3 (HTSUSA 2/ 2610.00.0060)			Total		
Country	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value 3/ (thou-sands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value 3/ (thou-sands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value 3/ (thou-sands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value 3/ (thou-sands)
1998:												
Belarus	--	--	--	--	--	--	-- r/	-- r/	-- r/	-- r/	-- r/	-- r/
Canada	21 r/	8 r/	$9 r/	--	--	--	--	--	--	21 r/	8 r/	$9 r/
Czech Republic	--	--	--	--	--	--	19 r/	8 r/	$8 r/	19 r/	8 r/	8 r/
India	-- r/	-- r/	-- r/	--	--	--	--	--	--	-- r/	-- r/	-- r/
New Caledonia	--	--	--	--	--	--	66	31	1	66	31	1
Philippines	5,290	2,120	576	--	--	--	362	170	96	5,650	2,290	672
Saudi Arabia	--	--	--	--	--	--	24	12	3	24	12	3
South Africa	--	--	--	89	40	$13	352,000	169,000	25,500	352,000	169,000	25,600
Total	5,310	2,120	585	89	40	13	352,000	170,000	25,600 r/	358,000	172,000	26,200 r/
1999:												
Canada	380	146	168	40	19	11	57	18	10	477	183	189
Philippines	4,000	1,320	456	--	--	--	--	--	--	4,000	1,320	456
South Africa	21,100	9,710	1,020	49	21	12	226,000	113,000	14,000	247,000	123,000	15,000
Total	25,500	11,200	1,650	89	40	24	226,000	113,000	14,000	252,000	124,000	15,700

r/ Revised. -- Zero.

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

2/ Harmonized Tariff Schedule of the United States of America code.

3/ Customs import value generally represents a value in the foreign country and therefore excludes U.S. import duties, freight, insurance and other charged incurred in bringing the merchandise to the United States.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY 1/

Country	Low-carbon (not more than 3% carbon) (HTSUSA 2/ 7202.49.5000)			Medium-carbon (more than 3% carbon but not more than 4% carbon) (HTSUSA 2/ 7202.49.1000)			High-carbon (more than 4% carbon) (HTSUSA 2/ 7202.41.0000)			Total (all grades)		
	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)
1998:												
Brazil	20	13	$45	--	--	--	--	--	--	20	13	$45
China	3,220	2,090	3,430	--	--	--	6,820	3,710	$3,460	10,000	5,800	6,890
Croatia	--	--	--	--	--	--	6,150	3,920	3,280	6,150	3,920	3,280
Germany	8,770	6,100	19,800	--	--	--	18	12	19	8,780	6,110	19,800
India	--	--	--	--	--	--	37,300	18,400	20,000	37,300	18,400	20,000
Japan	282	192	816	--	--	--	--	--	--	282	192	816
Kazakhstan	2,970	2,020	2,400	1,370	858	$614	51,200	34,200	30,700	55,600	37,000	33,700
Norway	--	--	--	--	--	--	5,000	3,050	2,360	5,000	3,050	2,360
Russia	25,500 r/	17,400	26,100 r/	--	--	--	41	25	21	25,500 r/	17,500	26,100 r/
South Africa	11,000	6,140	7,530	--	--	--	163,000	83,000	66,600	174,000	89,100	74,100
Sweden	40 r/	29 r/	78 r/	--	--	--	--	--	--	40 r/	29 r/	78 r/
Turkey	--	--	--	--	--	--	43,700	27,100	24,000	43,700	27,100	24,000
United Kingdom	84 r/	59 r/	133 r/	--	--	--	16	10	10	100 r/	69 r/	143 r/
Zimbabwe	1,940	1,300	1,750	--	--	--	52,500	32,500	31,100	54,400	33,800	32,900
Total	53,800	35,400	62,100	1,370	858	614	366,000	206,000	182,000	421,000	242,000	244,000
1999:												
Albania	--	--	--	--	--	--	3,750	2,360	1,780	3,750	2,360	1,780
China	758	511	927	--	--	--	4,360	2,590	2,380	5,120	3,100	3,310
Finland	--	--	--	--	--	--	5,060	2,780	1,940	5,060	2,780	1,940
France	--	--	--	--	--	--	6	4	7	6	4	7
Germany	6,840	4,780	14,000	--	--	--	--	--	--	6,840	4,780	14,000
India	--	--	--	--	--	--	5,010	3,090	1,930	5,010	3,090	1,930
Japan	1,010	697	2,330	--	--	--	--	--	--	1,010	697	2,330
Kazakhstan	3,960	2,770	3,060	--	--	--	154,000	106,000	68,500	158,000	108,000	71,500
Russia	16,800	11,500	13,200	--	--	--	7,830	5,230	5,070	24,600	16,700	18,300
South Africa	5,950	3,440	3,970	--	--	--	229,000	114,000	69,900	235,000	117,000	73,900
Sweden	34	24	74	--	--	--	--	--	--	34	24	74
Turkey	--	--	--	--	--	--	83,700	52,500	31,900	83,700	52,500	31,900
United Kingdom	61	43	131	3,000	1,950	1,120	2	1	2	3,060	1,990	1,250
United States	--	--	--	--	--	--	4	3	12	4	3	11
Zimbabwe	3,590	2,380	2,900	--	--	--	68,400	42,300	34,100	72,000	44,700	37,000
Total	39,000	26,100	40,700	3,000	1,950	1,120	562,000	331,000	218,000	604,000	359,000	259,000

