TITANIUM

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Titanium is a metallic element that occurs in many minerals, however, only ilmenite, leucoxene, and rutile have significant commercial value. Titanium metal alloys are corrosion resistant and have a high strength-to-weight ratio. The density of titanium is about 60% that of iron but it has comparable strength. Most titanium is not consumed in its metal form but as titanium dioxide (TiO_2), a white pigment in paints, paper, and plastics. TiO_2 is used as a pigment because of its whiteness, brightness, and opacity.

In 2002, numerous titanium mineral exploration and development projects were in progress. World demand for TiO_2 feedstock was estimated to be 4.6 million metric tons (Mt), a slight increase compared with 2001. Europe and Asia led the slight increase in the global demand for TiO_2 pigment. Depressed demand from commercial aerospace markets limited consumption of titanium metal.

Legislation and Government Programs

The Defense Advanced Research Projects Agency requested proposals for "research, development, and establishment of an industrially scalable processing capability for new production and processing methodologies for titanium metal and its alloys." One of the goals of this program is to establish a U.S.-based, high-volume, low-cost, and environmentally benign production capability that would enable widespread use of titanium and its alloys. Another major goal is the development and demonstration of unique, previously unattainable titanium alloys, microstructures, and properties that would enable new high-performance applications (Defense Advanced Research Projects Agency, 2002§[1]).

In accordance with section 3305 of Public Law 104-106, the Defense National Stockpile Center (DNSC) transferred 250 metric tons (t) of titanium sponge from the National Defense Stockpile (NDS) to the U.S. Department of the Army's Tank and Automotive Command for use in the weight-reduction portion of the main battle tank upgrade program. Fiscal year (FY) 2002 is the seventh year of this program, which provides for transfers of up to 250 metric tons per year (t/yr) of titanium sponge to continue through FY 2003. Although this material is provided to the Army without charge, the law specifies that the Army will pay the costs for transportation and handling. DNSC met its 6,350-t target for the sale of titanium sponge from the U.S. Government stockpile in FY 2002. At yearend 2002, the NDS held 13,200 t of titanium sponge (Defense National Stockpile Center, 2003§).

In December, DNSC announced the award of 2,720 t of titanium sponge to Goldman Titanium Co., Grandis Metals International Corp., Monico Alloys, Inc., SMP Co., and Wogen Titanium Ltd. The titanium sponge sold included material manufactured from the 1950s through the late 1970s (Defense National Stockpile Center, 2002§).

Production

Mineral Concentrates.—Titanium mineral concentrates of economic importance include ilmenite, leucoxene, rutile, slag, and synthetic rutile. Mining of titanium minerals is usually performed using surface methods. Dredging and dry mining techniques are used for the recovery of heavy-mineral sand deposits. Gravity spirals are used to separate the heavy-minerals suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often beneficiated to produce synthetic rutile or titaniferous slag. Although numerous technologies are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite. Titaniferous slag with a TiO_2 content of up to 95% is produced using pyrometallurgical processes.

U.S. mineral concentrate producers were E.I. du Pont de Nemours & Co. Inc. (DuPont), Iluka Resources Inc. (a subsidiary of Iluka Resources Ltd.), and Kerr-McGee Corp. DuPont's mining operations near Starke, FL, produced a mixed product containing ilmenite, leucoxene, and rutile that was used as a feedstock in DuPont's own TiO_2 pigment operations. Iluka's mining operation near Green Cove Springs, FL, produced rutile and ilmenite concentrates, and the Stony Creek, VA, operation produced ilmenite concentrates. Kerr-McGee's operation near Mobile, AL, produced synthetic rutile. Titanium slag was not produced in the United States.

Iluka Resources Ltd. completed an expansion of its Old Hickory operation near Stony Creek, VA. The expansion included opening a second mine and installing additional separation equipment. Iluka also announced mining initiatives in northern Florida and southern Georgia. At its Green Cove Springs, FL, operation, the company planned to relocate its mobile concentrator to a nearby deposit and eventually decommission its dredging operation. Near Lulaton, GA, Iluka planned to construct a concentrator and associated infrastructure to support mining nearby deposits (Iluka Resources Ltd., 2002b§).

Metal.—Titanium sponge is the raw form of titanium metal. Commercial production involves the chlorination of titanium-containing mineral feedstocks to produce titanium tetrachloride ($TiCl_4$). Many producers reduce $TiCl_4$ with magnesium to form titanium sponge. Titanium ingot is produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements, such as aluminum

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

and vanadium. Electron beam, plasma, scull, and vacuum-arc reduction are the commercial melting methods used to produce ingot. Titanium mill products are produced from the drawing, forging, and rolling of titanium ingot or slab into products of various sizes and shapes. These mill products include billet, pipe and tube, plate, rod and bar, sheet, strip, and wire. Titanium castings are produced by investment casting and rammed graphite mold casting. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel. The two standard grades of ferrotitanium that are normally produced contain 40% and 70% titanium.

U.S. producers of titanium sponge in 2002 were The Alta Group and Titanium Metals Corp. (Timet). Year-end domestic production capacity of titanium sponge was estimated to be 8,940 t (table 2). Data on domestic production of titanium sponge are not published in order to avoid disclosing company proprietary data. U.S. producers of titanium ingot were Allegheny Technologies Inc. (ATI), Howmet Corp., Lawrence Aviation Industries Inc., RMI Titanium Co., and Timet. About 20% of the 86,700 t/yr of domestic ingot capacity is based on cold hearth technology; the remainder uses vacuum-arc reduction. U.S. production of ingot and mill products decreased significantly compared with those of 2001 (table 3). U.S. producers of ferrotitanium included Galt Alloys Inc., Global Titanium Inc., and Shieldalloy Metallurgical Corp. Data on production of ferrotitanium were not available.

