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CHROMIUM

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CHROMIUM

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In 2005, the U.S. chromium supply (measured in contained chromium) was 124,000 metric tons (t) from recycled stainless steel scrap, 353,000 t from imports, and 474,000 t from Government and industry stocks. Supply distribution was 57,200 t to exports, 384,000 t to Government and industry stocks, and 511,000 t to apparent consumption. Chromium apparent consumption decreased by 8.02% compared with that of 2004.

Chromium has a wide range of uses in chemicals, metals, and refractory materials. Its use in iron, nonferrous alloys, and steel is for the purpose of enhancing hardenability or resistance to corrosion and oxidation. Production of stainless steel and nonferrous alloys are two of its more critical applications. Other applications are in alloy steel, catalysts, leather processing, pigments, plating of metals, 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 (OSHA) regulates workplace exposure.

Because the United States has small 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 ore resources, mining capacity, and ferrochromium production capacity are concentrated in the Eastern Hemisphere. In recognition of the vulnerability of long supply routes during a military emergency, chromium was held in the National Defense Stockpile (NDS) since before World War II in various forms, including chromite ore, chromium ferroalloys, and chromium metal. As a result of changed national security considerations since 1991, stockpile goals have been reduced, and inventory is being sold. Material for 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 (DOD), and the U.S. Department of Energy conduct alternative materials research.

Domestic Data Coverage

Domestic data for chromium materials were developed by the USGS by means of the monthly “Chromite Ores and Chromium Products” and “Consolidated Consumers” consumer surveys. High-carbon ferrochromium is the most consumed chromium-containing material. Stainless and heat-resisting steel producers accounted for most of chromium-containing material consumed.

Legislation and Government Programs

The Defense National Stockpile Center (DNSC) disposed of chromium materials under its fiscal year 2005 (October 1, 2004, through September 30, 2005) Annual Materials Plan (AMP) and announced the fiscal year 2006 plan. The DNSC’s fiscal year 2006 AMP set maximum disposal goals for chromium materials at 136,000 t of chromium ferroalloys, 90,700 t of chemical-grade chromite ore (or remaining inventory), 90,700 t of refractory-grade chromite ore (or remaining inventory), and 907 t of chromium metal (Defense National Stockpile Center, 2005).

The DNSC (a part of the Defense Logistics Agency) was created to reduce U.S. dependence on foreign sources for strategic and critical materials (Holder, 2005). The DNSC sells chromium materials on the open market to domestic and foreign buyers while avoiding undue market disruption and protecting against avoidable monetary loss. The DNSC sets annual sales ceilings by material in the AMP based on advice from the Market Impact Committee, which comprises representatives from several Federal Government agencies. The DNSC had set a sales ceiling of 140,000 t of ferrochromium in fiscal year 2003 with sales of 77,000 t (high-carbon, 61,000 t; low-carbon, 16,000 t); 100,000 t in each of 2004 and 2005 with sales of 100,000 t in 2004 (high-carbon, 74,000 t; low-carbon, 26,000 t); and 56,000 t in 2005 (high-carbon, 49,000 t; low-carbon, 7,000 t). The chromium metal sales ceiling was 450 t in each of the fiscal years 2003, 2004, and 2005. Actual sales of chromium metal were 103 t in 2003 (all of which was aluminothermic), 447 t in 2004 (384 t aluminothermic, 64 t electrolytic), and 479 t in 2005 (73 t aluminothermic, 406 t electrolytic). In April 2005, the DNSC held 355,000 t of high-carbon ferrochromium, 179,000 t of low-carbon ferrochromium, 4,500 t of electrolytic chromium metal, and 1,600 t of aluminothermic chromium metal in inventory.

Production

The major marketplace chromium materials are chromite ore, foundry sand, chromium chemicals, ferroalloys, and metal. In 2005, the United States produced chromium ferroalloys, metal, and chemicals, but no chromite ore. The United States is a major world producer of chromium metal and chemicals and of stainless steel (the major end use of chromium).

Oregon Resources Corporation [a subsidiary of Resource Finance and Investment Ltd. (Bermuda)] planned to start chromite ore production in 2006 at its surface mine in Coos County, OR (Resource Finance and Investment Ltd., 2006§[1]).

[1]References that include a section mark (§) are found in the Internet References Cited section.

Oregon Resources began construction on a 10-metric-ton-per-hour plant using spiral separators, high tension rolls, electrostatic separators, and rare earth magnets to separate and purify chromite, garnet, and zircon minerals. Oregon Resources reported proven reserves of 1.27 million metric tons (Mt) of mineral sands (proven plus probable reserves of 1.9 Mt; geologic resources of 6.4 Mt) that contained an average of 13% chromite. The company estimated that it would produce about 41,000 metric tons per year (t/yr) of foundry-grade chromite (Industrial Minerals, 2005).

Environment

The OSHA reviewed occupational exposure limits for hexavalent chromium and issued for public comment a proposed rule to reduce such exposure. The proposed exposure set an 8-hour time-weighted average exposure limit of 1 microgram per cubic meter (Dobos, 2005§). The new rule was expected to become final in 2006.

Huvinen (2006) studied the effect of chromium on human health. The study found that, for metallic chromium and chromium oxide, labeling and further testing are not required; however, basic chromium sulfate should be labeled, further risk testing should be done, and data gaps identified. The study found no long-term health effects for workers in the stainless steel or ferrochromium industries or for consumers of stainless steel.

Prices

Chromium materials are not openly traded. Purchase contracts are confidential between buyer and seller; however, 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 statistics are sources of chromium material prices and values, respectively.

Based on Platts Metals Week reported prices, the high-carbon ferrochromium price peaked at $0.76 per pound of contained chromium in 2005, surpassing the $0.72 per pound reached in 2004, and then dropped to $0.60 per pound (Ward, 2006). The price of low-carbon ferrochromium peaked at $1.10, not quite as high as the $1.17 as in 2004, and then dropped to about $0.90 per pound. Decreasing production of stainless steel in the second half of 2005 was cited as the major cause of ferrochromium price decrease—reduced stainless steel production resulted in reduced demand for ferrochromium, which resulted in a reduced price for ferrochromium. Elimination of ferrochromium production cutbacks and additional production capacity starting up contributed to the price decrease. The cost of ferrochromium was forecast to rise based on increasing costs in South Africa (resulting from factors of production, such as labor, transportation, and electrical energy; currency exchange rates; and compliance with environmental regulations), the major producer of high-carbon ferrochromium.

The average South African rand exchange rate, a significant factor in the price of chromite ore and ferrochromium, declined to R6.4 per U.S. dollar in 2005 from R10.5 per U.S. dollar in 2002 (Pacific Exchange Rate Service, 2006§).

Foreign Trade

The U.S. International Trade Commission determined that degassed chromium metal from Japan was dumped on the U.S. market. An antidumping duty of 129.32% was to be imposed in 2006 (U.S. Department of Commerce, International Trade Administration, 2005).

World Industry Structure

The chromium industry comprises chromite ore, chromium chemicals and metal, ferrochromium, stainless steel, and chromite refractory producers. Several trends are taking place simultaneously in this industry. The industry has eliminated excess chromium chemical production capacity, concentrating on production growth in surviving plants. Chromite refractory use has been declining; however, foundry use has been growing slowly. The amount of chromite ore from independent producers is declining, while that from vertically integrated producers is increasing. In other words, chromite ore mines tend now to be owned and operated by ferrochromium or chromium chemical producers. This trend is associated with the migration of ferrochromium production capacity from stainless-steel-producing countries to chromite-ore-producing countries, a trend that is nearly complete. While ferrochromium production capacity was rationalized in historically producing countries, which usually have been stainless-steel-producing countries, new furnaces or plants were constructed in chromite-ore-producing areas. The electrical power and production capacities of submerged- electric arc furnaces (EAF) used to produce ferrochromium have been increasing. Furnaces built recently have an electrical capacity in the tens of megavoltamperes. When ferrochromium plants were first built, furnaces rated in the low kilovoltampere range were common.

Production process improvements, such as agglomeration of chromite ore, preheating and prereduction of furnace feed, and closed-furnace technology, have been retrofitted at major producer plants and are being incorporated in newly constructed plants. Since the introduction of post-melting refining processes in the steel industry after 1960, there has been a shift in production to high-carbon ferrochromium from low-carbon ferrochromium. After years of ferrochromium production, slag stockpiles have built up. Recently developed processes efficiently recover ferrochromium from that slag, and processes have been or are being installed at heritage plant sites. In South Africa, the major chromite-ore- and ferrochromium-producing country, two trends are emerging—ferrochromium plants are being developed in the western belt of the Bushveld Complex, and ferrochromium production processes are being designed to accommodate chromite ore byproduct recovery from platinum operations.

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, based on the physical equipment of the plant and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that can be brought into production within a short period of time with minimum capital expenditure.

Because not all countries or producers make information about production capacity available, historical chromium trade data have been used to estimate production capacity. Reported production capacity changes result from both facility changes and knowledge about facilities. New information about a facility may result in the reevaluation of production capacity for that facility. Production capacities have been rated for the chromite ore, chromium chemical, chromium metal, ferrochromium, and stainless steel industries (table 7).

Production.—World chromite ore production in 2005 was about 19.1 Mt, of which about 93.4% was produced for the metallurgical industry; 3.1%, for the chemical industry; 2.8%, for the foundry industry; and 0.7%, for the refractory industry (International Chromium Development Association, 2006, p. 1).

Stainless Steel.—In 2005, world stainless steel production was 24.330 Mt, a decrease of 1.0% compared with that of 2004 (International Stainless Steel Forum, 2006§).

Nippon Steel and Sumikin Stainless Steel Corp. (NSSC) was the leading stainless steel producer in Japan with annual production capacity of 1.1 million metric tons per year (Mt/yr) distributed among its Hikari, Kashima, and Yawata plants (Omura, 2006). NSSC at Yawata produced raw low-interstitial ferritic grades of stainless steel that had formability and corrosion resistance properties between those of conventional ferritic grades and austenitic grades. The chromium content of interstitial ferritic grades ranged from 17% to 30%. This material was used in building materials, electric appliances, electric water heaters, kitchen utensils, molding, roofing, and water tanks. Omura also described the attributes and applications of various grades of ferritic stainless steel.

Molybdenum is used along with nickel and chromium to achieve corrosion resistance and toughness in stainless steel needed for chemical transportation, commercial kitchen, industrial process, and outdoor objects (such as sculptures, furniture, and signage). Molybdenum and chromium are also used in nickel-base alloys for stationary and jet engine turbines. World molybdenum production in 2004 was 180,000 t, 86% of which was consumed in metallurgical applications—23% to 33% for stainless steel and the balance in other metallurgical uses (Kinsman, 2006). This use of molybdenum in stainless steel assumed that 0% to 30% of molybdenum supply for stainless steel comes from scrap material feed. Stainless steel typically contains 2% molybdenum.

Stainless Steel Scrap.—The price of nickel in 2005 reached a historically high value, partly because of speculative investment. Nickel-containing stainless steel scrap availability increased in response to increasing nickel price until mid-2005 when stainless steel producers perceived a production slow down and stainless steel scrap suppliers used up their inventories. As a result, stainless steel scrap supply declined in the latter half of 2005 to 83% of that of the first half (Terörde, 2006). The trend in stainless steel scrap availability typically follows that of nickel price. The external austenitic scrap ratio—the consumption of external austenitic stainless steel scrap relative to production—ranged from 42% to 49% and averaged 44% compared with about 36% in 2001. External austenitic scrap ratios varied among regions between 2003 and 2005, as follows: United States, 61% to 69%; Europe, 36% to 46%; Japan, 33% to 40%; and the rest of Asia, 34% to 54%. World stainless steel production in 2005 was estimated to be 24.5 Mt, of which 15.4 Mt was austenitic, 6.4 Mt was ferritic, and 2.7 Mt was low-nickel, chromium-manganese stainless steel. Internal stainless steel scrap accounted for 3.2 Mt, and external, 7.1 Mt, leaving 14.2 Mt of stainless steel for which primary chromium units were required—equivalent to about 4.5 Mt of ferrochromium. From 2003 through 2005, secondary chromium units have accounted for 27% to 28% of chromium supply for stainless steel production.