r/ Revised. -- Zero.

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

2/ Harmonized Tariff Schedule of the United States of America code.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE 1/

HTSUSA 2/	Type	1998 Quantity (kilograms)	1998 Value (thousands)	1999 Quantity (kilograms)	1999 Value (thousands)	Sources, 1999
	Metals and alloys:					
	Chromium metal:					
8112.20.3000	Waste and scrap, gross weight	5,580 r/	$60 r/	17,800	$150	Russia (80%); Japan (10%); Singapore (7%); Germany (3%); United Kingdom (1%).
8112.20.6000	Other than waste and scrap, gross weight	9,520,000 r/	72,000 r/	9,010,000	56,400	China (28%); Russia (25%); France (23%); United Kingdom (23%).
7202.50.0000	Ferrochromium-silicon, gross weight	20,000,000	12,500	36,000,000	18,700	Kazakhstan (43%); Russia (37%); Brazil (13%); South Africa (4%); Zimbabwe (4%).
7202.50.0000	Ferrochromium-silicon, contained weight	6,770,000	--	12,700,000	--	
	Chemicals (gross weight):					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	4,220,000	7,900	6,730,000	12,000	Kazakhstan (77%); Italy (8%); Turkey (8%); Poland (2%); China (1%); France (1%); Germany (1%); Japan (1%); United Kingdom (1%).
2819.90.0000	Other	4,890,000	14,500	4,300,000	14,800	Germany (30%); Japan (25%); China (13%); Canada (9%); Austria (7%); Italy (5%); Poland (4%); United Kingdom (4%); Colombia (1%); France (1%); Russia (1%).
2833.23.0000	Sulfates of chromium	447,000	395	391,000	386	United Kingdom (53%); Mexico (21%); Germany (19%); South Africa (5%); Japan (1%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Chromates of lead and zinc	137,000	336	159,000	355	Norway (68%); Philippines (11%); China (10%); Canada (8%); Brazil (2%); Colombia (1%).
2841.30.0000	Sodium dichromate	9,130,000	8,150	10,400,000	7,770	United Kingdom (94%); Turkey (3%); Canada (2%); Argentina (1%).
2841.40.0000	Potassium dichromate	478,000	612	177,000	329	India (34%); United Kingdom (28%); Kazakhstan (11%); Netherlands (10%); Germany (9%); Switzerland (7%).
2841.50.0000	Other chromates and dichromates; peroxochromates	657,000	1,410	471,000	1,050	United Kingdom (96%); Austria (2%); Korea , Republic of (2%).
2849.90.2000	Chromium carbide	167,000	2,200	252,000	2,870	United Kingdom (60%); Japan (24%); Germany (13%); China (2%).
	Pigments and preparations based on chromium (gross weight):					
3206.20.0010	Chrome yellow	6,420,000	18,400	6,760,000	19,000	Canada (55%); Hungary (14%); Mexico (10%); China (8%); Korea, Republic of (7%); Colombia (3%); Japan (2%); Germany (1%).
3206.20.0020	Molybdenum orange	2,050,000	7,900	1,550,000	6,600	Canada (94%); Japan (2%); Germany (1%); Mexico (1%); Spain (1%).
3206.20.0030	Zinc yellow	4,170	7	34,000	32	Brazil (100%).
3206.20.0050	Other	1,030,000	3,910	1,250,000	4,330	France (45%); China (25%); Germany (14%); Canada (6%); Mexico (4%); Japan (2%); Korea, Republic of (2%); South Africa (2%); Switzerland (1%).

