TITANIUM

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Titanium is a metallic element that occurs in many minerals, such as anatase, brookite, ilmenite, leucoxene, perovskite, rutile, and sphene. Of these minerals, only ilmenite, leucoxene, and rutile have significant economic importance. In general, 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 has comparable strength. Tests on titanium in a seawater environment have shown no measurable evidence of corrosion (Titanium Metals Corp., 1998§[1]). The combination of superior corrosion resistance and high strength-to-weight ratio fuels titanium's use in various applications such as aircraft engines, deep-well drill pipe, golf clubs, and military tanks.

On a tonnage basis, most titanium is not consumed in its metal form but as titanium dioxide (TiO_2) pigment, a white pigment in paints, paper, and plastics. TiO_2 pigment is characterized by its purity, refractive index, particle size, and surface properties. The superiority of TiO_2 as a white pigment is due mainly to its high refractive index and resulting light-scattering ability, which impart excellent hiding power and brightness.

Owing to a slowing global economy, demand for TiO_2 pigment was slightly lower in 2001 than in 2000. Demand for titanium metal was relatively high on a historic basis; however, a slowing economy and the terrorist actions of September 11 signaled the beginning of a cyclic downturn in demand for titanium metal. Although demand for titanium minerals was lower in 2001 compared with that of 2000, numerous exploration and development projects were in progress.

Legislation and Government Programs

In accordance with section 3305 of Public Law 104-106, 250 metric tons (t) of titanium sponge was transferred 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) 2001 is the sixth 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 transportation and handling costs (U.S. Department of Defense, 2002).

In March, the U.S. Department of Defense's Defense National Stockpile Center (DNSC) met its 4,540-t target for the sale of titanium sponge from the U.S. Government stockpile in FY 2001 (Defense National Stockpile Center, 2001b). In December, the DNSC announced a revised Annual Materials Plan for FY 2002 to allow for 6,345 t of titanium sponge to be offered for sale. At yearend 2001, the National Defense Stockpile held 18,600 t of titanium sponge (U.S. Department of Defense, Defense National Stockpile Center, 2001a).

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. A dredge is often used for the recovery of titanium-mineral placer deposits. Gravity spirals are used for wet separation of heavy minerals, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often beneficiated to produce synthetic rutile and 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 a pyrometallurgical process.

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 Trail Ridge mining operations in 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 operations in Green Cove Springs, FL, and Stony Creek, VA, produced both rutile and ilmenite concentrates. Kerr-McGee's operation in Mobile, AL, produced synthetic rutile. Titanium slag was not produced in the United States.

Altair International Inc. operated a mineral separation pilot plant near its heavy mineral deposits near Camden, TN. During 2001, 970 t of ore was processed through the test facility. According to the company, processing of the sample material yielded titanium recoveries in excess of 80%. The company planned to continue operating the plant in 2002 (Altair International Inc., 2002§).

Iluka Resources planned to expand its Old Hickory heavy mineral mining operations in Virginia. Capacity was expected to increase by 50% to 225,000 t/yr of ilmenite and was scheduled to be completed by the third quarter of 2002. The expansion project included a second mining pit and mobile wet separation plant. In addition, the existing dry separation plant is expected to be upgraded to remove bottlenecks (Industrial Minerals, 2001d).

Exploratory drilling and ground magnetics were conducted at Radar Acquisitions Corp.'s Limon project near Denver, CO. According to the company, the heavy minerals resource estimate was 14.2 million metric tons (Mt) grading 2.3%

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

ilmenite, 2.9% garnet, 0.1% rutile, and 0.5% zircon. Data on reserves were not available. The project also had potential as a source of lignite coal (Radar Acquisitions Corp., 2001§).