Chromium Metal.—Major chromium metal producers included Russia and the United States (by the electrolytic process) and China, France, Russia, and the United Kingdom (by the aluminothermic process).

World chromium metal consumption reached 35,000 t (31,500 t aluminothermic and 3,500 t electrolytic) in 2005 (Lofthouse, 2006). Western world consumption ranged from 20,000 to 22,000 t between 1997 and 2001. The increasing consumption of chromium metal was attributed to strong superalloy demand for aerospace and oil exploration applications. Chromium metal was supplied by Europe (33.7%), Russia (31.4%), China (24.6%), and others (10.3%) in 2005, while it was used by North America (38.6%), Europe (31.4%), Far East (17.2%), China (7.1%), Russia (4.3%), and other (1.4%). Superalloys used in aerospace, automotive, electrical, oil and gas, petrochemical, pollution control, power generation, and process chemical applications accounted for most chromium metal demand.

World chromium metal consumption in 2005 was about 28,000 t compared with 24,000 t in 2004 and 23,000 t in 2003. Chromic oxide supply was identified as a potential constraint on chromium metal production (TEX Report, 2005c).

World Review

Albania.—Darfo S.p.A (Italy) produced chromite ore and ferrochromium. Darfo planned to double ferrochromium production capacity by 2008 (Metal-Pages, 2005a§).

Australia.—Pilbara Chromite Pty. Ltd. (a subsidiary of Consolidated Minerals Limited) produced 241,756 t of chromite ore in financial year 2005 (July 1, 2004, through June 30, 2005) compared with 243,221 t in 2004. Pilbara's chromite ore grade was 42% chromic oxide (Cr_2O_3); production capacity was 250,000 t/yr (Consolidated Minerals Limited, 2005§).

Brazil.—In 2004, Brazil produced 593,476 t of chromite ore (42.6% Cr_2O_3), exported 37,341 t of chromite ore (16,057 t of Cr_2O_3 content), and imported 44,763 t (20,143 t of Cr_2O_3 content). Brazil produced from a chromite ore reserve containing about 7.624 Mt Cr_2O_3-content. In 2004, Brazil produced 216,277 t of chromium ferroalloys, imported 13,480 t of ferrochromium, and exported 659 t (Gonçalves, 2006). Based on production of chromite ore and trade of chromite ore and chromium ferroalloys data reported above, Brazilian chromium apparent consumption in 2004 was 325,000 t. Expansion of Brazilian stainless steel production capacity was expected to increase domestic demand for domestically produced ferrochromium.

China.—Based on reported chromite ore production and trade of chromite ore and chromium ferroalloys and metal data (TEX

Report, 2006a, b, e), China's chromium apparent consumption in 2005 was 1.03 Mt, more than double that of 2003. China applied an export tax rebate, a domestic value added tax, and an export duty to chromium materials. On chromium, the export tax rebate was 13%, and the domestic value added tax was 17%. On ferrochromium, the export tax rebate was zero, the domestic value added tax was 17%, and the export duty tax was 5%.

China's demand for chromium ferroalloys increased along with its increasing production of stainless steel. China produced about 3.20 Mt of stainless steel in 2005 compared with 2.80 Mt in 2004. The increase in chromite ore imports and decrease in ferrochromium imports means that the increased demand for ferrochromium was met from domestic production, which posed problems for China because ferrochromium production is energy intensive, and China experienced shortfalls in energy supply. Many heritage ferroalloy plants were small, less energy efficient facilities than larger, more modern plants, and not as environmentally friendly as modern plants could be. To address these problems, the National Development and Reform Commission reviewed China's ferroalloy producing plants in the following five areas: technology and equipment, environmental protection, power consumption, resource consumption, and safety facilities (TEX Report, 2006m, n).

The Eurasian Industrial Association (Kazakhstan) planned to acquire Asmare Iron and Steel (a ferrochromium-silicon producer in Kuytun) located about 400 km from Kazakhstan. Asmare operated two 12,500 kilovoltampere furnaces (Metal-Pages, 2005b§).

China's stainless steel production was projected to grow to about 4.4 Mt in 2007 from 2.3 Mt in 2002, and ferrochromium production was projected to grow to 700,000 t in 2005 from 330,000 t in 2002, resulting in China's potential demand for chromite ore growing to 2.025 Mt from 1.14 Mt. China is the leading ferrochromium demand growth market, and Chinese ferrochromium production capacity will grow to meet Chinese demand as long as the price of chromite ore is sufficiently low. Kazakhstan's proximity to China gives providers an advantage, spuring interest in supplying China's chromium demand (Mirakhmedov, 2006).

China's stainless steel consumption rose to about 5.2 Mt in 2005 from 325,000 t in 1991, an average annual growth rate of 22%. During the same time period, stainless steel production rose to about 3 Mt from 260,000 t, an average annual growth rate of 19%. Among the issues facing China's stainless steel industry are rapid production capacity growth, excessive investment, inconsistent product quality, and the production of nonstandard 200 series products (International Stainless Steel Forum, 2005). It was estimated that, by 2010, China's stainless steel production capacity will exceed 16.3 Mt/yr and consumption will be 8 to 10 Mt/yr, at which time China will account for 45% of world stainless steel production and 30% of world consumption. China was expected to promote the use of ferritic grades owing to the high price of nickel (Wang, 2006).

Finland.—Outokumpu Oyj produced 572,000 t of marketable chromite ore from 1.1 Mt of run-of-mine ore and 235,000 t of ferrochromium in 2005 compared with 580,000 t of chromite ore from 1.2 Mt of run-of-mine ore and 264,000 t of ferrochromium in 2004. Outokumpu reported 2004 chromite ore proved reserves of 41 Mt grading 25% Cr_2O_3, indicated resources of 13 Mt grading 29% Cr_2O_3; and inferred resources of 73 Mt grading 29% Cr_2O_3. Outokumpu reported 1.65 Mt/yr stainless steel melting capacity at its Tornio Works (Outokumpu Oyj, 2006§).

Outokumpu studied the ferrochromium production process at its operation to improve sustainability by accounting for the increased cost and reduced quality of raw materials, increased energy cost, stricter environmental regulations, and demand for better working conditions (Daavittila, Honkaniemi, and Jokinen, 2004). Outokumpu found that the cost distribution of ferrochromium production in Europe was chromite ore, 30%; electricity, 30%; reducing agent, 20%; and other, 20%. Natural laws set the minimum amounts of chromite ore, reducing agent, and energy required to produce ferrochromium; however, real process inefficiencies resulted in material and energy use above these minima. Changes in production technology have improved production efficiency and profitability of ferrochromium operations. In particular, the historical movement from using lumpy ore to pelletized ore feed, from open to semiclosed to closed furnaces, from lower power to high-power furnaces, and the introduction of air and water cleaning processes has improved sustainability. Outokumpu identified the availability of furnace and other production equipment as the major profitability issue facing the ferrochromium industry, especially for larger furnaces. In addition, profitability can be improved by increased use of lower cost raw materials, increased furnace size, more efficient energy use and recovery, greater automation, and stricter environmental control.

The 21 European stainless steel producers operating in 1976 consolidated to 4 producers in 2001; the world stainless steel compound annual demand growth rate was 5.5% from 1980 through 2002; and Outokumpu was Europe's third ranked stainless steel producer (as measured by slab capacity) (Kaitue, 2005).

France.—Arcelor S.A. (a multinational company) reported 1.741 Mt of raw stainless steel production in 2005 compared with 2.453 Mt in 2004 (Arcelor S.A., 2006§). Arcelor's crude stainless steel production grew at more than 5% per year from 1978 through 2004; austenitic grades were more popular than ferritic grades. The popularity of grades may be changing owing to the increased cost of austenitic grades that result from the increased nickel and molybdenum prices (cost) (Charles, 2005).

India.—In fiscal year 2004-05 (April 1, 2004, through March 31, 2005), 20 mines collectively produced 3,639,848 t of chromite ore compared with 2,904,809 t of chromite ore in 2003-04 from a chromite ore recoverable reserve of 97.076 Mt (Indian Bureau of Mines, 2006§). Chromite ore exports were 745,119 t in 2004-05 compared with 1,116,401 t in 2003-04. Imports were 62,467 t in 2002-03 compared with 66,138 t in FY 2001-02. Ferrochromium production was reported to be 380,528 t in 2002-03 compared with 302,109 t in 2001-02. Exports were 62,467 t in 2002-03 compared with 66,138 t in 2001-02, and imports were 11,868 t in 2002-03 compared with 7,339 t in 2001-02 (Indian Bureau of Mines, 2005, p. 467, 482, 485). Based on this information, Indian apparent chromium consumption was 871,000 t in 2004-05 compared with 538,000 t in 2003-04 and 618,000 t in 2002-03.

Indian chromium ferroalloy production was 396,700 t in 2002-03, 302,100 t in 2001-02, 381,900 t in 2000-01, 313,800 t in 1999-2000, and 305,300 t in 1998-99 (Roy and Kumar, 2004). Capacity utilization was estimated to be 80% in 2004. Exports were 91,000 t in 2002-03, 101,000 t in 2001-02, 171,000 t in 2000-01, 161,000 t in 1999-2000, and 158,000 t in 1998-99.

Jindal Stainless Ltd., a stainless steel and ferrochromium producer, expanded its annual stainless steel and ferrochromium production capacity. Jindal produced ferrochromium at Vizag and developed a greenfield operation in Orissa State to produce ferrochromium and stainless steel. The Vizag plant had a high-carbon ferrochromium production capacity of 40,000 t/yr. The Orissa plant started the operation with an annual ferrochromium production capacity of 80,000 t/yr and planned to start a second 80,000-t/yr furnace in 2006. A 500-megawatt (MW) captive powerplant was to be installed that could accommodate high-carbon ferrochromium production of 250,000 t/yr and stainless steel production of 1.6 Mt/yr (Jindal Stainless, 2006§).

IMFA Group [comprising Indian Charge Chrome Ltd. (ICCL), an export-oriented producer, and Indian Metals and Ferro Alloys Ltd. (IMFA), a domestic-oriented producer] is integrated from chromite ore mining through ferrochromium production, including thermoelectric power generation. IMFA completed installation of a 27-megavoltampere (MVA) furnace with ferrochromium production capacity of 35,000 t/yr at its Choudwar, Orissa, plant at a cost of about $11 million, bringing its installed electrical capacity to 157 MVA. IMFA planned to add a 27-MVA and a 48-MVA furnace and a 120-MW powerplant at Choudwar. IMFA Group reported fiscal year 2004-05 chromite ore production to be 252,189 t, and ferrochromium production, 105,211 t compared with 77,746 t in 2003-04. ICCL planned to open captive chromite mines in Mahagiri, Orissa, upon receipt of environmental permits (Metal-Pages, 2005g§; IMFA Group, 2006§).

Electrical power availability and coal as a reducing agent limited ferrochromium production. Indian ferrochromium production power consumption was 3,800 kilowatthours per metric ton, which accounted for 45% of total production cost. Labor productivity was about one-half that of a South African plant and one-fifth that of a Finish one. Raw material transportation and power and reductant costs, small plant size, and production automation were reported to be challenges to the Indian production increasing to meet growing demand in China and India (Roy and Kumar, 2004).