r/ Revised. -- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States of America code.

Source: U.S. Census Bureau.

TABLE 12
PRINCIPAL WORLD CHROMITE ORE PRODUCERS, 1999

Country 1/	Company
Albania	Albkrom (Government owned).
Brazil	Cia. de Ferro Ligas da Bahia S.A.
	Elkem ASA (Norway).
	Mineracão Vila Nova Ltda.
	Magnesita S.A.
China	Huazang Smelter.
	Shashen.
	Xizang Kangjinla.
	Xinjiang Karamay Gold Mine.
	Xinjiang Non-Ferrous Metals Industry Corp.
Finland	Outokumpu Oy.
	Outokumpu Steel Oy.
	Outokumpu Chrome Oy.
India	Ferro Alloys Corp. Ltd.
	Indian Metals and Ferroalloys Ltd.
	Indian Charge Chrome Ltd.
	Misrilall Mines Ltd.
	Mysore Mineral Ltd.
	Orissa Mining Corporation Limited.
	The Tata Iron and Steel Co. Ltd.
Indonesia	PT. Palabim Mining-PT. Bituminusa.
Iran	Faryab Mining Co.
Kazakhstan	Donskoy Ore Dressing Complex.
Madagascar	Kraomita Malagasy.
Oman	Oman Chromite Company SAOG.
Philippines	Benguet Corporation.
	Heritage Resources & Mining Corporation.
	Krominco Inc.
	Velore Mining Corporation.
Russia	Saranov Complex.
South Africa	ASA Metals (Pty.) Ltd.
	African Mining and Trust Co. Ltd.
	Rustenburg Minerals Development Co. (Pty.) Ltd.
	Zeerust Chrome Mine Ltd.
	Bafokeng Chrome Holdings.
	Bayer AG (Germany).
	Bayer (Pty.) Ltd.
South Africa--Continued	Canadian Gold S.A. (Pty.) Ltd.
	Goudini Chrome (Pty.) Ltd.
	Hernic Ferrochrome (Pty.) Ltd.
	National Manganese Mines Pty. Ltd.
	Pilanesberg Chrome (Pty.) Ltd.
	Rooderand Chrome Mine (Pty.) Ltd.
	Rustenburg Minerals Development Company.
	SA Chrome and Alloys (Pty.) Ltd.
	Samancor Limited.
	Eastern Chrome Mines.
	Western Chrome Mines.
	Vereeniging Refractories Ltd.
	Bophuthatswana Chrome Co. (Pty.) Ltd.
	Marico Chrome Corp. (Pty.) Ltd.
	Xstrata AG (Switzerland).
	Xstrata S.A. (Pty.) Ltd.
	Chromecorp (Pty.) Ltd.
	Consolidated Metallurgical Industries Ltd.
Sudan	Advanced Mining Works Co. Ltd.
Turkey	Aycan Madencilik Ltd. Sti.
	Bilfer Madencilik A.S.
	Birlik Madencilik Dis Tic. Insaat San. ve Tic. A.S.
	Cevher Madencilik ve Ticaret A.S.
	Dedeman Madencilik Sanayi ve Ticaret A.S.
	Eti Holdings.
	Hâyri Ögelman Mining Co. Ltd.
	Pinarbasi Madencilik Sanayi ve Ticaret Ltd.
	Tekfen Dis. Ticaret A.S.
	Tevfik Refik Bayoglu Madencilik.
	Tut. Gen. Ticaret Ltd. Sti.
	Türk Maadin Sirketi A.S.
United Arab Emirates	Derkek Raphael & Co.
	Dewent Mining Ltd.
Zimbabwe	Zimasco (Pvt.) Ltd.
	Zimbabwe Alloys Ltd.