TiO_2 Pigment.—TiO_2 pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. In the chloride process, rutile is converted to $TiCl_4$ by chlorination in the presence of petroleum coke. $TiCl_4$ is oxidized with air or oxygen at about 1,000° C, and the resulting TiO_2 is calcined to remove residual chlorine and any hydrochloric acid that may have formed in the reaction. Aluminum chloride is added to the $TiCl_4$ to assure that virtually all the titanium is oxidized into the rutile crystal structure. Although either process may be used to produce pigment, the decision to use one process instead of the other is based on numerous factors, including raw material availability, freight, and waste disposal costs. In finishing operations, the crude form of the pigment is milled to produce a controlled distribution of particle size and surface treated or coated to improve its functional behavior in different media. Some typical surface treatments include alumina, organic compounds, and silica.

TiO_2 pigment produced by either process is categorized by crystal form as either anatase or rutile. Rutile-type pigment is less reactive with the binders in paint when exposed to sunlight than is the anatase type and is preferred for use in outdoor paints. Anatase pigment has a bluer tone than the rutile type, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which TiO_2 pigment is produced and subsequently finished, TiO_2 pigment can exhibit a range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO_2 pigment in 2002 was 1.41 Mt, a 6% increase compared with that of 2001. U.S. producers of TiO_2 pigment were DuPont, Kerr-McGee, Louisiana Pigment Co. LP (an NL Industries Inc. and Huntsman Corp. joint venture) and Millennium Inorganic Chemicals Inc. (MIC). TOR Minerals International Inc. (TOR Minerals) produced a buff pigment from finely ground synthetic rutile (table 4). Capacity utilization for the domestic pigment industry was about 90%.

In 2002, Kerr-McGee made plans to increase productivity at its domestic TiO_2 pigment facilities in 2003. At Savannah, GA, new chloride technology with a larger oxidizer was expected to be operational by the end of 2003. Once the process improvements are implemented, capacity at the Savannah facility was expected to increase by 19,000 t/yr. Expansions at the company's Hamilton, MS, facility were expected to increase capacity to 225,000 t/yr, a 20% increase since 2000 (Kerr-McGee Corp., 2003§).

DuPont changed the name of its titanium mineral and pigment business unit from DuPont White Pigment & Mineral Products to DuPont Titanium Technologies. According to the company, the new name reflects its overall business direction and is broad enough to encompass future business initiatives (E.I. du Pont de Nemours and Co., 2002§).

Altair Nanotechnologies, Inc. was granted a U.S. patent for processing titaniferous ore to titanium dioxide pigment. Although no specific details were available, the process is based on technology acquired from Broken Hill Proprietary. Altair has filed seven additional patent applications and has an equal number under development (Altair Nanotechnologies, Inc., 2002§).

Radar Acquisitions Corp. (RAC) was examining lignite coal and heavy-mineral sand deposits near Limon, CO (145 kilometers southeast of Denver). If developed, the project would incorporate an integrated mining approach to recover coal and heavy minerals. In 2002, RAC announced it had had signed a lease agreement to acquire a 100% interest in 6,220 hectares of land from RME Land Corp., a subsidiary of Anadarko Petroleum Corp. (Radar Acquisitions Corp., 2002§).

Consumption

Mineral Concentrates.—On a gross weight basis, about 98% of the domestic consumption of titanium mineral concentrates was used to produce TiO_2 pigment. The remaining 2% was used to produce titanium metal, welding rod coatings and fluxes, and miscellaneous other products. Based on TiO_2 content, domestic consumption of titanium minerals concentrates was 1.40 Mt, an 8% increase compared with that of 2001 (table 6). Consumption of ilmenite and slag increased by 10%, and consumption of rutile and synthetic rutile was nearly unchanged compared with those of 2001.

Consumption data for titanium concentrates are developed by the U.S. Geological Survey from a voluntary survey of domestic operations. Of the 20 operations canvassed, 16 responded, representing 59% of the consumption data in table 6. Data for nonrespondents were estimated based on prior-year consumption with some adjustments for present-year trends.

Metal.—Titanium metal alloys are used in aerospace and other industries for their high strength-to-weight ratio and corrosion resistance. Overall consumption of titanium sponge and scrap by the titanium industry decreased by 33% compared with that of 2001. Scrap supplied a calculated 40% of ingot

feedstock. Estimated U.S. mill product usage by application was as follows: aerospace, 55% and nonaerospace uses, 45%. Nonaerospace uses included those in the consumer goods, marine, medical, oil and gas, pulp and paper, and specialty chemical industries (table 3).

A significant quantity of titanium in the form of sponge, scrap, and ferrotitanium is consumed in the steel and nonferrous alloy industries. Consumption by the steel industry is largely associated with the production of stainless steels and is used for deoxidation, grain-size control, and carbon and nitrogen control and stabilization. Reported consumption of titanium products in steel and other alloys was 8,000 t, a 2% decrease compared with that of 2001 (table 7).

TiO_2 Pigment.—The largest uses of TiO_2 pigment, based on TiO_2 pigment shipments in the United States, were paint and coatings (52.6%), plastics and rubber (26.5%), and paper (14.9%). Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

In the paint and coatings industry, TiO_2 pigment is used in architectural, equipment, and special-purpose applications and is widely used in white and color formulations. The TiO_2 content for paint and coatings varies significantly.

The plastics industry consumes rutile-grade pigment in a variety of applications such as polyethylene bags and vinyl window frames. TiO_2 pigment provides opacity and acts as a barrier against ultraviolet light degradation. TiO_2 pigment often is introduced as pelletized concentrate containing up to 50% by weight TiO_2 in a carrier resin; however, liquid and dry concentrates also are used by the industry. The TiO_2 content for plastics normally ranges from 3% to 25% by weight of the finished product.

TiO_2 pigment in paper products provides opacity and brightness. The paper industry consumes TiO_2 pigment as filler and in coatings. Paper products contain a high percentage of non-TiO_2 base minerals as filler material with the typical TiO_2 content less than 5% of the dry weight of paper. Anatase-grade pigment is preferred in the paper industry because it is less abrasive to papermaking machinery.

In the United States, apparent consumption of TiO_2 pigment was 1.12 Mt, a 2% increase compared with that of 2001 (table 5).

Stocks

On a TiO_2 content basis, year-end consumer inventories of titanium mineral concentrates decreased by 20% compared with those of 2001 (table 9). While consumer stocks of natural rutile and synthetic rutile decreased by 36%, stocks of ilmenite and slag decreased by 11% compared with those of 2001.