Iran.—Iran's Ministry of Industry and Mines completed the conversion of a ferrosilicon smelter at Sabzevar, Korasan-e Razavi Province to ferrochromium production. The Sabzevar smelter had a 20-MVA furnace with high-carbon ferrochromium production capacity of 20,000 t/yr and planned to use about 78,000 t/yr of locally mined chromite ore from Neishabur and Sabzevar (Pyromet Technologies (Pty.) Ltd., 2005§).

Japan.—In 2005, Japan imported 954,383 t of high-carbon and 65,133 t of low-carbon ferrochromium; 108,074 t of stainless steel scrap;103,778 t of chromite ore; 4,965 t of chromium metal; and 2,160 t of ferrochromium silicon. Japan produced 3,584,879 t of stainless and heat-resisting steel (TEX Report, 2006c, d, f-k, o, q). Based on available data reported above, Japanese chromium apparent consumption was 599,000 t in 2005.

Kazakhstan.—Kazchrome reported chromite ore production of 3.566 Mt in 2005 compared with 3.26 Mt in 2004, and high-carbon ferrochromium production of about 835,000 t in 2005 compared with 780,000 t in 2004. In addition to high-carbon ferrochromium production, Kazchrome produced 40,000 t of medium-carbon and 30,000 t of low-carbon ferrochromium, 42,000 t of ferrochromium-silicon, and 1,200 t of chromium metal in 2004. Chromite ore was produced at Donskoy Mine, Aqtobe Oblysy; ferrochromium at Aksu, Pavlodar Oblysy, and Aktobe, Aqtobe Oblysy, and chromium metal at Aktobe. Kazchrome completed construction of a pelletizing plant based on Outkumpu technology. The pelletizing plant was expected to start in 2006 with a production capacity of 700,000 t/yr (Sittard, 2005; TEX Report, 2005d; Metal-Pages, 2005f§; Ryan's Notes, 2006b).

Oriel Resources plc (United Kingdom) planned to develop the Voskhod chromite deposit in Aqtobe Oblysy. Voskhod had 18.7 Mt of indicated chromite ore resources grading 46.2% Cr_2O_3. The deposit was discovered in 1963 in the Kemirsayskiy Massif, located about 3 kilometers (km) south of Donskoy GOK, 100 km east of the city of Aktobe, and 30 km east of the city of Khromtau. The deposit comprises one large lens of massive to disseminated chromite at a depth of 98 to 440 meters (m). A preliminary assessment called for underground mining by the sublevel caving method to produce about 700,000 t/yr at an average grade of 43.7% Cr_2O_3 for about 25 years. The plant would include crushing, milling, dense media separation, and gravity concentration to produce 322,000 t/yr of lumpy ore at 49% Cr_2O_3 and 189,000 t/yr of concentrate at 55% Cr_2O_3. Construction was planned to start in 2006; production, in 2007 (Oriel Resources plc, 2005§).

Korea, Republic of.—Korea imported 511,769 t of ferrochromium (476,248 t of high-carbon and 35,521 t of low-carbon) in 2005. Changwon Specialty Steel Co., Ltd. started construction of a 30-t argon-oxygen-decarburization furnace. Once installed, Changwon's stainless steel production capacity would be about 275,000 t/yr. Based on the ferrochromium data reported above, Korean chromium apparent consumption was 285,000 t in 2005(TEX Report, 2006l).

Kosovo.—The Kosovo Trust Agency sought foreign investment in chromite ore mining.

Madagascar.—Pan African Mining Corp. started exploration of chromite deposits around the Zafindravoay chrome property where the Government mined chromite until 1987 (Olian, 2005§).

Pakistan.—Pakistan produced chromite ore, which it planned to trade with China. Al Abbas Industries built a ferroalloy plant at Dhabeji Industrial Park, and planned to produce ferrochromium (Metal-Pages, 2005c§).

Russia.—Russia exported 419,469 t of ferrochromium in 2005 (243,005 t of high-carbon, 176,465 t of low-carbon) compared with 271,471 t in 2004 (109,840 t of high-carbon, 161,631 t of low-carbon) (TEX Report, 2006p).

Chelyabinsk Electro Metallurgical Combine (ChEMK) in Kemerovo Oblast operated the Kongor Chrome Mine and the JSC Kuznetskie Ferrosplavy. Kongor Chrome Mine, near the settlement of Kharp in Yamalo-Nenetskiy Autonomous Region, is part of the Tsentralnoye chromite deposit in the Rayiz Mountain range north of the Arctic Circle. The mine has 6 Mt of reserves and 100 Mt of resources. Kongor produced 800,000 t grading 40% Cr_2O_3 in 2005 and planned to produce 1.4 Mt in 2006 and 1.5 Mt in 2007. ChEMK was constructing a concentrator near the mine. ChEMK produced 275,000 t of high-carbon ferrochromium and 130,000 t of medium carbon ferrochromium at Chelyabinsk Electrometallurgical Combine in Chelyabinsk, Chelyabinsk Oblast, and at JSC Kuznetskie Ferrosplavy in Novokuznetsk, Kemerovo Oblast. With the development of its Konor Mine, ChEMK planned to shift ferrochromium production to Kuznetskie, which had the capacity to produce 450,000 t/yr of high-carbon ferrochromium and 135,000 t/yr of low-carbon ferrochromium (Lundman, 2006).

Russian Chrome 1915 (formerly Khrompik Company) in Ekaterinburg, Sverdlovsk Oblast, was Russia's leading chromium chemical producer, having a production capacity of about 30,000 t/yr of chromium chemicals. Company ownership was split equally between Kermas Group (United Kingdom) and Luigi Stoppani Company (Italy). Kermas planned to sell its share to Klyuchevsky Ferroalloy Plant. Russian Chrome provided about 4,800 t/yr of chromium oxide to Klyuchevsk (Kommersant Daily, 2006§).

Kluchevsky Ferroalloy Plant in Sverdlovsk Oblast produced chromium ferroalloys and aluminothermic chromium metal. Kluchevsky produced 9,188 t of chromium metal in 2004 from a capacity of 9,800 t/yr (Metal-Pages, 2005e§).

Serov Ferroalloy Plant produced between 40,000 and 50,000 t of low-carbon ferrochromium in 2004 from a capacity of 70,000 t/yr. Kermas Group (the majority owner of Serov) planned to sell its share to International Mineral Resources (Metal-Pages, 2006c§).

SZFK-Northwest Ferroalloys Company (owned about one-third by IST and two-thirds by IPH Polychrom Holding B.V.) planned to complete a ferrochromium plant at Tikhvin, Leningrad Region, about 200 km from St. Petersburg. The plant's production capacity was planned to be 140,000 t/yr, comprising four 16.5-MVA furnaces. Construction of the plant was expected to be completed in 2006 at a cost about $97.2 million. SZFK planned to first smelt imported chromite ore and then to switch over to chromite ore mined by the company's subsidiary Karelmet Joint Stock Company, which planned to develop the Agonozerskoye chromite deposit in Karelia Region (Metal-Pages, 2006b§).

The Republic of Bashkortostan put the 20-year rights to the Apshakskaya and Klyuchevskaya chromite ore properties up for auction at a starting price of about $7,000 each. Apshakskaya had resources of 10,500 t; Klyuchevskaya had reserves of 35,000 t (Metal-Pages, 2006a§).

South Africa.—The ferrochromium industry has been growing at about 5% per year, which is equivalent to production from two to three new furnaces per year. National issues currently facing the South African chromium industry include environmental concerns over chromium emissions and dust generation and adequacy of electrical power supply, transportation facilities, and shipping facilities. Black empowerment legislation requires 26% ownership by formerly underrepresented groups by 2014. Black empowerment and the sale of Samancor's Chrome Division resulted in ownership realignments among chromite ore and ferrochromium producers, while anticipated demand increases resulted in new chromite ore mines, ferrochromium furnace renovations, and new furnaces that increased production capacity and decreased pollution.

The South African ferrochromium industry is critically dependent on the South African electrical power generating authority (Eskom), the transportation authority (Transnet), and the port authority (National Ports Authority of South Africa) to provide the infrastructure necessary to produce, process, and export chromite ore and ferrochromium. Eskom provides most of South Africa's electricity from coal-fired powerplants. Since 1994, Eskom has connected 3.2 million homes to the national power grid. Eskom reported that it is embarking on a 5-year, R93 billion program to increase electrical power generation capacity. During the next 20 years, Eskom planned to reopen powerplants mothballed in the 1980s, to develop hydropower and liquid natural gas, to improve efficiency in generation and use, and to enter into partnerships (Visagie, 2006). The National Ports Authority reported that Durban (handling 24% of cargo), Richards Bay (50%), and Saldanha (19%) were South Africa's major ports. The National Ports Authority planned to complete constructing the Port of Ngqura by 2020 to accommodate very large, container-carrying vessels and to add bulk cargo capacity later. The National Ports Authority has moved its national development plan forward by 10 years to meet demand for its services (Jones, 2006).

In 2004, South Africa produced 7.645 Mt of chromite ore from which it produced 2.965 Mt of chromium ferroalloys and exported 0.513 Mt of chromite ore and 2.617 Mt of ferrochromium (Kweyama, 2005). Based on available data reported above, South African chromium apparent consumption was 708,000 t in 2004. Since 1994, chromite ore export sales as a fraction of production have decreased to less than one-tenth from about one-fourth, while chromite ore production has more than doubled.

Chrome Corporation (Australia) took over the Ruighoek Mine formerly owned by Batlhako Mining Limited. The mine is located in the North-West Province west of Sun City; chromite ore was last produced in 1993 from the LG6 seam. The company planned to produce 300,000 t/yr of chromite ore from the LG6 seam equally divided between surface and underground operations from an indicated resource of 5 Mt and inferred resource of 23 Mt (Creamer, 2005).

Samancor Chrome (owned 60% by BHP Billiton and 40% by Anglo American plc) operated chromite ore mines and ferrochromium smelters until midyear, when it was purchased by Kermas Group (United Kingdom) for $469 million. Kermas is a vertically and horizontally integrated chromium materials producer. Kermas also owned Serov and Chrome 1915 in Russia, Elektrowerk Weisweiler GmbH (EWW) in Germany, and chromite ore mines in Turkey. EWW and Serov produced low-carbon ferrochromium. Samancor comprised five business units—Eastern Chrome Mines and Western Chrome Mines, producing chromite ore, and Ferrometals, Middleburg

Ferrochrome, and Tubatse, producing ferrochromium. Samancor renovated the Eastern Chrome Mines, significantly extending their operating life (Konchar, 2005; Lanham, 2005).

International Ferrometals Ltd. (IFM), an Australian company formerly known as Transvaal Ferroalloys, raised one-half of the R2.12 billion it needed to develop the Buffelsfontein chromite deposit and construct a ferrochromium plant. Buffelsfontein had 28.6 Mt of chromite ore reserves grading 36.6% Cr_2O_3 and inferred resources of 29.6 Mt at the same grade (Ryan's Notes, 2005b; Metal-Pages, 2005d§). IFM gained access to the Sky deposit from Purity Metals Holdings. The Sky deposit held 28.4 Mt of chromite ore reserves grading 36.6% Cr_2O_3 and 29.6 Mt of inferred reserves at the same grade (Ryan's Notes, 2005c). IFM planned to produce 267,400 t/yr of ferrochromium from chromite ore from the MG1 and MG2 seams of the Bushveld Complex in North-West Province. The operation would include a mine, a pelletizing plant (400,000 t/yr capacity), and two 66-MVA furnaces, with the potential to add two more furnaces. IMF contracted Pyromet to build the plant; ferrochromium production was expected to start in 2007 (Cromberge, 2005).