1/ Other chromite-producing countries included Burma, Cuba, Pakistan, and Vietnam.

TABLE 13
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 1999

Country 1/	Company
Albania	Albkrom (Government owned).
Brazil	Cia. de Ferro Ligas da Bahia S.A.
Chile	Carbomet Industrial SA.
China	Dandong Ferroalloy Plant.
	Emei Ferroalloy (Group) Co. Ltd.
	Gansu Huazang Metallurgical Group Co. Ltd.
	Hanzhong Ferroalloy Works (Government owned).
	Hengshang Iron & Steel
	Hunan Ferroalloy (Government owned).
	Hunan Lengshuijiang Electrochemical Works.
	Jiangyin Ferroalloy Factory (Government owned).
	Jilin Dongfeng Ferroalloy Works.
	Jilin Ferroalloy Group Co. Ltd.
	Jilin Huinan Ferroally Works.
	Jinzhou Ferroalloy (Group) Co. Ltd.
	Liaoyang Ferroalloy Group Corp.
	Nanjing Ferroalloy Plant (Government owned).
	Ningjin Metal Smelting Co. Ltd.
	Qinghai Datong Ferroalloy Works
	Quinhai Sanchuan Ferroalloy Co. Ltd.
	Taonan Ferroalloy Works.
	Urad Zhongqi Ferrochrome Group Corp.
	Xibei Ferroalloy Works (Government owned).
	Zhejiang Hengshan Ferroalloy Works.
Croatia	Dalmacija Ferro-Alloys Works.
Finland	Outokumpu Oy.
	Outokumpu Steel Oy.
	Outokumpu Chrome Oy.
Germany	Elektrowerk Weisweiler GmbH.
India	Andhra Ferro Alloys Limited.
	Baheti Metal & Ferro Alloys Ltd.
	Bharat Thermite Ltd.
	Deepak Ferro Alloys Ltd.
	Eastern Metals & Ferro Alloys Ltd.
	Ferro Alloys Corp. Ltd.
	Charge Chrome Plant.
	Ferro-Alloys Unit.
	GMR Vasavi Industries Ltd.
	Hi-Tech Electrothermics Ltd.
	Indian Metals and Ferroalloys Ltd.
	Indian Charge Chrome Ltd.
	Industrial Development Corp.
	Ispat Alloys Ltd.
	Jindal Strips Ltd.
	Ferro Alloys Division.
	Mandsaur Ferro Alloys Ltd.
	Metramet Ferroalloys Pvt. Ltd.
	Monnet Industries Ltd.
	Nav Chrome Limted.
	Nava Bharat Ferro Alloys Ltd.
	Raghuvir Ferro Alloy Pvt. Ltd.
	Shri Girija Smelters Limited.
	Srinivasa Ferro Alloys Ltd.
	Standard Chrome Ltd.
	The Sandur Manganese & Iron Ores Ltd.
India--Continued	The Tata Iron and Steel Co. Ltd.
	Bamnipal Plant.
	Joda Plant.
	VBC Ferro Alloys Ltd.
	V.K. Ferro Alloys Private Ltd.
Iran	Faryab Mining Co.
	Abadan Ferroalloys Refinery.
Italy	Darfo S.p.A.
	Fornileghe S.p.A.
	Mineralsider S.p.A.
Japan	Japan Metals and Chemicals Co. Ltd.
	Nippon Denko Co., Ltd.
	NKK Corporation.
	Showa Denko K.K.
Kazakhstan	Aksusky Ferroalloy Plant.
	Aktyubinsk Ferroalloy Plant.
Macedonia	Jugochrom.
Norway	Elkem ASA.
Philippines	Araneta Properties.
	Ferrochrome Philippines Inc.
	Philippines Minerals & Alloy Corporation.
Poland	Huta "Laziska" Ferroalloy Plant.
Romania	S.C. Ferom S.A.
Russia	Chelyabinsk Electrometallurgical Integrated Plant.
	Klutchevsk Ferroalloy Plant.
	Metall Joint Venture.
	Serov Ferroalloys Plant.
Slovakia	Oravske Ferozliatinarske Zavody.
Slovenia	Tovarna Dusika Ruse-Metalurgija d.d.
South Africa	ASA Metals (Pty.) Ltd.
	Associated Manganese Mines of South Africa Ltd.
	Feralloys Ltd.
	Hernic Ferrochrome (Pty.) Ltd.
	Samancor Limited.
	Batlhako Ferrochrome Ltd.
	Ferrometals Division.
	Middelburg Ferrochrome Division.
	Palmiet Ferrochrome Division.
	Tubatse Ferrochrome Division.
	Xstrata A.G. (Switzerland).
	Xstrata S.A. (Pty.) Ltd.
	Chromecorp (Pty.) Ltd.
	Consolidated Metallurgical Industries Ltd.
	Lydenburg Works.
	Rustenburg Works.
Sweden	Vargön Alloy AB.
Turkey	Eti Holdings.
	Eti Elektromatalurji.
	Eti Krom.
Ukraine	Zaporozhye Ferro-Alloy Works.
United States	Eramet Marietta, Inc.
Zimbabwe	Maranatha Ferrochrome.
	Zimasco (Pvt.) Ltd.
	Zimbabwe Alloys Ltd.