Metal.—Titanium sponge is the raw form of titanium metal. The first production step involves the chlorination of titanium-containing mineral feedstocks to produce titanium tetrachloride ($TiCl_4$). The next step is usually based on the Kroll process where $TiCl_4$ is reduced 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 and vanadium. Electron beam, plasma, 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 commonly produced by the following two techniques: 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 2001 included The Alta Group, Allegheny Technologies Inc. (ATI), and Titanium Metals Corp. (Timet). Owing to poor market conditions, ATI idled its 6,800 t/yr of sponge capacity in Albany, OR, during the first half of 2001. Yearend domestic operating capacity of titanium sponge was estimated to be 8,940 t/yr (table 2). Data on domestic production of titanium sponge is not been published in order to avoid disclosing company proprietary data. U.S. producers of titanium ingot included ATI, Howmet Corp., Lawrence Aviation Industries Inc., RMI Titanium Co., and Timet. About 43% of the 90,800 t/yr of domestic ingot capacity is based on cold hearth technology; the remainder uses vacuum-arc reduction. U.S. production of ingot increased by 13% compared with that of 2000 (table 3). More than 30 domestic companies were known to produce titanium mill products and castings from ingot and billet. U.S. production of mill products increased by 9% compared with that of 2000.

U.S. producers of ferrotitanium included Galt Alloys Inc., Global Titanium Inc., and Shieldalloy Metallurgical Corp. Data on production of ferrotitanium were not available.

In October, Timet was implementing reductions in operating rates at its Henderson, NV, and Morgantown, PA, facilities. At Henderson, Timet planned to reduce its ingot production by about 40%. At Morgantown, Timet planned to stop production on one of its three electron beam melting furnaces and reduce the operating rate on another furnace. Ingot production at Morgantown was expected to decline by about 20% (Titanium Metals Corp., 2001).

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 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 fine-size 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 crystalline form.

Although either process may be used to produce pigment, the decision to use one process instead of the other is based on a number of 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, silica, and organic compounds.

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 2001 was 1.33 Mt, a 5% decrease compared with that of 2000. 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). In addition, TOR Minerals International Inc. produced a buff pigment from finely ground synthetic rutile (table 4). Capacity utilization for the domestic pigment industry was about 85%.

In September, as part of a cost reduction plan, MIC temporarily idled the 44,000-t/yr sulfate-route TiO_2 pigment plant at its Hawkins Point facility in Baltimore, MD. Prior to its closure, the plant was a source of anatase-grade pigment for the paper industry. The closure left Kerr-McGee's Savannah, GA, plant as the only domestic producer using the sulfate process. The 50,000-t/yr chloride-route TiO_2 pigment plant at the Hawkins Point facility was not expected to be affected by the closure. As part of a debottlenecking program, capacity at MIC's Ashtabula, OH, facility was increased by 10,000 t/yr (Industrial Minerals, 2001g).

Consumption

Mineral Concentrates.—About 97% of the domestic consumption of titanium mineral concentrates was used to produce TiO_2 pigment. The remaining 3% 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 1.30 Mt, an 8% decrease compared with that of 2000 (table 6). On a gross weight basis, consumption of ilmenite and slag decreased by 6% and consumption of rutile and synthetic rutile decreased by 10% compared with those of 2000.

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 58% 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 increased by 18% compared with that of 2000. Sponge consumption increased by 44% compared with that of 2000, and scrap consumption decreased by 8%. Scrap supplied a calculated 61% of ingot feedstock. Estimated U.S. mill product usage by application was as follows: aerospace, 60%, and nonaerospace uses, 40%. 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 8,020 t, an 8% decrease compared with that of 2000 (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 (49.3%), plastics (25.0%) and paper (15.6%). 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 primarily consumes rutile-grade pigment. TiO_2 pigment is used in a variety of plastics applications. Primarily, 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 2001, U.S. apparent consumption of TiO_2 pigment was 1.10 Mt, a 5% decrease compared with that of 2000 (table 5).

Stocks

On a TiO_2 content basis, yearend consumer inventories of titanium mineral concentrates decreased by 7% compared with those of 2000 (table 9). While consumer stocks of rutile and synthetic rutile increased by 17%, stocks of ilmenite and slag decreased by 16% compared with those of 2000.

On a gross weight basis, yearend producer stocks of TiO_2 pigment were about 159,000 t, a 13% increase compared with those of 2000. During the year, pigment stocks had fallen to a low of 138,000 t in August, then rose significantly in the last quarter (U.S. Department of Commerce, U.S. Census Bureau, 2002§).

Owing to sales from the DNSC inventory, Government stocks of sponge decreased by 29% compared with that of 2000. Industry stocks of sponge increased by 27%, and stocks of scrap decreased by 4% compared with those of 2000. Stocks of titanium ingot decreased by 11% compared with those of 2000 (table 3).