ASA Metals (Pty.) Ltd. produced chromite ore and ferrochromium at Burgersfort, North-West Province. ASA operated two EAF and a pelletizing plant with pellet production capacity of 500,000 t/yr and ferrochromium production capacity of 240,000 t/yr. ASA planned to add two more furnaces and a pelletizing plant at a cost of R1.5 billion that would double annual ferrochromium production capacity. ASA also planned to add 800,000 t/yr of chromite ore production capacity near to its Dilokong Mine, raising its annual chromite ore production capacity to 1.15 Mt/yr (Ryan's Notes, 2005a; TEX Report, 2005a).

Columbus Stainless Steel (Pty.) Ltd. produced stainless steel in Middelburg, Mpumalanga Province. Melt shop production was about 718,094 t in 2004 compared with 643,000 t in 2003, 550,000 t in 2002, and 516,000 t in 2001 (Acerinox, S.A., 2005§).

Feralloys Limited (owned by Assmang Ltd.) produced chromite ore at the Dwarsrivier Mine and ferrochromium at the Machadodorp plant. Feralloys' ferrochromium production capacity was 300,000 t/yr from four furnaces. The Dwarsrivier Mine had a production capacity of 600,000 t/yr, and the company planned to increase capacity to 1 Mt/yr. Dwarsrivier started underground mining. Feralloys started testing chromite ore from the Lionore Mine, where nickel and chromite ore were produced (TEX Report, 2005b).

Tata Iron and Steel Co., Ltd. (India) announced plans to build a ferrochromium plant at Richards Bay, Kwazulu-Natal Province, a port city removed from South Africa's chromite mines. Tata is a major chromite ore and ferrochromium producer in India. Initial production capacity at the plant was planned to be 120,000 t/yr at a cost of R600 million and with the potential to double. Construction was expected to begin in 2006 with startup in 2008 (Creamer, 2005§).

Hernic (Pty.) Ltd. produced chromite ore and ferrochromium at Brits, North-West Province. Hernic contracted Outokumpu to install a 75-MVA closed furnace with equipment to pelletize, sinter, and preheat furnace feed. The new furnace, the fourth at the plant, started operation in 2005 and was expected to operate at the full production rate of about 160,000 t/yr in 2006, consuming 66 to 67 MW. Hernic planned to reconstruct its old open furnaces as semiclosed furnaces near the Bokontein deposit, about 10 km from the current plant (Mitsubishi Corporation, 2005§).

Xstrata S.A. (Pty.) Ltd. reported operating 5 chromite ore mines and 18 ferrochromium furnaces. Xstrata produced 3.604 Mt of chromite ore in 2005, about 72% of capacity, compared with 4.220 Mt in 2004. In 2005, Xstrata's chromite ore production by mine was as follows: Kroondal, 1.863 Mt; Thorncliffe, 1.210 Mt; Waterval, 445,000 t; Horizon, 52,000 t; and Boshoek, 34,000 t. In 2004, Xstrata's chromite ore production by mine was as follows: Kroondal, 2.134 Mt; Thorncliffe, 1.274 Mt; Waterval, 405,000 t; Boshoek, 253,000 t; Horizon, 131,000 t; and Chrome Eden, 23,000 t. Xstrata reported ferrochromium production of 1.290 Mt in 2005, about 80% of capacity, compared with 1.489 Mt in 2004. In 2005, Xstrata's ferrochromium production by plant was as follows: Rustenburg, 383,000 t; Lydenburg, 374,000 t; Wonderkop, 333,000 t; Bosheok, 196,000 t; and Gemni plant, 4,000 t. In 2004, Xstrata's ferrochromium production by plant was as follows: Lydenburg, 393,000 t; Rustenburg, 393,000 t; Wonderkop, 311,000 t; Bosheok, 218,000 t; and Gemni plant, 173,000 t.

Xstrata announced plans to start construction on a new smelter with production capacity of 336,000 t/yr from two 63-MVA furnaces at a cost of $270 million; production would begin in 2007. The new plant would use Premus technology developed by Xstrata at its Lydenburg plant.

Merafe Resources Limited, joint-venture partner of Xstrata at the Boshoek plant, purchased Samancor's share of the Wonderkop plant, which Samancor held in joint-venture partnership with Xstrata. The purchase made Merafe and Xstrata joint-venture partners in two ferrochromium plants, Bosheok and Wonderkop. Merafe and Xstrata purchased chromite ore resources from Samancor in the Krondal and Marikana mining areas. The resources were near Xstrata's existing Waterval and Kroondal Mines. Xstrata and Merafe planned to build a 1.2-Mt/yr agglomeration plant, comprising two production lines using Outokumpu technology, at a cost of $125 million for sintering and pelletizing chromite ore feed for the Wonderkop and Rustenburg operations. Xstrata entered a joint-venture agreement with Anglo American Platinum Corp. Ltd., on the Mototolo project in which byproduct chromite tailings from the Bushveld UG2 seam would be agglomerated at Wonderkop plant. Xstrata had a production capacity of 1.6 Mt/yr of chromite ore from reserves of 51 Mt (Xstrata Plc., 2005§).

Sudan.—Sudan reported chromite ore resources at the Ignessa Hills area in Blue Nile State, the Qala En Nahal area, the Eastern Naba Mountains, the Red Sea Hills region, the Jebel Rahib area in Darfur State, and other areas in northern and southern Sudan. All of these deposits lay in the Ingessana massif, which is the central part of the Ingessana-Kurmuk ophiolite belt (Ministry of Energy and Mining, The Geological Research Authority of the Sudan, 1999§).

Taiwan.—Taiwan imported 255,869 t of ferrochromium (239,877 t of high-carbon and 15,992 t of low-carbon) (TEX Report, 2006r). Based on available data reported above, chromium apparent consumption was 142,000 t in 2005.

Turkey.—Etibank A.Ş. brought one furnace back into production at its Elazig smelter. The furnace had an electrical power rating of 17 MVA and high-carbon ferrochromium production capacity of 25,000 t/yr. A second furnace was to be brought back into production in 2006, and two more 30-MVA furnaces were being planned (Ryan's Notes, 2006a).

United Kingdom.—Elementis plc produced sodium dichromate at Eaglescliff, Stockton-on-Tees, England, and Castle Haynes, NC. Elementis planned to close one of its two sodium-dichromate-producing kilns at its Eaglescliff plant, thereby reducing chromium chemical production capacity in England by one-half to 50,000 t/yr. The company planned to stop producing chromium sulfate and chromic acid and focus on chromic oxide and sodium dichromate from which the chromic oxide is made. Eaglescliff is a supplier of chromic oxide for chromium metal production; about 1.6 t of chromic oxide is required to produce 1 t of chromium metal (Elementis plc, 2005§).

London & Scandinavian Metallurgical Co. (LSM) produced chromium metal by the aluminothermic process. LSM reported that chromium metal demand was strong owing to recovery in the aerospace industry (Metal Bulletin, 2006).

Since the 1980s, average world annual stainless steel production growth has been 5% to 6% and has most recently been driven by increasing demand from China. The recent use of stainless steel by end-use market in the United Kingdom was process industries, 23%; domestic and household, 17%; general engineering, 17%; construction, 16%; transportation, 15%; and food processing and distribution, 12%. A similar distribution for Italy yielded chemical and petrochemical industries, 20%; foodstuffs, 20%; household appliances, 18%; catering, 12%; building, 10%; transportation, 8%; energy, 5%; pharmaceuticals, 4%; and others, 3% (British Stainless Steel Association, 2004).

Vietnam.—Vietnam produced chromite ore containing 38% to 39% Cr_2O_3, which it exported to China. The Government of Vietnam licensed Viet Nam Coal and Mineral Industrial Group to construct facilities, and exploit, process, and export chromite ore (Business Finance, 2005§).

Qian Ding Special Steel [a subsidiary of Chien Shing (Taiwan)] planned to build a 720,000-t/yr stainless steel plant in Ba Ria-Vung Tau Province at a cost of $700 million. Qian Ding planned to export 80% of its production to Taiwan (Metal Bulletin, 2005c).

Zimbabwe.—Maranatha Ferrochrome (Pvt.) Ltd., Zimbabwe Mining and Smelting Company Consolidated (Zimasco), and Zimbabwe Alloys Limited produced high-carbon ferrochromium. Benscore Investments (Private) Limited purchased Zimbabwe Alloys from Anglo American for about $10 million. Mining companies were concerned that the Government of Zimbabwe would expropriate mining operations without compensation as the Government had done in the farming sector.

Current Research and Technology

Mineral Processing and Industrial Applications.—South Africa's Council for Mineral Technology (Mintek) has been conducting Government- and commercial-sponsored research and development on chromite ore and ferrochromium. Researchers at Mintek studied platinum-group-metal recovery from chromite tailings, EAF processing of stainless steel dust, and the chromium-platinum phase diagram. Mintek demonstrated a flotation procedure at the laboratory scale that separates platinum-group metals from chromite tailings and worked on a feasibility study for the production of 20,000 ounces per year of platinum from one chromite operation. Mintek participated in Mogale Alloys (Pty.) Ltd.'s stainless steel project through the Mintek wholly owned commercial subsidiary Mindev (Pty.) Ltd. Mogale commissioned a stainless steel dust agglomeration plant and started smelting a combination of chromite ore and stainless steel dust in its 40-MVA furnace at Samancor's Palmiet Ferrochrome Plant. Mogale gets stainless steel dust from the Columbus Stainless plant, which takes back part of the Mogale's chromium-nickel-containing alloy production. Mogale's ferrochromium production capacity was about 40,000 t/yr. Mintek studied direct current (DC) arc furnace ferrochromium production using chromite ore in a fluidized bed flash preheater. Preheating the chromite feed materials resulted in a 20% energy savings. Mintek studied the metallurgical characteristics, such as creep, phase diagrams, and tensile strength, of chromium-containing platinum-base alloys (platinum-aluminum-chromium and platinum-chromium-ruthenium) that could replace nickel-base superalloys. Mintek also studied the possibility of increasing the 50-MVA DC smelting electrical capacity limit imposed by the current-carrying capacity of one electrode by developing a furnace with two independently powered cathodes (South African Council for Mineral Technology, 2004§).

Research.—Johnson (2006) studied the anthropogenic chromium materials cycle at the global, regional, and country level, accounting for 98% of chromite ore and more than 99% of stainless steel production among 9 regions containing 54 countries. These countries accounted for 94% of the global gross domestic product and 77% of the world's population. The study found that chromium flow into in-use stocks was proportional to chromium flow into use by country and region. The leading flows into use (in descending order of amount) by region were Europe, Asia, and North America. The study found that metal goods and other uses and industrial machinery dominated end uses in the leading regions and industrial waste, end-of-life vehicles, and other uses dominated discard flows. Measured in contained chromium, Africa dominated world trade, while Asia dominated finished-product trade to North America.

Technology.—Chromium is used in combustion- and steam-driven electrical-power-generating turbines. Austenitic stainless steel is used for fuel injectors; 9% to 12% chromium-containing forgeable steels are used for blades; chromium-containing nickel-base alloys (superalloys) are used in hot sections. Directionally solidified alloys used in the most demanding regions contain 5% to 15% chromium (Metal Bulletin, 2005b). Chromium is supplied for these alloys (in order of decreasing quantity of chromium units consumed for superalloy production) principally by chromium metal, high-carbon ferrochromium, and low-carbon ferrochromium.

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, the stainless steel industry performance largely determines the performance of the chromium industry in the United States and worldwide.

The trend to supply chromium in the form of ferrochromium by countries that mine chromite ore was interrupted as China became a major consumer of chromite ore; however, the trend was expected to continue eventually. The rising cost of ferrochromium sustained independent ferrochromium producers; however, other factors being equal, ferrochromium production is most cost effective when the ferrochromium plant is close to the chromite mine. With new efficient and reliable ferrochromium production facilities in chromite-ore-producing countries, ferrochromium capacity and production are expected to diminish in market-driven-economy countries that produce ferrochromium without nearby chromite ore resources. Other factors of production, such as electrical energy or labor costs can offset chromite ore transportation costs. Further vertical integration of the chromium industry is expected as chromite-ore-producing countries expand ferrochromium or stainless steel production capacity.