1/ Other ferrochromium-producing countries include Spain and Taiwan.

TABLE 14
CHROMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1995	1996	1997	1998	1999 e/
Albania 4/	160,000	143,000	106,000 e/	86,000 r/ e/	85,000
Australia	--	6,000	31,000	130,000	130,000
Brazil 5/	447,963	408,495	300,000	360,000 r/	350,000
Burma	1,000 e/	1,000 e/	3,299 r/	4,059 r/	3,200
China e/	94,000	130,000	120,000	150,000	160,000
Cuba	30,693	37,300	44,000	49,044 r/	35,750 6/
Finland	597,605	573,904	589,000	611,000 e/	610,000
Greece	5,000 e/	11,725	12,020	12,000 e/	12,000
India	1,536,386	1,363,205	1,363,049	1,311,310 r/	1,300,000
Indonesia e/	10,000	13,300	2,156 6/	4,700 r/	6,355 6/
Iran	371,100	130,220 r/	168,984 r/	211,555 r/	254,685 6/
Kazakhstan	2,417,000	1,190,000	1,798,300 r/	1,602,700 r/	2,405,000 6/
Macedonia e/	5,000	5,000	5,000	5,000	5,000
Madagascar	106,107	137,210	139,700	104,300 r/	105,000
Oman	5,300	15,252 r/	18,000 r/	28,684 r/	26,004 6/
Pakistan	17,000 e/	27,987	23,763 r/	8,885 r/	16,279 6/
Philippines	111,035	107,068 r/	87,500	53,871 r/	19,566 6/
Russia	151,400	96,700	150,000 e/	130,000 e/	100,000
South Africa	5,086,000 r/	5,078,000 r/	6,162,000 r/	6,480,000 r/	6,817,050 6/
Sudan e/	44,988 6/	12,000 r/	30,500 r/	20,000 r/	10,000
Turkey	2,080,043	1,279,032	1,702,633 r/	1,404,470 r/	770,352 6/
United Arab Emirates	37,000	56,000	61,000 e/	76,886 r/	60,000
Vietnam	25,000 r/	37,000 r/	51,000 r/	54,000 r/	50,000
Zimbabwe	707,433	697,311	670,000 e/	605,000 r/ e/	650,000
Total	14,000,000 r/	11,600,000	13,600,000 r/	13,500,000 r/	14,000,000

e/ Estimated. r/ Revised. -- Zero.