Year-end producer stocks of TiO_2 pigment were about 137,000 t, a 14% decrease compared with those of 2001. During the year, pigment stocks rose to a high of 157,000 t in March and fell to a low of 120,000 t in October.

Owing to sales from the DNSC inventory, Government stocks of sponge decreased by 29% compared with that of 2001. Industry stocks of sponge increased by 84%, and stocks of scrap and ingot decreased by 23% and 45%, respectively, compared with those of 2001 (table 3).

Prices

The yearend published price range for bulk rutile mineral concentrates was $430 to $470 per metric ton, a decrease of about 5% compared with that of 2001. The year-end price range for bagged rutile concentrates commonly used in the welding rod coatings industry was $400 to $540 per ton, a 10% decrease compared with that of 2001. Year-end prices of ilmenite concentrates decreased by 8% compared with those of 2001. Published prices for titanium slag were not available. Based on U.S. Customs Service value of imports, the yearend unit value of Canadian slag increased slightly, while the unit value South African slag increased 6% (table 10). The average unit value of all slag imports for 2002 increased 8% compared with that of 2001.

Yearend published prices for anatase- and rutile-grade pigment decreased 3% and 14%, respectively, compared with those of 2001. Based on the quantity and value of imports, however, the unit value of TiO_2 pigments decreased by 8% compared with those of 2001.

Decreased production of mill products resulted in less scrap available for recycling. Based on duty paid value of imports, the yearend value of titanium sponge increased by 2% compared with that of 2001. Published prices for titanium scrap turnings increased by 57%, and prices for ferrotitanium increased by 32% compared with those of 2001.

Foreign Trade

Mineral Concentrates.—Compared to imports, the United States exports a minor amount titanium minerals concentrates. In 2002, exports of titanium mineral concentrates were 3, 810 t, a 51% decrease compared with 2001 (table 11).

The leading import sources of ilmenite in 2002 were Australia (67%), Ukraine (13%), and Malaysia (13%). Imports of ilmenite for 2002 were 395,000 t, a 15% decrease compared with those of 2001. South Africa (79%) and Canada (21%) were the major import sources of titanium slag. Overall slag imports decreased by 25%, compared with those of 2001. Australia (61%) and South Africa (35%) were the major import sources of natural and synthetic rutile. In 2002, increases in natural rutile imported from Australia and Ukraine led to a 7% increase in overall imports of natural rutile compared with that of 2001. Synthetic rutile imports, primarily from Australia (98%), were 179,000 t, a 40% increase compared with imports in 2001. Titaniferous iron ore (classified as ilmenite by the U.S. Census Bureau) from Canada is used by the steel industry to protect the crucibles of blast furnaces. In this report, imports of titaniferous iron ore from Canada are separated from ilmenite statistics (table 12).

Metal.—Imports of titanium metal are primarily in the form of titanium sponge (50%) and waste and scrap (29%). Kazakhstan (56%), Japan (38%), and Russia (5%) were the major sources of imported titanium sponge. Japan (39%), the United Kingdom (15%), France (13%), and Germany (8%) were the leading sources of imported waste and scrap.

Compared with those of 2001, imports of unwrought metal, including sponge and waste and scrap, decreased by 33% in 2002. Imports of wrought products and castings decreased by 15% compared with 2001. Imports of ferrotitanium primarily used in the iron and steel industry decreased by 10% compared with those of 2001.

Although the United States was import reliant on unwrought titanium, the Nation was a net exporter of wrought products. Exports of wrought products exceeded imports of wrought products by a ratio of more than 2:1. Compared with those of 2001, exports of wrought products and castings decreased 8% (table 11).

TiO_2 Pigment.—The United States continued to be a net exporter of TiO_2 pigment. In 2002, exports surpassed imports by a ratio of 2.3 to 1. Exports of titanium pigment and oxide were 540,000 t, a 30% increase compared with that of 2001. About 90% of exports was in the form of finished pigment with more than 80% TiO_2 content.

During 2002, 231,000 t of TiO_2 pigment and oxide was imported, a 11% increase compared with the previous year (table 14). The leading import sources of titanium pigment and oxide were Canada (28%), Germany (12%), France (10%), and China (6%). Compared with those of 2001, imports of titanium pigment containing more than 80% TiO_2 increased by 7% to 184,000 t; other titanium pigment decreased by 27% to 4,500 t; and titanium oxide (unfinished pigment) increased 40% to 43,100 t (table 14).

World Review

World production of titanium mineral concentrates was 6.4 Mt (4.6 Mt of contained TiO_2). Australia, Canada, India, Norway, and South Africa continued to lead the world's production of titanium mineral concentrates (table 15). The largest commercial producers of titanium mineral concentrates (in descending order) were Iluka Resources, Richards Bay Iron and Titanium Pty. Ltd., QIT-Fer et Titane Inc., and Titania A/S. In 2002, numerous mineral sands projects were under development and had the potential to oversupply the titanium feedstock market.

World TiO_2 pigment production was estimated to be 3.98 Mt (Minerals Sands Report, 2003c). France, Germany, Japan, the United Kingdom, and the United States were the leading producing countries of TiO_2 pigment. The largest commercial producers of TiO_2 pigment (in descending order) were DuPont, MIC, Huntsman Corp., Kerr-McGee, Kronos Inc., and Ishihara Sangyo Kaisha, Ltd.

Titanium sponge was produced in China, Japan, Kazakhstan, Russia, Ukraine, and the United States. Commercial ingot production capacity existed in France, Germany, Japan, Russia, the United Kingdom, and the United States. Major producers of titanium mill products were located primarily in China, France, Germany, Japan, Italy, Russia, the United Kingdom, and the United States.

Australia.—Bemax Resources NL received approval from the New South Wales Minister of Planning to develop its Ginko heavy-mineral deposit in the Murray Basin. If the project remains on schedule, the mine and separation plant would be commissioned in the second half of 2003 (Industrial Minerals, 2002a).

Doral Mineral Industries Ltd. commissioned the Dardanup Mineral Sands project in Western Australia. The project is expected to produce about 110,000 t/yr of ilmenite and 10,000 t/yr of leucoxene. The ore will be processed at the company's dry separation plant near Picton (Western Australia Cabinet, 2002§).