Chromite Ore.—Chromite ore production capacity is in balance with average consumption. 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 or mine-plant ownership. As platinum mining moves to chromite-bearing seams, a greater portion of chromite is likely to be supplied as byproduct from such operations. In addition, platinum may become a byproduct of some chromite operations.

Of chromite ore produced, 91% is used by the metallurgical industry; 95% of that is used to make stainless steel (Banerjee, 2006). The compound annual growth rate of stainless production from 1980 through 2004 was 5.62%, an annual growth rate that exceeds the annual growth rates of aluminum, copper, zinc, lead, and steel (excluding stainless). Assuming that future growth of stainless steel production is 3.5%, the scrap feed as a percent of stainless steel production is 30%, austenitic-to-ferritic ratio is 3:1, austenitic stainless steel averages 18% chromium, and ferritic stainless steel averages 12% chromium, in 2056, stainless steel production would be 100 Mt/yr, ferrochromium production would be 30 Mt/yr, and chromite ore production would be about 75 Mt/yr. At this growth rate, reserves in Finland, India, Kazakhstan, South Africa, Zimbabwe, and other countries would support 2004-56 cumulative production of 1,800 Mt of chromite ore. Many economic and physical factors will affect the distribution of production.

Platinum mining of the Merensky Reef in South Africa had reached depths that make platinum mining from the UG2 Reef economically competitive (Cramer, Basson, and Nelson, 2004). Unlike the Merensky Reef, the UG2 Reef contains chromite. UG2 ore contains 10% to 25% Cr_2O_3 with a chromium-to-iron ratio of 1.35:1. Chromite is recovered after the platinum is extracted at a grade of 40% to 42% Cr_2O_3 from platinum concentrator tailings. Ferrochromium smelters that pelletize their feed and the DC arc furnace can use this chromite. Chromite can also be recovered from the LG6 and MG1 and MG2 seams. Byproduct chromite from platinum mining operations could reach 21.7 Mt/yr in 2006 at a grade of 41% to 42% Cr_2O_3. For comparison, this would be more than double the chromite ore production from primary operations and enough to produce more than 7 Mt/yr of ferrochromium.

Chromium Chemicals.—Major producing countries where large sodium dichromate plants (production capacity in excess of 100,000 t/yr) operate included Kazakhstan, Russia, and the United States. Moderate-sized production facilities were located in China, Japan, Romania, South Africa, Turkey, and the United Kingdom. Small-scale local producers operated in China and India.

Chromated copper arsenate (CCA) had dominated wood preservation for consumer use until December 2003 when manufacturing ceased owing to the compounds arsenic content (Morgan, 2006). CCA use dropped to 24,500 t/yr in 2004 and 2005, which accounted for 11,600 t/yr of chromic acid consumed, from about 81,500 t/yr in 2002 and 2003, which accounted for 38,750 t/yr of chromic acid consumed. Acid copper chromate (ACC) is an arsenic-free, chromium-containing wood treatment that could gain market share abandoned by CCA. More than 98% of hexavalent chromium is converted to trivalent in the fixation process. ACC use has been estimated to increase to 54,000 t in 2007 from the current 38,000 t, which would require 27,000 to 39,000 t of chromic acid.

Nonmetallurgical chromite ore uses—chemical, foundry sand, and refractory—were strongly affected by metallurgical demand because the metallurgical industry can now efficiently use fine ore typically consumed in nonmetallurgical applications (King, 2005). Elementis Chromium, with plants in the United Kingdom and the United States, and Chrome International South Africa were major chromium chemical producers.

Ferrochromium.—Ferrochromium production is electrical energy intensive. Charge-grade ferrochromium requires 2,900 to 4,100 kilowatthours of electrical energy per metric ton of product, with efficiency varying by ore grade, operating conditions, and production process. Thus, ferrochromium plant location reflects a cost balance between raw materials and electrical energy supply.

The quarterly price of high-carbon ferrochromium reached $0.75 per pound the highest value since before 2000 (Bennett, 2005; Ali, 2006). The consumption trend of ferrochromium is like that of stainless steel production. An additional 2.3 Mt/yr of ferrochromium production capacity was planned for between 2005 and 2010, with an additional 1.8 Mt/yr under consideration. More than one-half of the planned capacity increases were to start in 2005 or 2006. Most of the planned capacity additions (1.1 Mt/yr) were for South Africa, followed by India (510 Mt/yr) and Kazakhstan (400 Mt/yr).

Since 1998, specific consumption of coke (tons of coke consumed per ton of ferrochromium produced) has increased to about 0.31 from about 0.27 and was expected to rise to 0.33 as closed furnace technology displaces semiclosed and open furnaces. Since 1990, world coke production had gone to about 425 Mt/yr, mostly from China, from about 360 Mt/yr, mostly from Europe. South African carbon reductant demand was projected to increase to more than 3 Mt/yr by 2010 (about one-half of which would be for ferrochromium production) from about 1.6 Mt/yr in 1998. Coke production capacity was being constructed in South Africa, where 450,000 t/yr of added capacity was to be commissioned in 2006 (Joubert, 2005).

Strong growth (1.9% to 8.3% per year between 2006 and 2010) in stainless steel production and increased ferrochromium demand that would be met by increased production in South Africa were forecast despite the increasing cost of production there (McLaughlin, 2006). From 2006 to 2010, an additional 1.85 Mt/yr of ferrochromium production capacity would be required to meet demand driven primarily by China. South African producers Xstrata and Merafe planned to meet that demand through Project Lion (a greenfield ferrochromium plant based on Premus technology that will add 1 Mt/yr of ferrochromium production capacity) and Project Bokamoso (the retrofitting of Xstrata's ferrochromium plants in the western Bushveld based on Outkumpu technology that will add 1.2 Mt/yr of agglomeration capacity). Lower specific electrical energy requirements, lower coke demand, and higher metal recovery that result from using the Premus and Outkumpu processes will offset higher production costs attributed to a stronger rand relative to the dollar and higher electrical energy and transportation costs in South Africa. The Premus process required only 2.4 megawatthours and 20% coke consumption per metric ton of ferrochromium produced, with a chromium recovery of 88%.

Stainless Steel.—Stainless steel demand was expected to grow in the long term. Short-term demand fluctuations can exceed long-term demand growth. World stainless steel production in 2005 was about the same as that of 2004; production grew in China and decreased in other geographic areas. Between 2004 and 2010, when supply and demand would be in balance in China, China's share of world stainless steel production capacity was projected to increase to 35% from 17%; however, demand was expected to grow by only 8%. That means that non-Chinese stainless steel production capacity currently being used to meet Chinese demand will become excess capacity in 2010 (Metal Bulletin, 2005a). Ferrochromium production does not limit stainless steel production because a large share of chromium in stainless steel comes from recycled stainless steel scrap. The price of those stainless steel grades that require nickel are sensitive to the nickel price.

Stainless steel production was expected to be 156 Mt in 2050, equivalent to an average annual growth rate of 4.5%, which is somewhat less that the historical growth rate of 5.9% form 1970-2005 (Pariser, 2006). As the price of nickel increases, the percentage of manganese austenitic stainless steel and ferritic stainless steel, which do not require nickel, increases at the expense of austenitic grades, which require nickel.

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TABLE 1

SALIENT CHROMIUM STATISTICS[1]

		2001	2002	2003	2004	2005
World, production, contained chromium:						
Chromite ore (mine)[2]	metric tons	3,680,000 r	4,410,000 r	4,630,000 r	5,340,000 r	5,810,000 e
Ferrochromium (smelter)[3]	do.	2,670,000	2,880,000 r	3,460,000	3,750,000 r	3,740,000 e
Stainless steel[4]	do.	3,180,000 r	3,480,000 r	3,860,000 r	4,180,000 r	4,130,000 e
U.S. supply:						
Components of U.S. supply, contained chromium:						
Domestic mines	do.	--	--	--	--	--
Secondary	do.	141,000	174,000	180,000	168,000	124,000
Imports:						
Chromite ore	do.	62,000	35,300	55,300	49,500	52,900
Chromium chemicals	do.	12,800	17,400	10,300	6,040	11,400
Chromium ferroalloys	do.	156,000	203,000	243,000	261,000	278,000
Chromium metal	do.	8,190	7,430	8,570	9,630	11,000
Stocks, January 1:						
Government	do.	825,000	706,000	643,000	560,000	466,000
Industry[6]	do.	14,400	16,700	8,390	9,870	7,900
Total	do.	1,220,000	1,160,000	1,150,000	1,060,000	951,000
Distribution of U.S. supply, contained chromium:						
Exports:						
Chromite ore	do.	20,000	7,680	32,800	14,000	13,700
Chromium chemicals	do.	13,200	10,500	9,710	14,500	18,900
Chromium ferroalloys and metal	do.	9,840	10,800	3,770	6,250	24,700
Stocks, December 31:						
Government	do.	816,000 e, 5	643,000	560,000	466,000	375,000
Industry[6]	do.	16,700	8,390	9,870	7,900 r	8,600
Total	do.	875,000	681,000	616,000	509,000 r	441,000
Production, reported:[7]						
Chromium ferroalloy and metal net production:						
Gross weight	do.	W	W	W	W	W
Chromium content	do.	W	W	W	W	W
Net shipments, contained chromium	do.	W	W	W	W	W
Consumption:						
Apparent, contained chromium	do.	344,000	479,000	532,000	555,000	511,000
Reported:						
Chromite ore and concentrates, gross weight	do.	W	W	W	W	W
Chromite ore, average Cr_2O_3	percent	45.0	45.4	45.0	45.0	45.0
Chromium ferroalloys:[8]						
Gross weight	metric tons	351,000	407,000	411,000	449,000	431,000
Contained chromium	do.	202,000	236,000	240,000	262,000	250,000
Chromium metal, gross weight	do.	5,890	5,080	5,140	5,690	7,280
Stocks, December 31, gross weight:						
Government:						
Chromite ore	do.	636,000 e, 5	339,000	235,000	135,000	73,400
Chromium ferroalloys	do.	906,000 e, 5	767,000	691,000	595,000	492,000
Chromium metal	do.	7,430 e, 5	7,220	7,120	6,670	6,190
Industry:						
Producer[9]	do.	W	W	W	W	W
Consumer:						
Chromite ore[10]	do.	W	W	W	W	W
Chromium ferroalloys[11]	do.	28,100	13,800	16,300	13,100	14,300
Chromium metal	do.	210	230	242	182	228
Prices, average annual:						
Ferrochromium, chromium content[12]	dollars per pound	$0.324	$0.317	$0.433	$0.690 r	$0.684
Standard chromium metal, gross weight[13]	do.	$4.24	NA	NA	NA	NA
Vacuum chromium metal, gross weight[13]	do.	$5.43	NA	NA	NA	NA

See footnotes at end of table.