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

2/ Table includes data available through June 23, 2000.

3/ Figures for all countries represent marketable output unless otherwise noted.

4/ Direct shipping plus concentrate production.

5/ Average Cr_2O_3 content was as follows: 1995-96--42.2%; 1997--37.4%; 1998--34.5%; and 1999--39%.

6/ Reported figure.

TABLE 15
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country	1995	1996	1997	1998	1999 e/
Albania	42,986	31,189	31,454	29,960	28,500
Brazil 3/	100,969	77,231	76,250 r/	100,000 r/ e/	100,000
Chile	2,730	2,079 r/	2,000	2,000 e/	2,000
China e/	500,000	423,000	480,000	424,000	400,000
Croatia	26,081	10,559	24,231	11,770	10,000
Finland	246,805	227,811	236,652	230,906	235,000
Germany	21,665	25,303	25,856	20,879	16,960 4/
India 5/	303,537	261,666	286,973	345,125	350,000
Iran	11,900	10,500	11,450	13,745	14,000
Italy	51,017	29,915	11,295	11,487	12,000
Japan 3/	210,445	193,695	186,432	142,931	119,777 4/
Kazakhstan	511,600	352,000	600,000	535,000	597,946 4/
Macedonia	3,765	3,780	460	--	--
Norway	148,000	108,900	145,124	174,678 r/	159,714 4/
Philippines	50,450	6,736	--	-- e/	--
Poland	18,334	3,785	5,900	3,600	3,500
Romania	15,053	9,650	950	873 r/	--
Russia e/	290,000	135,000	247,000	203,000 4/	249,000 4/
Slovakia	65,260	19,900	11,394	11,715	6,986 4/
Slovenia	23,247	22,819	9,232	10,621	560 4/
South Africa 6/	1,517,100 r/	1,478,000	1,939,500 r/	2,025,300 r/	2,263,021 4/
Spain	1,320	805	490	1,145	935 4/
Sweden	130,170	138,110	101,842	123,958	113,140 4/
Turkey	94,251	101,450	108,320 r/	110,175 r/	110,000
United States 7/	72,500	36,800	60,700	W	W
Zimbabwe	254,142	243,000	233,386	246,782	240,000
Total	4,710,000 r/	3,950,000	4,840,000 r/	4,780,000 r/	5,030,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.
1/ World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
2/ Table includes data available through June 23, 2000.
3/ Includes high- and low-carbon ferrochromium.
4/ Reported figure.
5/ Includes ferrochrome and charge chrome.
6/ Includes high- and low-carbon ferrochromium and ferrochromium-silicon.
7/ Includes high- and low-carbon ferrochromium, ferrochromium-silicon, chromium metal, and other chromium materials.

TABLE 16
WORLD CHROMIUM ANNUAL PRODUCTION CAPACITY OF CHROMITE ORE,
FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL IN 1999 1/