Mineral Deposits Ltd. (MDL) submitted an exploration license for approval by the New South Wales Department of Mineral Resources. The license covers an area of approximately 11.1 square kilometers (km^2) near Kempsey on the coast of New South Wales. The deposit is about 2 hours trucking distance north of the company's dry processing plant at Hawks Nest in which spare capacity exists. The deposit contains an estimated 26 Mt, grading 0.53% heavy minerals. The grade is about double that of current ore reserves being extracted by MDL at its nearby Fullerton and Viney Creek dredging operations. Once a mining lease is obtained, MDL planned to relocate its existing dredges (Mineral Deposits Ltd., 2002b§).

Iluka Resources and Outokumpu-Lurgi Metallurgie GmbH completed pilot-plant testing of a new process to produce synthetic rutile. The new "NewGenSR" process was expected to allow processing of a wider range of ilmenite to produce synthetic rutile. The plant was expected to be in production by 2006 (Iluka Resources Ltd., 2002a§). In the Murray Basin, Iluka Resources acquired two tenements from Consolidated Broken Hill Ltd. One tenement is near Wamberra, the other near Ivanhoe. The two tenements cover a 10,000-km^2 area near the company's existing holdings (Mineral Sands Report, 2002a).

Canada.—Titanium Corp. Inc. began a drilling program at its heavy-minerals deposit near Truro, Nova Scotia. The objective of the program was to expand the identified resources of the deposit to the south and to the west, and substantiate existing results by tightening up the space between drill holes. Prior to the drilling program, probable reserves were estimated to be 6.4 Mt of iron and heavy minerals (Industrial Minerals, 2002k).

China.—Pangang Titanium Co. was expanding its hard-rock titaniferous-magnetite and TiO_2 pigment processing capacity near Panzhihua, Sichuan Province. TiO_2 pigment capacity was expected to increase from the current 10,000 t/yr to 50,000 t/yr through the addition of 40,000 t/yr of sulfate-route production capacity. Pangang also planned to increase its ilmenite concentrate capacity from the 200,000 t/yr to 400,000 t/yr by 2005. Construction of a slag plant was scheduled to begin in 2003 (Minerals Sands Report, 2002b). In 2002, China was reported to have produced 390,000 t of TiO_2 pigment. Although China's total TiO_2 pigment capacity was estimated to be 450,000 t/yr, none of its individual plant capacities exceed 20,000 t/yr (Mineral Sands Report, 2003a).

Finland.—Kemira announced it was increasing the sulfate-route TiO_2 pigment capacity at its Pori facility to 130,000 t/yr. The 10,000-t/yr increase was expected to be fully operational in 2003. Another increase in capacity, scheduled for completion by 2005, would bring capacity at Pori to 150,000 t/yr (Industrial Minerals, 2002c).

France.—MIC doubled ultrafine TiO_2 pigment capability at its Thann facility. Of the 30,000 t/yr of TiO_2 pigment capacity at Thann, 10,000 t/yr is now dedicated to ultrafine TiO_2. Ultrafine TiO_2 is used in applications such as electroceramics, photocatalysts, and ultraviolet radiation blockers (Industrial Minerals, 2002e).

The Gambia.—Carnegie Corp. Ltd. formed an agreement with Astron Ltd. to process a zircon-rich stockpile created by heavy-mineral producer British Titan Products in the late 1950s. Future plans include studying the potential for mining heavy minerals and silica sand deposits along the Gambia coastline (Carnegie Corp. Ltd., 2002§).

India.—U.S.-based WGI Heavy Minerals Inc. (formerly Western Garnet International Ltd.) announced new reserve estimates of ilmenite (500,000 t) and garnet (800,000 t) at its Srikurman deposit in Andhra Pradesh. The company announced it had obtained a 30-year lease for the property. Construction of a heavy-mineral separation plant was scheduled for 2003, with initial production to begin in 2004 (WGI Heavy Minerals, Inc., 2003§).

MDL and Ticor completed the first phase of a feasibility study on the Kudiraimozhi deposit in Tamil Nadu. This study was predicated on producing 140,000 t of synthetic rutile; 12,800 t of natural rutile; and 11,200 t of zircon annually over a mine life of more than 50 years. The study indicated an internal rate of return of 11%, however, Ticor elected not to proceed with the second phase of the study. MDL planned to continue to pursue the development of its deposits in Tamil Nadu (Mineral Deposits Ltd., 2002a§).

Tata Iron & Steel Company Ltd. (Tata Steel) signed a memorandum of understanding with the Government of Tamil Nadu to undertake a feasibility study of the mineral sands available in Tamil Nadu. Subject to the results of feasibility study, Tata Steel may venture into TiO_2 pigment and, in time, titanium metal production (Tata Iron & Steel Company Ltd., 2002§).

Japan.—According to the Japan Titanium Society, Japan's production of titanium sponge in 2002 was 25,200 t, up from 24,900 t in 2001. Production of TiO_2 pigment in Japan was 241,000 t, a 7% decrease compared with 2001 (Mineral Sands Report, 2003b).

Kenya.—Tiomin Resources Inc. continued the development of its titanium deposits in Kenya. Following a 2-year review, an environmental license was granted by the Government of Kenya in July. A mining lease was approved in December 2002. Tiomin expects to initiate construction of the Kwale project in 2004. According to a feasibility study, the Kwale deposit could produce 330,000 t/yr of sulfate-grade ilmenite, about 38,000 t/yr of zircon, and more than 75,000 t/yr of rutile during the first 6 years of production (Tiomin Resources Inc., 2003§).

Madagascar.—The Government of Madagascar granted QIT Madagascar Minerals SA environmental permits for its mining project near Fort Dauphin. The permit clears the way for the next phase of the project, which will include market and engineering studies (Industrial Minerals, 2002h).

Mozambique.—Following the completion of a feasibility study, WMC Resources Ltd. agreed to acquire 100% interest in the Corridor Sands project from Southern Mining Corp. (SMC). Previously, SMC owned 100% of Corridor Sands and WMC had the right to earn a controlling interest in the project by funding 90% of the cost of a feasibility study, financing a portion of SMC's equity contribution to the project, and providing additional support. Under the agreement, Industrial Development Corp. retained its option to acquire a 10% interest in the project (WMC Resources Ltd., 2003§).