TABLE 1—Continued

SALIENT CHROMIUM STATISTICS[1]

		2001	2002	2003	2004	2005
U.S. supply—Continued:						
Consumption—Continued:						
Prices, average annual—Continued:						
Electrolytic chromium metal, gross weight[14]	dollars per pound	$4.50	$4.50	$4.50	$4.50	$4.50
Aluminothermic chromium metal, gross weight[15]	do.	$2.08	$2.08	$1.84	$2.27	$2.72
Value of trade:[16]						
Exports, contained chromium	thousands	$89,400	$67,600	$58,400	$80,700	$116,000
Imports, contained chromium	do.	$239,000	$256,000	$322,000	$477,000	$583,000
Net exports, contained chromium[17]	do.	-$149,000	-$188,000	-$264,000	-$397,000	-$468,000
Stainless steel:						
Production:						
Gross weight[18]	metric tons	1,820,000	2,190,000	2,220,000	2,400,000	2,240,000
Contained chromium[19]	do.	296,000	369,000	373,000	407,000	373,000
Average grade, dimensionless[20]		0.1629	0.1687 r	0.1683	0.1697 r	0.1667
Shipments, gross weight[21]	metric tons	1,670,000	1,720,000	1,790,000	1,880,000	1,730,000
Exports, gross weight	do.	249,000	273,000	327,000	323,000	371,000
Imports, gross weight	do.	761,000	752,000	639,000	811,000	770,000
Scrap, gross weight:						
Receipts	do.	832,000	1,020,000	1,060,000	987,000	731,000
Consumption	do.	1,220,000	1,380,000	1,430,000	1,410,000	1,060,000
Exports	do.	438,000	342,000	505,000	478,000	585,000
Imports	do.	42,300	81,000	89,200	146,000	111,000
Value of trade:						
Exports	thousands	$752,000	$742,000	$895,000	$1,030,000	$1,340,000
Imports	do.	$1,430,000	$1,350,000	$1,320,000	$2,230,000	$2,630,000
Scrap exports	do.	$270,000	$252,000	$382,000	$548,000	$670,000
Scrap imports	do.	$24,100	$49,400	$70,200	$160,000	$124,000
Net exports[17, 22]	do.	-$433,000	-$405,000	-$115,000	-$809,000	-$744,000

[e]Estimated. [r]Revised. NA Not available. 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% chromium.

[4]Calculated assuming chromium content of stainless steel to average 17% chromium.

[5]2001 stocks were estimated based on the previous accounting system and reported sales. Stocks after 2001 are those reported by the National Defense Stockpile.

[6]Includes consumer stocks of chromium ferroalloys and metal and other chromium-containing materials.

[7]Includes chromium ferroalloys and metal and other chromium materials in the United States.

[8]Chromium ferroalloy, chromite ore, and other chromium-containing materials excluding chromium metal.

[9]Chromium ferroalloy and metal producer stocks of chromium ferroalloys and metal.

[10]Chemical, chromium ferroalloy and metal, and refractory producer stocks of chromite ore.

[11]Consumer stocks of chromium ferroalloys, chromite ore, and other chromium-containing materials excluding chromium metal.

[12]Time-weighted average U.S. price of imported high-carbon chromium that contains 50% to 55% chromium as reported in Platts Metals Week.

[13]Time-weighted average U.S. price of electrolytic chromium metal as reported in American Metal Market.

[14]Time-weighted average U.S. price of domestically produced electrolytic chromium metal as reported by Ryan's Notes.

[15]Time-weighted average U.S. price of imported aluminothermic chromium metal as reported by Ryan's Notes.

[16]Includes chromite ore and chromium ferroalloys, metal, and chemicals.

[17]Negative data indicate that imports are greater than exports.

[18]Source: American Iron and Steel Institute annual report of stainless and heat-resisting raw steel production and shipments.

[19]Estimated mass-weighted average of the mean chromium content of stainless steel production by grade. Uncertainty is approximatly ± 0.01 owing to the range of chromium chemical specification limits by stainless steel grade.

[20]Ratio of estimated mass-weighted average chromium content of stainless steel production by grade to production. Expressed as a fraction. Source: American Iron and Steel Institute quarterly reports of stainless and heat-resisting raw steel production by grade.

[21]Source: American Iron and Steel Institute annual report of stainless and heat-resisting raw steel shipments.

[22]Includes stainless steel and stainless steel scrap.

TABLE 2

U.S. REPORTED CONSUMPTION AND STOCKS OF CHROMIUM PRODUCTS[1]

(Metric tons)

	2004		2005		Change[2]	
	Gross weight	Chromium content	Gross weight	Chromium content	Quantity	Percentage
Consumption by end use:						
Alloy uses:						
Iron alloys:						
Steel:						
Carbon steel	6,510	3,920	6,460	3,870	-51	-1
High-strength low-alloy steel	7,970	4,410	9,370	5,000	1,400	18
Stainless and heat-resisting steel	375,000	219,000	355,000	205,000	-19,500	-5
Full alloy steel	20,300	12,200	20,900	12,000	652	3
Tool steel	5,920	3,580	5,360	3,250	-560	-9
Superalloys	14,000	10,700	16,200	12,600	2,140	15
Other alloys[3]	21,700	12,400	21,700	12,600	36	--
Other uses not reported above	3,320 r	2,060 r	3,400	2,240	73	2
Total	454,000	268,000	439,000	257,000	-15,900	-3
Consumption by material:						
Low-carbon ferrochromium	37,100 r	25,200 r	36,200	24,500	-926	-2
High-carbon ferrochromium	372,000	222,000	354,000	209,000	-18,000	-5
Ferrochromium silicon	35,700	13,800	35,700	13,900	24	--
Chromium metal	5,690	5,690	7,280	7,270	1,580	28
Chromite ore	2,670	840	4,010	1,280	1,340	50
Chromium-aluminum alloy	617	420	549	380	-68	-11
Other chromium materials	507	295	659	267	152	30
Total	454,000	268,000	439,000	257,000	-15,900	-3
Consumer stocks:						
Low-carbon ferrochromium	2,120 r	1,440 r	2,170	1,470	47	2
High-carbon ferrochromium	9,560	5,690	10,700	6,300	1,100	12
Ferrochromium silicon	1,190	461	1,170	456	-19	-2
Chromium metal	182	182	228	228	46	25
Chromite ore	78	25	110	35	32	41
Chromium-aluminum alloy	89	61	120	83	31	35
Other chromium materials	64	37	75	31	11	17
Total	13,300	7,900 r	14,500	8,600	1,250	9
National Defense Stockpile stocks:[4]						
Chromite ore:[5]						
Chemical[6]	46,300	13,300	3,590	1,030	-42,800	-92
Refractory[7]	88,300	21,100	69,800	16,700	-18,500	-21
Chromium ferroalloys:[8]						
High-carbon ferrochromium[9]	398,000	284,000	319,000	228,000	-78,500	-20
Low-carbon ferrochromium[9]	197,000	141,000	173,000	123,000	-24,900	-13
Chromium metal[10]	6,670	6,670	6,190	6,190	-479	-7

[r]Revised. -- Zero.

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

[2]Change based on gross weight quantity of current year compared with that of previous year.

[3]Includes cast irons, welding and alloy hard-facing rods and materials, wear- and corrosion-resistant alloys, and aluminum, copper, magnetic, nickel, and other alloys.

[4]The source for stockpile materials is the Defense Logistics Agency, Defense National Stockpile Center.

[5]Metallurgical grade chromite ore was used up in 2002.

[6]Chromium content estimated using 28.6% chromium.

[7]Chromium content estimated using 23.9% chromium.

[8]Ferrochromium silicon was used up in 2002.

[9]Chromium content estimated using 71.4% chromium.

[10]Chromium content estimated using 100% chromium.

TABLE 3

VALUE OF IMPORTS AND U.S. PRICE QUOTATIONS FOR CHROMIUM MATERIALS[1]

Material		2004 Contained chromium	2004 Gross weight	2005 Contained chromium	2005 Gross weight
Value:[2, 3]					
Chromite ore:					
Not more than 40% chromic oxide	dollars per metric ton	(4)	(4)	2,270	475
More than 40% but less than 46% chromic oxide	do.	776	239	257	81
46% or more chromic oxide	do.	349	113	476	153
Average	do.	354	114	437	140
Ferrochromium:					
Not more than 3% carbon:					
Not more than 0.5% carbon	do.	2,130	1,430	2,340	1,590
More than 0.5% but not more than 3% carbon	do.	2,150	1,440	1,890	1,230
Average (less than 0.5% but not more than 3%)	do.	2,140	1,430	2,310	1,560
More than 3% but not more than 4% carbon	do.	1,160	604	(5)	(5)
More than 4% carbon	do.	1,230	690	1,310	762
Average (all grades)	do.	1,320	754	1,430	846
Chromium metal	do.	XX	5,820	XX	8,010
Price:[6]					
High-carbon ferrochromium:[7]					
50% to 55% chromium	cents per pound	68.95	XX	68.40	XX
60% to 65% chromium	do.	68.55	XX	67.32	XX
Low-carbon ferrochromium:[7]					
0.05% carbon	do.	117	XX	118	XX
0.10% carbon	do.	103	XX	104	XX
0.15% carbon	do.	95	XX	100	XX
Chromium metal:					
Domestic, electrolytic[8]	do.	XX	450	XX	450
Imported:					
Aluminothermic[8]	do.	XX	227	XX	272
Aluminothermic[9]	do.	XX	185	XX	NA

NA Not available. XX Not applicable.

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

[2]Mass-weighted average based on customs value and weight of imported material.

[3]Reported by the U.S. Census Bureau.

[4]No imports of not more than 40% chromite ore were reported in 2004.

[5]No imports of more that 3% but not more than 4% carbon ferrochromium were reported in 2005.

[6]Time-weighted average based on prices reported by material in trade journals.

[7]Source: Platts Metals Week.

[8]Source: Ryan's Notes.

[9]Source: American Metal Market.

TABLE 4
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2004 Quantity (kilograms)	2004 Value (thousands)	2005 Quantity (kilograms)	2005 Value (thousands)	Principal destinations in 2005
2610.00.0000	Chromite ore and concentrate, gross weight	43,100,000	$10,400	42,600,000	$9,940	China (66.2%); Canada (17.1%); Mexico (10.8%); Sweden (5.4%).
	Metal and alloys, gross weight:					
8112.21.0000	Unwrought chromium powders	261,000	3,250	169,000	2,940	Canada (35.3%); Japan (23.4%); Germany (16.2%); Belgium (5.4%); Singapore (5.2%); Mexico (4.9%); Malaysia (3.1%); China (1.6%); Italy (1.2%).
8112.22.0000	Chromium metal waste and scrap	125,000	3,320	227,000	4,260	Japan (75.5%); Belgium (11.4%); Germany (5.0%); Netherlands (3.6%); Austria (2.7%); Singapore (1.8%).
8112.29.0000	Chromium metal other than unwrought powders and waste and scrap	545,000	11,000	628,000	9,680	Japan (64.5%); Singapore (6.4%); Chile (5.3%); Saudi Arabia (4.8%); Peru (3.8%); Mexico (3.2%); South Africa (2.4%); Brazil (2.1%); Taiwan (2.0%); Canada (1.3%).
	Total chromium metal	931,000	17,600	1,020,000	16,900	
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium:[3]					Netherlands (81.8%); Canada (11.1%); Mexico (5.3%); Brazil (1.3%).
	Gross weight	6,580,000	7,570	30,700,000	31,100	
	Contained weight	4,060,000	XX	20,100,000	XX	
7202.49.0000	Low-carbon ferrochromium:[4]					Netherlands (66.1%); Mexico (22.8%); Canada (7.5%).
	Gross weight	1,410,000	3,090	5,460,000	7,560	
	Contained weight	852,000	XX	3,540,000	XX	
7202.50.0000	Ferrochromium-silicon:					Canada (62.7%); Mexico (23.9%); Malaysia (13.1%).
	Gross weight	1,150,000	1,300	147,000	186	
	Contained weight	403,000	XX	51,400	XX	
	Total ferroalloys:					
	Gross weight	9,140,000	12,000	36,300,000	38,900	
	Contained weight	5,320,000	XX	23,700,000	XX	
	Chemicals, gross weight:					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	10,700,000	14,300	9,000,000	11,000	China (25.8%); Brazil (16.8%); India (14.0%); Chile (11.1%); Republic of Korea (8.7%); Taiwan (4.9%); Japan (2.6%); Mexico (2.6%); Indonesia (2.2%); Colombia (1.9%); Thailand (1.4%); Hong Kong (1.7%); Canada (1.0%).
2819.90.0000	Other	2,130,000	7,840	1,660,000	7,300	Canada (28.3%); Brazil (14.8%); United Kingdom (11.3%); Taiwan (6.0%); Mexico (5.4%); Hong Kong (3.6%); Chile (3.5%); Venezuela (3.4%); Japan (3.2%); France (3.1%); India (2.4%); Thailand (2.3%); Germany (2.0%); Australia (1.5%); Singapore (1.3%); Malaysia (1.2%); South Africa (1.2%).
2833.23.0000	Chromium sulfates	38,500	417	78,900	376	Hong Kong (26.5%); Colombia (24.7%); Canada (19.7%); Republic of Korea (9.6%); Germany (6.5%); Taiwan (5.6%); Singapore (5.4%).