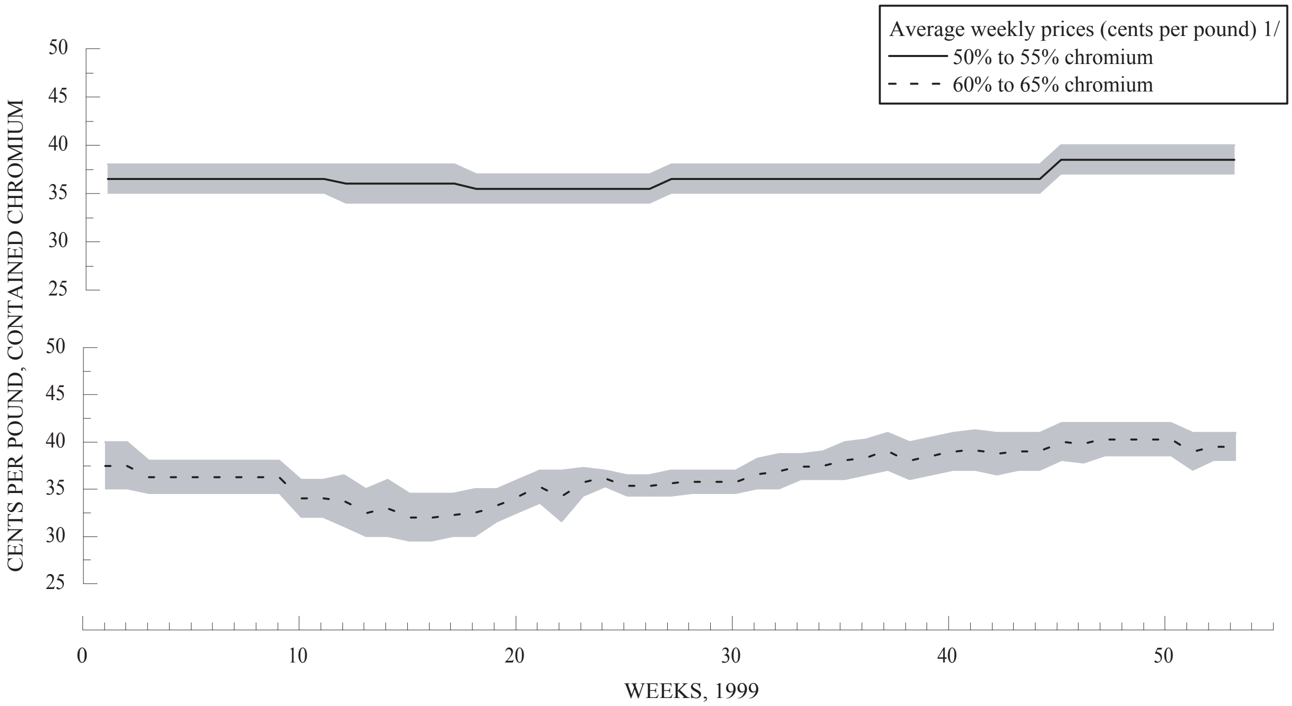
(Thousand metric tons, contained chromium)

	Ore	Ferro-chromium	Metal	Chemicals	Stainless steel
Albania	48	27	--	--	--
Argentina	--	--	--	6	--
Austria	--	--	--	--	8
Bangladesh	--	--	--	--	3
Belgium	--	--	--	--	119
Brazil	135	62	--	--	41
Burma	1	--	--	--	--
Canada	--	--	--	--	39
Chile	--	1	--	--	--
China	48	272	6	21	60
Croatia	--	17	--	--	--
Cuba	15	--	--	--	7
Czech Republic	--	--	--	--	5
Finland	184	128	--	--	102
France	--	--	7	--	204
Germany	--	17	1	--	255
Greece	4	--	--	--	--
India	462	183	(2/)	8	111
Indonesia	4	--	--	--	--
Iran	112	9	--	2	--
Italy	--	32	--	--	204
Japan	--	113	1	17	660
Kazakhstan	728	398	1	42	--
Korea, Republic of	--	--	--	--	306
Macedonia	2	2	--	5	--
Madagascar	42	--	--	--	--
Norway	--	106	--	--	--
Oman	9	--	--	--	--
Pakistan	8	--	--	3	--
Philippines	33	26	--	--	--
Poland	--	12	--	5	--
Romania	--	--	--	9	--
Russia	46	180	16	60	60
Slovakia	--	38	--	--	--
Slovenia	--	15	--	--	13
South Africa	1,950	1,060	--	24	95
Spain	--	1	--	--	204
Sudan	14	--	--	--	--
Sweden	--	86	--	--	128
Taiwan	--	1	--	--	167
Turkey	626	69	--	10	54
Ukraine	--	--	--	--	33
United Arab Emirates	23	--	--	--	--
United Kingdom	--	--	7	52	92
United States	--	20	3	56	390
Vietnam	16	--	--	--	--
Zimbabwe	213	163	--	--	--
Total	4,720	3,040	42	320	3,360

-- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

FIGURE 1

U.S. IMPORTED HIGH-CARBON FERROCHROMIUM, AVERAGE WEEKLY PRICES IN 1999

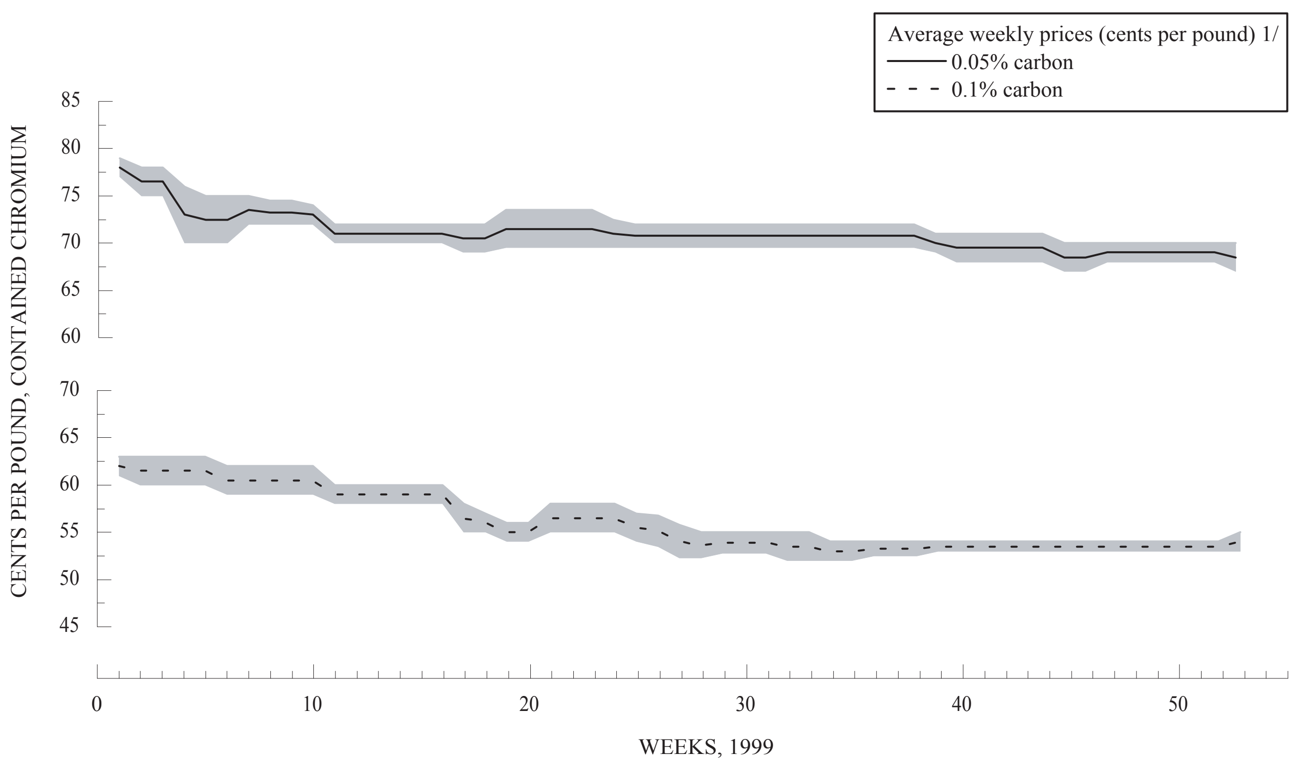


1/ Average weekly price shown against price range background.

Source: Platt's Metals Week

FIGURE 2

U.S. IMPORTED LOW-CARBON FERROCHROMIUM, AVERAGE WEEKLY PRICES IN 1999



1/ Average weekly price shown against price range background.

Source: Platt's Metals Week

FIGURE 3

U.S. CONSUMPTION OF CHROMIUM FERROALLOYS AND METAL, BY END USE