Kenmare Resources plc. issued an invitation to bid for the construction and implementation of the Moma Titanium Minerals Project. Moma is scheduled to come onstream in 2004 and may produce in excess of 600,000 t/yr of ilmenite and 13,000 t/yr of rutile. Heavy-mineral reserves include 14.4 Mt of ilmenite (Kenmare Resources plc., 2003§).

Sierra Leone.—Sierra Rutile Ltd. began preliminary work to reopen its rutile mining operation. The mine has been idle since the 1995 when civil conflict interrupted its operation. Prior to its closure, Sierra Rutile was estimated to have produced 150,000 t/yr of ilmenite and 60,000 t/yr of rutile (Industrial Minerals, 2002i).

South Africa.—Ticor SA (formerly Iscor Heavy Minerals) started shipments of mineral concentrates from its recently commissioned Hillendale mine and separation facility near Empangeni. Construction of a slag facility was underway and the first furnace was scheduled to be completed by 2003 (Industrial Minerals, 2002g). The first furnace was expected to produce 125,000 t/yr of TiO_2 slag and 70,000 t/yr of pig iron. In August, plans were approved to move forward with the construction of a second furnace (Industrial Minerals, 2002j).

Huntsman Tioxide acquired the outstanding 40% interest in the minority in the 40,000-t/yr TiO_2 pigment plant in Umbogintwini, Kwazulu Natal from AECI Ltd. Prior to the acquisition, Huntsman managed the plant and its sales (Industrial Minerals, 2002b).

MRC Resources Ltd. planned to proceed with the development of its Xolobeni project. The deposit was estimated to contain more than 13 Mt of heavy minerals. According to MRC, the ilmenite from the deposit is suitable for producing an 86% TiO_2 chloride-grade slag (Industrial Minerals, 2002f).

Spain.—Huntsman Tioxide was increasing capacity at its sulfate-route TiO_2 pigment facility near Huelva by 17,000 t/yr. The project was expected to raise capacity to 97,000 t/yr by late 2005 (Huntsman International LLC, 2003§).

Sri Lanka.—Lanka Mineral Sands Corp. was preparing to resume full operation at its heavy-mineral operation near Pulmoddai. In 1997, operations were interrupted when Tamil separatists sank a bulk carrier and cut off water supply to the wet separation plant. Prior to the disruption, production capacity was about 180,000 t/yr of ilmenite (Industrial Minerals, 2002d).

United Kingdom.—Huntsman Tioxide commissioned a new plant at its TiO_2 pigment facility at Greatham. The new plant allowed the company to close an older, higher cost plant located at Greatham and increase annual production capacity of the facility to 100,000 t/yr of chloride-based TiO_2 (Huntsman International LLC, 2003§).

Outlook

During the next 5 years, global economic growth is expected to increase TiO_2 pigment consumption by about 3% per year. Because approximately 95% of all titanium minerals are consumed to produce TiO_2 pigment, consumption of titanium minerals is expected to continue to follow a similar trend.

Demand for titanium metal by commercial aerospace producers is expected to remain depressed for the immediate future. However, growth in airline passenger traffic is expected

to result in a 5% per year demand growth during the next decade. Demand for titanium consumer goods, chemical process equipment, and military hardware is expected to increase moderately during the next few years.

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TABLE 1
SALIENT TITANIUM STATISTICS[1]

(Metric tons unless otherwise specified)

		1998	1999	2000	2001	2002
United States:						
Ilmenite and titanium slag:						
Imports for consumption		1,010,000	1,070,000	918,000	1,060,000	840,000
Consumption[2]		1,300,000	1,280,000	1,250,000	1,180,000	1,300,000
Rutile concentrate, natural and synthetic:						
Imports for consumption		387,000	344,000	438,000	325,000	390,000
Consumption		421,000	494,000	537,000	483,000	487,000
Sponge metal:						
Imports for consumption		10,900	6,000	7,240	13,300	10,700
Consumption		28,200	18,100	18,200	26,200	17,300
Price, yearend	dollars per pound	$4.54	$3.58	$3.95	$3.58	$3.64
Titanium dioxide pigment:						
Production		1,330,000	1,350,000	1,400,000	1,330,000	1,410,000
Imports for consumption		200,000	225,000	218,000	209,000	231,000
Consumption, apparent[3]		1,140,000	1,160,000	1,150,000	1,100,000	1,120,000
Price, December 31:	dollars per pound					
Anatase		$0.96-0.98	$0.92-0.94	$0.92-0.94	$0.92-0.94	$0.85-0.95
Rutile		$0.97-0.99	$0.99-1.02	$0.99-1.02	$1.00-1.09	$0.85-0.95
World, production:						
Ilmenite concentrate		4,560,000	4,150,000	5,010,000 [4]	5,110,000 [r, 4]	4,950,000 [e, 4]
Rutile concentrate, natural		438,000	348,000	387,000 [5]	377,000 [r, 5]	408,000 [e, 5]
Titaniferous slag		2,050,000	2,120,000 [r]	2,010,000 [r]	2,040,000 [r]	2,050,000 [e]

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits; except prices.
[2]Excludes consumption used to produce synthetic rutile.
[3]Production plus imports minus exports plus stock decrease or minus stock increase.
[4]Includes U.S. production of ilmenite, lexucoxene, and rutile, rounded to one significant digit, to avoid disclosing company proprietary data.
[5]U.S. production of rutile included with ilmenite to avoid revealing company proprietary data.

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2002[1, 2]

		Yearend capacity (metric tons)	
Company	Plant location	Sponge	Ingot[3]
Allegheny Technologies Inc.	Albany, OR	--	10,900
Do.	Monroe, NC	--	11,800
Do.	Richland, WA	--	10,000
Alta Group	Salt Lake City, UT	340	--
Howmet Corp.	Whitehall, MI	--	3,200
Lawrence Aviation Industries Inc.	Port Jefferson, NY	--	1,400
RMI Titanium Co.	Niles, OH	--	16,300
Titanium Metals Corp.	Henderson, NV	8,600	12,300
Do.	Morgantown, PA	--	20,000
Do.	Vallejo, CA	--	800
Total		8,940	86,700

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Estimated operating capacity based on 7-day-per-week full production.
[3]Includes electron-beam, plasma, and vacuum-arc-reduction capacity.