See footnotes at end of table.

TABLE 4—Continued
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2004 Quantity (kilograms)	2004 Value (thousands)	2005 Quantity (kilograms)	2005 Value (thousands)	Principal destinations in 2005
	Chemicals, gross weight—Continued:					
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Zinc and lead chromate	74,500	$236	65,500	$269	Canada (67.0%); Mexico (9.3%); Trinidad and Tobago (7.5%); Jamaica (4.1%); Barbados (3.5%); El Salvador (2.1%); Guatamala (1.5%); Nicaragua (1.5%); New Zealand (1.4%).
2841.30.0000	Sodium dichromate	21,200,000	12,300	37,200,000	25,000	Japan (56.7%); Mexico (22.9%); Canada (12.6%); Peru (2.1%); Germany (1.8%); China (1.4%); Taiwan (1.0%).
2841.50.0000	Other chromates, dichromates, and peroxochromates:					
2841.50.1000	Potassium dichromate	23,400	63	127,000	285	Canada (61.4%); Brazil (30.4%); Australia (7.1%).
2841.50.9000	Other	514,000	1,740	529,000	1,650	France (24.9%); Republic of Korea (16.3%); China (14.3%); Mexico (12.4%); Canada (10.4%); Malaysia (6.2%); Hong Kong (5.6%); Portugal (2.5%); India (1.8%); Saudi Arabia (1.7%); Taiwan (1.0%).
3206.20.0000	Pigments and preparations, gross weight	671,000	3,780	767,000	4,090	Canada (42.9%); Mexico (17.9%); Colombia (5.2%); Honduras (4.5%); Philippines (3.5%); Australia (2.9%); France (2.6%); Switzerland (2.3%); Taiwan (2.3%); Thailand (1.8%); Republic of Korea (1.7%); Venezuela (1.5%); Italy (1.3%); United Kingdom (1.1%); India (1.0%).

XX Not applicable.

[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.

[3]More than 4% carbon.

[4]Not more than 4% carbon.

Source: U.S. Census Bureau.

TABLE 5

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

Country	Not more than 0.5% carbon (HTS[2] code 7202.49.5090)			More than 0.5% carbon, but not more than 3% carbon (HTS[2] code 7202.49.5010)			More than 3% carbon, but not more than 4% carbon (HTS[2] code 7202.49.1000)			More than 4% carbon (HTS[2] code 7202.41.0000)			Total all grades		
	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)
2004:															
China	194 [r]	126 [r]	$341 [r]	20	9	$42	--	--	--	--	--	--	214 [r]	135 [r]	$383 [r]
Germany	4,930	3,490	8,930	63	44	72	--	--	--	--	--	--	4,990	3,530	9,010
India	--	--	--	--	--	--	--	--	--	12,900	8,110	$10,400	12,900	8,110	10,400
Japan	2,060	1,450	4,780	--	--	--	--	--	--	--	--	--	2,060	1,450	4,780
Kazakhstan	1,170	788	1,660	2,020	1,400	3,520	--	--	--	87,000	60,200	84,200	90,200	62,400	89,300
Russia	17,900	12,400	24,700	2,100	1,450	2,830	--	--	--	9,170	6,220	7,560	29,200	20,100	35,100
South Africa	5,010	2,730	4,270	1,520	927	1,780	30	16	$18	244,000	122,000	145,000	251,000	126,000	151,000
Turkey	135	92	262	--	--	--	--	--	--	--	--	--	135	92	262
Zimbabwe	--	--	--	--	--	--	--	--	--	44,600	26,500	28,200	44,600	26,500	28,200
Total	31,400	21,100	44,900	5,720	3,830	8,250	30	16	18	398,000	223,000	275,000	435,000	248,000	328,000
2005:															
Australia	--	--	--	--	--	--	--	--	--	13	9	11	13	9	11
China	94	66	212	--	--	--	--	--	--	13	8	11	107	74	223
France	4	3	8	--	--	--	--	--	--	--	--	--	4	3	8
Germany	5,810	4,070	11,700	--	--	--	--	--	--	--	--	--	5,810	4,070	11,700
India	--	--	--	20	13	17	--	--	--	20	12	16	40	24	33
Japan	2,870	2,010	8,130	--	--	--	--	--	--	--	--	--	2,870	2,010	8,130
Kazakhstan	3,910	2,680	5,880	870	601	1,370	--	--	--	115,000	79,400	112,000	119,000	82,700	119,000
Mexico	41	34	72	--	--	--	--	--	--	--	--	--	41	34	72
Russia	27,300	18,800	39,600	1,830	1,240	2,030	--	--	--	35,100	23,000	28,900	64,300	43,000	70,500
South Africa	2,950	1,630	2,760	810	446	905	--	--	--	187,000	93,600	115,000	190,000	95,600	119,000
Sweden	38	27	136	--	--	--	--	--	--	260	173	293	298	201	428
Turkey	5	3	12	--	--	--	--	--	--	--	--	--	5	3	12
Zimbabwe	--	--	--	--	--	--	--	--	--	61,200	36,200	47,500	61,200	36,200	47,500
Total	43,000	29,300	68,500	3,530	2,300	4,330	--	--	--	398,000	232,000	303,000	444,000	264,000	376,000

[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.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2004 Quantity (kilograms)	2004 Value[3] (thousands)	2005 Quantity (kilograms)	2005 Value[3] (thousands)	Principal sources in 2005
	Chromite ore:					
2610.00.0020	Not more than 40% Cr_2O_3:					Canada (100%).
	Gross weight	--	--	36,000	$17	
	Cr_2O_3 content	--	XX	11,000	XX	
2610.00.0040	More than 40%, but less than 46% Cr_2O_3:					South Africa (100%).
	Gross weight	1,690,000	$404	29,700,000	2,400	
	Cr_2O_3 content	761,000	XX	13,700,000	XX	
2610.00.0060	46% or more Cr_2O_3:					South Africa (100%).
	Gross weight	151,000,000	17,100	135,000,000	20,700	
	Cr_2O_3 content	71,600,000 r	XX	63,600,000	XX	
	Total:					
	Gross weight	153,000,000	17,500	165,000,000	23,100	
	Cr_2O_3 content	72,400,000 r	XX	77,300,000	XX	
	Metals and alloys:					
7202.50.0000	Ferrochromium-silicon:					Kazakhstan (77.0%); Russia (23.0%).
	Gross weight	30,600,000	31,500	33,700,000	31,600	
	Cr_2O_3 content	12,500,000	XX	14,100,000	XX	
	Chromium metal, gross weight:					
8112.21.1000	Unwrought chromium powders	1,350,000	9,070	1,050,000	15,000	Russia (33.0%); China (31.6%); Japan (28.5%); Spain (3.6%); Germany (1.8%); France (1.2%).
8112.22.0000	Waste and scrap	74,000	491	57,500	564	Singapore (63.9%); Japan (25.4%); Germany (9.7%); United Kingdom (0.9%).
8112.29.0000	Other than waste and scrap	8,200,000	46,500	9,850,000	72,100	Russia (29.1%); China (26.9%); France (26.2%); United Kingdom (17.0%).
	Total	9,630,000	56,000	11,000,000	87,700	
	Chemicals, gross weight:					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	7,000,000	10,500	11,400,000	21,600	Turkey (41.9%); Kazakhstan (24.7%); United Kingdom (23.1%); China (5.5%); South Africa (3.8%).
2819.90.0000	Other	2,960,000	8,400	3,200,000	11,000	China (42.8%); Japan (22.9%); Germany (16.5%): United Kingdom (6.8%); Colombia (2.6%); Spain (2.3%); Poland (1.8%); France (1.4%); Russia (1.2%); Taiwan (0.8%); Hong Kong (0.5%).
2833.23.0000	Sulfates of chromium	111,000	161	288,000	438	United Kingdom (92.0%); Kazakhstan (7.0%); India (1.0%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Chromates of lead and zinc	710,000	1,630	614,000	1,440	Republic of Korea (70.6%); Austria (17.7%); Colombia (6.7%); Japan (3.3%); China (1.5%).
2841.30.0000	Sodium dichromate	494,000	380	8,980,000	5,360	United Kingdom (90.1%); South Africa (7.6%); China (1.2%); Canada (0.6%).
2841.50.0000	Other chromates and dichromates; peroxochromates:					
2841.50.1000	Potassium dichromate	105,000	187	84,000	156	Kazakhstan (91.9%); India (6.7%); Japan (1.0%).
2841.50.9000	Other	570,000	1,240	212,000	507	Austria (97.0%); France (1.4%); India (1.0%).

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

		2004		2005		
HTS[2] code	Type	Quantity (kilograms)	Value[3] (thousands)	Quantity (kilograms)	Value[3] (thousands)	Principal sources in 2005
	Chemicals, gross weight—Continued:					
2849.90.2000	Chromium carbide	138,000	$1,630	131,000	$2,150	Japan (33.1%); Canada (18.8%); Germany (16.7%); United Kingdom (15.1%); Austria (10.6%); China (5.6%).
	Pigments and preparations based on chromium, gross weight:					
3206.20.0010	Chrome yellow	5,300,000	12,400	4,770,000	13,600	Canada (40.1%); Republic of Korea (32.0%); Mexico (17.3%); China (5.2%); Hungary (2.2%); Colombia (1.3%); Japan (1.2%).
3206.20.0020	Molybdenum orange	1,030,000	4,760	983,000	4,780	Canada (71.3%); Mexico (15.0%); France (10.3%); Colombia (0.9%); Germany (0.9%); India (0.6%).
3206.20.0030	Zinc yellow	15,600	29	11,000	28	Mexico (96.4%); Canada (3.6%).
3206.20.0050	Other	1,200,000	2,980	1,750,000	3,700	France (45.2%); China (20.0%); Canada (16.1%); Russia (7.9%); Belgium (5.1%); Poland (2.2%); Germany (1.8%); India (0.8%).

[r]Revised. XX Not applicable. -- 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 charges incurred in bringing the merchandise into the United States.