TABLE 3
COMPONENTS OF U.S. TITANIUM METAL SUPPLY AND DEMAND[1]

(Metric tons)

Component	2001	2002
Production:		
Ingot	44,600	22,700
Mill products	27,900	19,900
Exports:		
Sponge	2,170	2,810
Waste and scrap	7,500	6,000
Other unwrought[2]	3,840	2,650
Wrought products and castings[3]	6,700	6,140
Total	20,200	17,600
Imports:		
Sponge	13,300	10,700
Waste and scrap	11,600	6,270
Other unwrought[2]	3,040	1,670
Wrought products and castings[3]	3,170	2,690
Total	31,100	21,400
Stocks, yearend:		
Government, sponge (total inventory)	18,600	13,200
Industry:		
Sponge	6,340	11,700
Scrap	4,920	3,760
Ingot	6,180	3,390
Consumption, reported		
Sponge	26,200	17,300
Scrap	17,000	11,600
Ingot	30,900	18,400
Shipments:		
Mill products (net shipments):	23,000	16,200
Forging and extrusion billet	11,000	6,020
Plate, sheet, strip	6,600	5,960
Rod, bar, fastener stock, wire	4,560	3,220
Other[4]	837	1,050
Castings (shipments)	704	389
Receipts, scrap:		
Home	5,760	7,570
Purchased	16,800	10,700

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes billet, blooms, ingot, powder, sheet bar, slab, and other.
[3]Includes castings, foil, pipes, profiles, tubes, other wrought and articles of titanium not elsewhere specified or included.
[4]Data for pipe, tubing, and other have been combined to avoid disclosing company proprietary data.

TABLE 4
CAPACITIES OF U.S. TITANIUM DIOXIDE PIGMENT PLANTS ON DECEMBER 31, 2002[1, 2, 3]

Company	Plant location	Yearend capacity (metric tons per year)		
		Sulfate process	Chloride process	Total
E.I. du Pont de Nemours & Co. Inc.	De Lisle, MS	--	300,000	300,000
Do.	Edgemoor, DE	--	154,000	154,000
Do.	New Johnsonville, TN	--	380,000	380,000
Kerr-McGee Corp.	Savannah, GA	54,000	91,000	145,000
Do.	Hamilton, MS	--	188,000	188,000
Louisiana Pigment Co. LP	Lake Charles, LA	--	140,000	140,000
Millennium Inorganic Chemicals Inc.	Ashtabula, OH	--	210,000	210,000
Do.	Baltimore, MD	--	50,000	50,000
Total		54,000	1,510,000	1,570,000

-- Zero.
[1]Estimated operating capacity based on 7-day-per-week full production.
[2]Table does not include TOR Minerals International's Corpus Christi, TX, production capacity of about 16,400 metric tons per year of buff TiO_2 pigments that is produced by refining and fine grinding of synthetic rutile.
[3]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 5
COMPONENTS OF U.S. TITANIUM DIOXIDE PIGMENT SUPPLY AND DEMAND[1]

(Metric tons unless otherwise specified)

		2001		2002	
		Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production[2]		1,330,000	1,250,000 e	1,410,000	1,320,000 e
Shipments:[3]					
Quantity		1,370,000	1,290,000	1,530,000	1,430,000
Value	thousands	$2,590,000	$2,590,000	$2,750,000	$2,750,000
Exports		415,000	391,000 e	540,000	507,000 e
Imports for consumption		209,000	197,000 e	231,000	217,000 e
Stocks, yearend[e]		159,000	150,000 e	137,000	128,000 e
Consumption, apparent[e, 4]		1,100,000	1,040,000	1,120,000	1,060,000

[e]Estimated.
[1]Data are rounded to no more than three significant digits.
[2]Excludes production of buff pigment.
[3]Includes interplant transfers.
[4]Production plus imports minus exports plus stock decrease or minus stock increase.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6
U.S. CONSUMPTION OF TITANIUM CONCENTRATES[1]

(Metric tons)

	2001		2002	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Ilmenite and titanium slag:[2, 3]				
Pigments	1,160,000	NA	1,280,000	NA
Miscellaneous[4]	15,400	NA	16,000	NA
Total	1,180,000	856,000	1,300,000	951,000
Rutile, natural and synthetic:				
Pigments	455,000	NA	464,000	NA
Miscellaneous[4]	28,500	NA	22,900	NA
Total	483,000	448,000	487,000	452,000
Total concentrates:				
Pigments	1,620,000	NA	1,750,000	NA
Miscellaneous[4]	43,900	NA	38,900	NA
Total	1,660,000	1,300,000	1,780,000	1,400,000

NA Not available.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[3]Excludes ilmenite used to produce synthetic rutile.
[4]Includes alloys, carbide, ceramics, chemicals, glass fibers, titanium metal, welding-rod coatings and fluxes.

TABLE 7
U.S. CONSUMPTION OF TITANIUM PRODUCTS IN STEEL AND OTHER ALLOYS[1, 2]

(Metric tons)

	2001[r]	2002
Carbon steel	3,160	2,210
Stainless and heat-resisting steel	2,950	2,760
Other alloy steel (includes HSLA and tool steel)	753	963
Total steel	6,860	5,930
Superalloys	925	1,410
Alloys, other than above	393	636
Miscellaneous and unspecified	18	18
Total consumption	8,200	8,000

[r]Revised.
[1]Includes ferrotitanium, titanium scrap, and other titanium additives.
[2]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS,
TITANIUM DIOXIDE CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2001	2002
Coated fabrics and textiles	0.1	0.1
Paint, varnish, lacquer	49.3	52.6
Paper	15.6	14.9
Plastics and rubber	26.0	26.5
Other[2]	9.0	5.9
Total	100.0	100.0

[1]Excludes exports.
[2]Includes agricultural, building materials, ceramics, coated fabrics and textiles, cosmetics, food, paper, and printing ink. Also includes shipments to distributors.

TABLE 9
U.S. STOCKS OF TITANIUM CONCENTRATES AND PIGMENT, DECEMBER 31[1]

(Metric tons)

	2001		2002	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Mineral concentrates:[2]				
Ilmenite and titanium slag	286,000	221,000	243,000	197,000
Rutile, natural and synthetic	127,000	118,000	81,700	75,400
Titanium pigment[3]	159,000	150,000 e	137,000	128,000 e

eEstimated.
[1]Data are rounded to no more than three significant digits.
[2]Consumer stocks.
[3]Data from U.S. Census Bureau. Producer stocks only.

TABLE 10
PUBLISHED PRICES OF TITANIUM CONCENTRATES AND PRODUCTS

		2001	2002
Mineral concentrates:			
Ilmenite, free on board (f.o.b.) Australian ports[1]	per metric ton	$90.00-110.00	$85.00-100.00
Rutile, bagged, f.o.b. Australian ports[1]	do.	475.00-565.00	400.00-540.00
Rutile, bulk, f.o.b. Australian ports[1]	do.	450.00-500.00	430.00-470.00
Titanium slag, Canada 80% TiO_2[2]	do.	335	340
Titanium slag, Canada 95% TiO_2[2]	do.	518	527
Titanium slag, South Africa, 85% TiO_2[2]	do.	419	445
Metal:			
Sponge[2]	per pound	3.58	3.64
Scrap, turnings, unproccessed[3]	do.	0.68-0.70	1.07-1.10
Ferrotitanium, 70% Ti[3]	do.	1.60-1.70	2.16-2.18
Pigment:			
TiO_2 pigment, f.o.b. U.S. plants, anatase[4]	do.	0.92-0.94	0.85-0.95
TiO_2 pigment, f.o.b. U.S. plants, rutile[4]	do.	1.00-1.09	0.85-0.95

[1]Source: Industral Minerals.
[2]Landed duty-paid unit value based on U.S. imports for consumption.
[3]Source: Platts Metals Week.
[4]Source: Chemical Market Reporter.

TABLE 11
U.S. EXPORTS OF TITANIUM PRODUCTS, BY CLASS[1]

Class	2001 Quantity (metric tons)	2001 Value (thousands)	2002 Quantity (metric tons)	2002 Value (thousands)
Metal:				
Unwrought:				
Sponge	2,170	$13,800	2,810	$17,600
Waste and scrap	7,500	18,300	6,000	14,200
Other unwrought:				
Billets	210	5,020	261	6,920
Blooms, sheet bars, slabs	1,620	47,700	1,130	31,500
Ingots	1,510	21,600	908	12,500
Other[2]	492	17,400	352	11,400
Wrought products and castings:				
Bars, rods, profiles, wire	3,440	108,000	2,680	95,500
Other	3,260	156,000	3,460	148,000
Total metal	20,200	387,000	17,600	338,000
Ores and concentrates	7,800	3,130	3,810	2,260
Pigment and oxides:				
80% or more titanium dioxide pigments	349,000	550,000	485,000	734,000
Other titanium dioxide pigments	29,500	51,200	26,800	42,600
Titanium oxides	36,700	65,800	28,300	46,200
Total	415,000	667,000	540,000	823,000

[1]Data are rounded to no more than three significant digits, may not add to totals shown.
[2]Includes titanium powders and other unwrought.

Source: U.S. Census Bureau.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATES, BY COUNTRY[1]

Concentrate and country	2001 Quantity (metric tons)	2001 Value (thousands)	2002 Quantity (metric tons)	2002 Value (thousands)
Ilmenite:				
Australia	261,000	$20,100	265,000	$30,700
India	25,300	2,430	11,000	803
Malaysia	74,200	4,780	50,500	3,520
Ukraine	107,000	10,100	52,800	5,080
Vietnam	--	--	15,800	1,180
Total	467,000	37,400	395,000	41,300
Titanium slag:				
Canada	258,000	98,900	94,900	41,600
South Africa	336,000	140,000	350,000	152,000
Other[2]	-- r	-- r	68	22
Total	594,000	239,000	445,000	194,000
Rutile, natural:				
Australia	56,000	29,700	61,000	28,100
South Africa	141,000	58,600	138,000	57,500
Ukraine	--	--	11,600	4,430
Other[2]	422 r	230 r	329	129
Total	197,000	88,500	211,000	90,100
Rutile, synthetic:				
Australia	103,000	30,000	176,000	56,800
Malaysia	3,040	1,780	2,760	1,620
South Africa	8,000	2,530	--	--
Ukraine	13,500	4,660	--	--
Other	22 r	63 r	44	13
Total	127,000	39,000	179,000	58,500
Titaniferous iron ore, Canada[3]	55,500	6,500	36,600	3,330

rRevised. -- Zero.

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

[2]Data being verified by the U.S. Census Bureau.

[3]Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux. Titaniferous iron ore from Canada is classified as ilmenite under the Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau. Data adjusted by the U.S. Geological Survey.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY[1]

Class and country	2001 Quantity (metric tons)	2001 Value (thousands)	2002 Quantity (metric tons)	2002 Value (thousands)
Unwrought:				
Sponge:				
Japan	4,900	$38,600	4,130	$32,800
Kazakhstan	5,690	34,400	6,010	36,400
Russia	2,220	11,800	525	2,570
Other	450	1,430	74	421
Total	13,300	86,200	10,700	72,200
Waste and scrap:				
Australia	109	404	--	--
Belgium	360	648	149	298
Canada	427	1,160	198	285
France	1,590	6,730	818	2,610
Germany	1,310	6,000	509	2,030
Israel	132	361	120	144
Italy	537	1,810	174	555
Japan	3,000	10,200	2,440	7,360
Mexico	423	1,300	474	819
Russia	445	1,520	8	22
Sweden	212	901	20	85
Taiwan	367	1,040	197	518
United Kingdom	2,440	8,240	941	2,500
Other	233 r	458 r	221	572
Total	11,600	40,800 r	6,270	17,800
Ingot and billet:				
Germany	269	2,450	209	2,710
Russia	1,790	22,900	854	9,590
United Kingdom	165	5,580	68	2,470
Other	130 r	4,580 r	80	3,060
Total	2,360	35,500	1,210	17,800
Powder:				
China	133	960	63	360
Other	27	880	12	760
Total	160	1,840	75	1,120
Other:[2]				
France	194	1,100	161	528
Japan	163	1,150	104	336
Other	165 r	1,330 r	128	693
Total	522	3,580	392	1,560
Wrought products and castings:[3]				
Canada	179	4,590	244	6,820
China	164	4,550	85	1,920
Italy	141	2,670	168	4,760
Japan	590	14,300	557	14,100
Russia	1,780	37,000	1,360	25,300
Other	315 r	9,670 r	271	9,600
Total	3,170	72,800	2,680	62,500
Ferrotitanium and ferrosilicon-titanium	4,120	10,800	3,700	9,960

r Revised. -- Zero.