TABLE 7
WORLD PRODUCTION CAPACITY OF CHROMITE ORE, FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL, AND APPARENT CONSUMPTION IN 2005[1]

(Thousand metric tons of contained chromium)

Country	Production capacity					Apparent consumption[2]
	Ore	Ferrochromium	Metal	Chemicals	Stainless steel	
Afghanistan	2	--	--	--	--	--
Albania	48	24	--	--	--	28
Argentina	--	--	--	13	--	21
Australia	78	--	--	--	--	-52
Austria	--	--	--	--	8	100
Belgium	--	--	--	--	120	111
Brazil	197	113	--	--	96	180
Canada	--	--	--	--	--	24
China	69	468	6	70	595	1,070
Cuba	13	--	--	--	--	4
Czech Republic	--	--	--	--	2	--
Finland	174	138	--	--	221	164
France	--	--	7	--	112	97
Germany	--	18	1	--	298	261
Greece	1	--	--	--	--	(3)
India	980	318	(3)	4	306	530
Indonesia	--	--	--	--	--	-31
Iran	67	12	--	2	--	(3)
Italy	--	--	--	--	272	235
Japan	1	8	1	17	714	563
Kazakhstan	1,080	637	2	37	--	395
Korea, Republic of	--	--	--	--	425	266
Madagascar	42	--	--	--	--	35
Oman	9	--	--	--	--	-13
Pakistan	45	--	--	3	--	-6
Philippines	21	--	--	--	--	-4
Poland	--	--	--	--	--	3
Russia	232	333	16	31	17	313
Slovakia	--	1	--	--	--	(3)
Slovenia	--	--	--	--	13	-1
South Africa	2,300	1,540	--	23	122	616
Spain	--	--	--	--	204	107
Sudan	11	--	--	--	--	--
Sweden	--	81	--	--	119	77
Taiwan	--	--	--	--	272	212
Turkey	259	23	--	17	--	35
Ukraine	--	--	--	--	19	(3)
United Arab Emirates	2	--	--	--	--	(3)
United Kingdom	--	--	7	17	85	66
United States	--	20	3	38	425	266
Vietnam	59	--	--	--	--	--
Yugoslavia	--	--	--	--	91	--
Zimbabwe	247	165	--	--	--	127
Total	5,930	3,900	43	272	4,540	XX

XX Not applicable. -- Zero.

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

[2]Apparent consumption is chromite ore production plus chromite ore, ferrochromium, and chromium metal net imports. Net imports are imports minus exports. Based on data reported by the International Chromium Development Association. A negative apparent consumption indicates that exports are greater than production plus imports.

[3]Less than ½ unit.

TABLE 8

CHROMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2001	2002	2003	2004	2005
Afghanistan[4]	5,682	6,136	6,364	6,591 r	-- e
Albania[5]	129,700 r	72,600 r	98,000 r	54,430 r	66,270
Australia	11,800	132,665	138,826	265,987	241,865
Brazil[6]	409,049	283,991	404,477	593,476 r	676,643
Burma[e]	307	318	341	-- e	-- e
China[e]	182,000	180,000	200,000	200,000	200,000
Cuba	49,500 r	20,400 r	33,300 r	40,300 r	40,000 e
Finland	575,126	566,090	549,040	579,780	598,000 e
India	1,677,924	2,698,577	2,210,000	2,948,944	3,255,162
Iran	145,170 r	512,640 r	97,238 r	138,775 r	223,563
Kazakhstan	2,045,700	2,369,400	2,927,500	3,267,000	3,579,000
Madagascar	23,637	11,000	45,040	77,386	140,847
Oman	30,150 r	27,444	13,000	18,585	18,386
Pakistan	64,000	62,005	98,235	129,500 r	148,432
Philippines	26,932	23,703	12,967 r	70,001 r	60,424
Russia	69,926	74,300	116,455	320,200	772,000
South Africa	5,502,010	6,435,746	7,405,391	7,677,000 r	7,502,762 p
Sudan	20,500	14,000	37,000	26,000	21,654
Turkey	389,759	313,637	229,294 r	506,421 r	858,729
United Arab Emirates[e]	10,000	--	--	7,089 [7]	--
Vietnam[e]	70,300	80,000	120,000	150,000	85,000
Zimbabwe	780,150	749,339	637,099	668,391	819,903
Total	12,200,000 r	14,600,000 r	15,400,000 r	17,700,000 r	19,300,000

[e]Estimated. [p]Preliminary. [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 30, 2006.

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

[4]Gross weight estimated assuming an average grade of 44% chromic oxide (Cr_2O_3).

[5]Direct shipping plus concentrate production.

[6]Average chromic oxide (Cr_2O_3) content was as follows: 2001–43.5% (revised); 2002–40.1%; 2003–41.1% (revised); 2004–42.6% (revised); and 2005–42.6%.

[7]Reported figure.

TABLE 9

FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2001	2002	2003	2004	2005
Albania	11,900	22,100	37,800	47,700 r	35,780
Brazil[3]	110,468	164,140 r	204,339	216,277	185,533
China[e]	310,000	330,000	500,000	640,000 r	750,000
Croatia	361	--	--	--	--
Finland	236,710	248,181	250,490	264,492	234,881
Germany	19,308	20,018	18,318	24,857	22,672
India[4]	267,395	311,927	468,677	527,100	611,373
Iran[e]	8,430 [5]	8,000 r	10,000 r	7,750 r, 5	8,000
Japan[3]	111,167	91,937	19,427	13,472 r	12,367
Kazakhstan	761,900	835,800	993,000	1,080,993 r	1,156,168
Norway	82,600	61,100	--	--	--
Russia	210,600	210,000	357,000	454,000 e	578,000
Slovakia	5,968	5,695	1,924	1,784	867
South Africa[6]	2,141,000	2,351,122	2,813,000	2,965,000 r	2,581,578
Sweden	109,198	118,823	110,529	128,191	127,451
Turkey	50,735	11,200	35,393	28,701 r	26,043
United States[7]	W	W	W	W	W
Zimbabwe	243,584	258,164	245,200	193,077	235,000 e
Total	4,680,000	5,050,000 r	6,070,000	6,590,000 r	6,570,000

[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 inculdes data available through June 30, 2006.

[3]Includes high- and low-carbon ferrochromium.

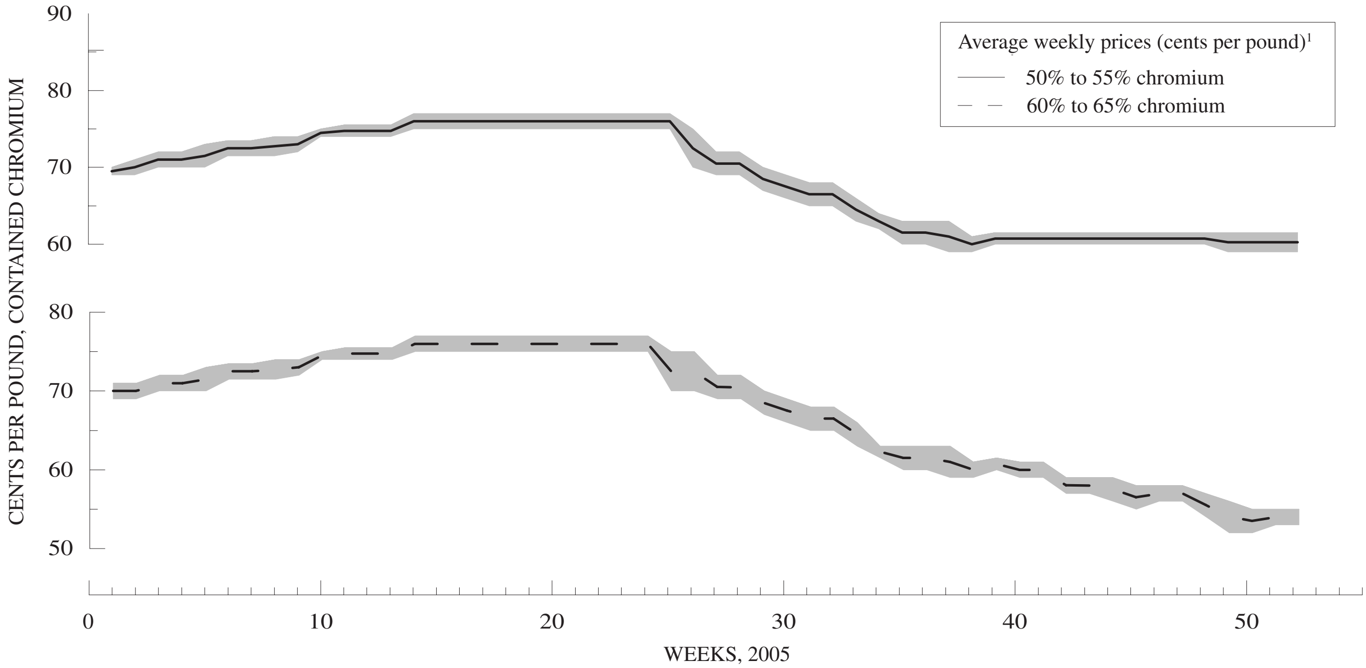
[4]Includes ferrochrome and charge chrome.

[5]Reported figure.

[6]Includes high- and low-carbon ferrochromium and ferrochromiumsilicon.

[7]Includes chromium metal, high- and low-carbon ferrochromium, ferrochromiumsilicon, and other chromium materials.

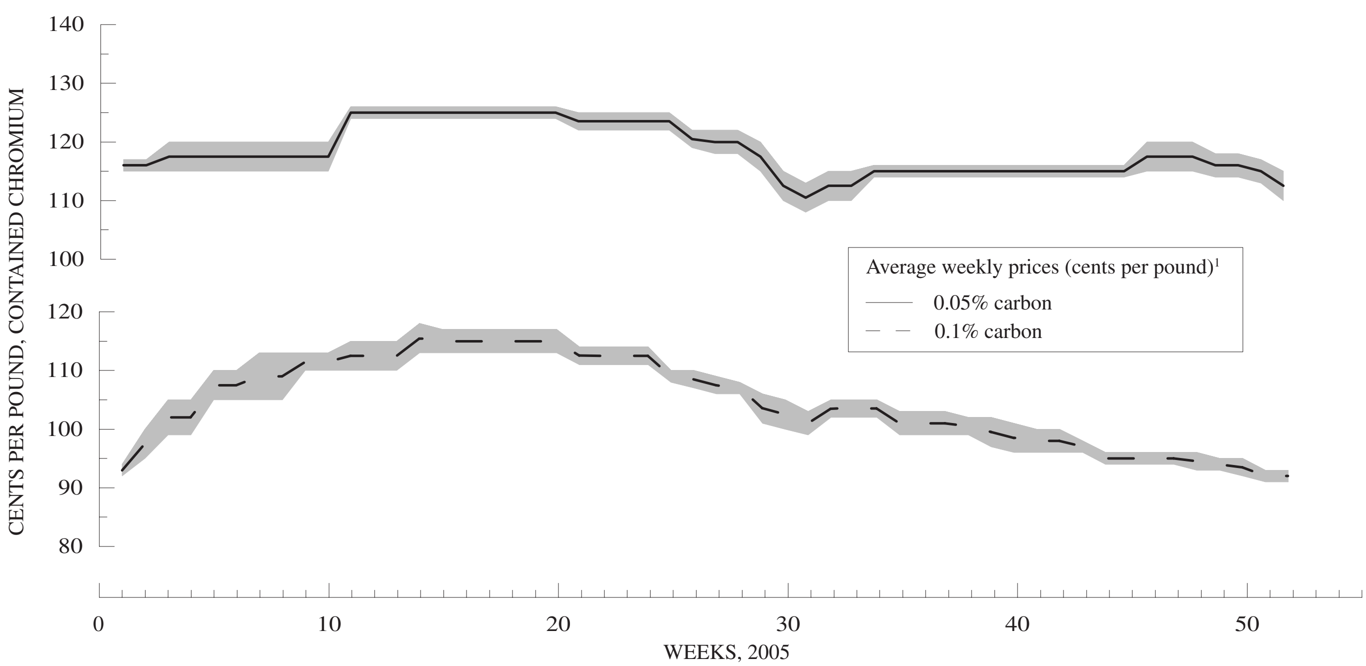
FIGURE 1
U.S. IMPORTED HIGH-CARBON FERROCHROMIUM IN 2005



[1]Average weekly price shown against price range background.

Source: Platts Metals Week.

FIGURE 2
U.S. IMPORTED LOW-CARBON FERROCHROMIUM IN 2005



[1]Average weekly price shown against price range background.

Source: Platts Metals Week.