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

[2] Includes blooms, sheet bars, slabs, and other unwrought.

[3] Includes bars, castings, foil, pipes, plates, profiles, rods, sheet, strip, tubes, wire, and other.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENTS, BY COUNTRY[1]

Country	2001 Quantity (metric tons)	2001 Value (thousands)	2002 Quantity (metric tons)	2002 Value (thousands)
80% or more titanium dioxide:				
Belgium	1,970	$3,630	2,680	$4,030
Canada	58,600	101,000	62,700	99,600
China	4,880	6,330	6,530	7,790
Finland	3,340	6,650	3,800	7,250
France	6,940	10,400	5,460	8,230
Germany	18,400	38,600	22,300	39,900
Italy	11,500	17,900	11,700	17,300
Japan	5,840	16,900	8,890	17,900
Korea, Republic of	5,390	7,130	5,900	7,180
Mexico	6,530	10,800	8,750	11,900
Norway	4,740 r	8,110	4,710	7,300
Singapore	3,980	6,830	2,240	3,380
Slovenia	2,480	4,260	2,760	3,910
South Africa	8,020	13,200	9,700	14,300
Spain	14,000	22,500	7,570	10,800
Ukraine	10,500	13,200	3,200	3,940
United Kingdom	3,370	5,530	12,100	18,700
Other	1,310 r	1,750 r	2,660	3,760
Total	172,000	294,000	184,000	287,000
Other titanium dioxide:				
Austria	226	4,560	130	1,840
Belgium	807	1,750	169	277
Canada	2,380	5,060 r	1,770	4,750
China	525	549	577	643
France	523	1,810	456	1,760
Germany	943	2,740	728	2,650
United Kingdom	231	3,580	131	3,040
Other	541 r	4,240 r	542	3,610
Total	6,180 r	24,300 r	4,500	18,600
Titanium oxide:				
Brazil	26	27	4,130	5,680
China	5,900	6,630	7,380	7,750
Czech Republic	2,270	3,780	3,470	5,060
France	12,100	18,500	17,000	27,500
Germany	1,510	2,480	3,830	10,400
Japan	419	4,090	1,090	4,680
Korea, Republic of	3,650	4,880	2,960	3,680
Poland	2,120	3,640	2,010	2,780
Other	2,770 r	4,180 r	1,160	2,110
Total	30,700	48,200	43,100	69,600
Grand total	209,000	367,000	231,000	375,000

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

Source: U.S. Census Bureau.

TABLE 15
TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1, 2]

(Metric tons)

Concentrate type and country	1998	1999	2000	2001	2002[e]
Ilmenite and leucoxene:[3, 4]					
Australia:					
Ilmenite	2,413,000	1,976,000	2,146,000	2,017,000	1,917,000 [5]
Leucoxene	30,000	32,000	27,000	30,000	39,000 [5]
Brazil[6]	103,000	96,000	123,000	111,113 [r]	115,000
China[e]	175,000	180,000	185,000	185,000	185,000
Egypt	125,000	130,000	125,000	125,000	125,000
India[e]	378,000	378,000	380,000	430,000	460,000
Malaysia	124,689	127,695	124,801	129,750 [r]	106,046 [5]
Norway[e]	590,000	600,000	750,000	750,000	750,000
Sri Lanka	34,118	--	--	--	--
Ukraine	507,435	536,542	576,749	650,000 [r]	670,000
United States	W	W	400,000 [7]	500,000 [7]	400,000 [5, 7]
Vietnam	80,000 [e]	91,000 [e]	174,000	180,000	180,000
Total	4,560,000	4,150,000	5,010,000 [8]	5,110,000 [r, 8]	4,950,000 [8]
Rutile:					
Australia	238,000	179,000	208,000	206,000	218,000 [5]
Brazil[6]	1,800	4,300	3,162	1,791 [r]	2,000
India[e]	16,000	16,000	17,000	19,000	18,000
South Africa[e]	130,000	100,000	100,000	90,000	100,000
Sri Lanka	1,930	--	--	--	--
Ukraine[e]	50,000	49,000	58,600	60,000	70,000
United States	W	W	(9)	(9)	(9)
Total	438,000	348,000	387,000	377,000 [r]	408,000
Titaniferous slag:[10]					
Canada[e]	950,000	950,000	950,000	950,000	900,000
South Africa	1,100,000 [e]	1,168,000 [r]	1,057,000 [r]	1,090,000 [r]	1,150,000
Total	2,050,000	2,120,000 [r]	2,010,000 [r]	2,040,000 [r]	2,050,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1]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 July 15, 2003.

[3]Ilmenite is also produced in Canada and South Africa, but this output is not included here because most of it is duplicative of output reported under "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

[4]Small amounts of titanium minerals were reportedly produced in various countries. Information is, however, inadequate to make reliable estimates of output levels.

[5]Reported figure.

[6]Excludes production of unbeneficiated anatase ore.

[7]Includes rutile to avoid revealing company proprietary data. Rounded to one significant digit.

[8]Includes U.S. production, rounded to one significant digit, of ilmenite, leucoxene, and rutile to avoid revealing company proprietary data.

[9]Included with ilmenite to avoid revealing company proprietary data; not included in "Total."

[10]Slag is also produced in Norway, but this output is not included under "Titaniferous slag" to avoid duplicative reporting.