Prices

The yearend published price range for bulk rutile mineral concentrates was $450 to $500 per metric ton, a decrease of about 2% compared with that of 2000. Meanwhile, the price range for bagged rutile concentrates commonly used in the welding rod coatings industry was $475 to $565 per ton, nearly unchanged compared with that of 2000. Yearend prices of ilmenite concentrates increased by 6% compared with those of 2000. Published prices for titanium slag were not available. Based on U.S. Customs Service value of imports, however, prices for Canadian slag decreased by about 6%, and prices for South African slag were nearly unchanged compared with those of 2000 (table 10).

Yearend published prices for anatase-grade pigment were unchanged, and rutile-grade pigments increased by 4% compared with those of 2000. Based on U.S. Customs Service value of imports, however, the average unit value of unfinished pigments and TiO_2 pigments with more than 80% TiO_2 content decreased by 4% compared with those of 2000.

Based on duty paid value of imports, the yearend value of titanium sponge decreased by 9% compared with that of 2000. Published prices for titanium scrap turnings decreased by 11%, and prices for ferrotitanium increased by 4% compared with those of 2000.

Foreign Trade

Mineral Concentrates.—The U.S. Department of Commerce's Census Bureau collects import and export data for mineral concentrates on a gross-weight basis.

Exports of titanium mineral concentrates are small relative to imports. In 2001, exports of titanium mineral concentrates were 7,800 t, a 59% decrease compared with exports in 2000 (table 11).

Imports of titaniferous iron ore from Canada (classified as ilmenite by the U.S. Census Bureau) are separated from ilmenite statistics in this report. In 2001, the leading import sources of ilmenite were Australia (56%), Ukraine (23%), and Malaysia (16%). Imports of ilmenite for 2001 were 467,000 t, a 21% increase compared with those of 2000. Increased imports from Australia and Malaysia contributed to the significant rise in imported ilmenite.

Canada (43%) and South Africa (57%) were the only import sources of titanium slag in 2001. Slag imported from Canada more than doubled, and overall slag imports increased by 11%, compared with that of 2000. Imports of slag from South Africa

decreased by 16%.

Australia (49%) and South Africa (43%) were the major sources of natural and synthetic rutile. In 2001, decreases in natural rutile imported from Australia led to a 25% decrease in overall imports of natural rutile compared with 2000. Synthetic rutile imports, primarily from Australia (81%), were 127,000 t, a 27% decrease compared with imports in 2000 (table 12).

Metal.—Imports of titanium metal are primarily in the form of titanium sponge (43%) and waste and scrap (37%). Kazakhstan (43%), Japan (37%), and Russia (17%) were the major sources of imported titanium sponge. Japan (26%), the United Kingdom (21%), France (14%), and Germany (11%) were the leading sources of imported waste and scrap. Compared with those of 2000, imports of unwrought metal, including sponge and waste and scrap, increased by 68% in 2001. Imports of wrought products and castings increased by 9% compared with 2000. Imports of ferrotitanium used in the iron and steel industry decreased by 32% compared with those of 2000.

Although the United States was import reliant on unwrought titanium, the Nation was a net exporter of wrought products. Increased exports of wrought products resulted in a 30% increase in all titanium export forms compared with those of 2000 (table 11).

TiO_2 Pigment.—The United States continued to be a net exporter of TiO_2 pigment. In 2001, exports exceeded imports by 2 to 1. Quantitatively, exports of titanium pigment and oxide were 415,000 t, a 10% decrease compared with that of 2000. About 84% of exports are in the form of finished pigment with more than 80% TiO_2 content. Approximately 9% of exports are in the form of unfinished pigment with the remaining 7% in other pigment with less than 80% TiO_2.

During 2001, 209,000 t of TiO_2 pigment and oxide was imported, a 4% decrease compared with the previous year (table 14). The leading import sources of titanium pigment were Canada (29%), Germany (10%), France (9%), and Spain (7%). Compared with those of 2000, imports of titanium pigment containing more than 80% TiO_2 decreased by 5% to 172,000 t; other titanium pigment decreased by 27% to 6,410 t; and titanium oxide (unfinished pigment) increased 6% to 30,700 t (table 14).

World Review

Owing to a slowing global economy, demand for titanium mineral concentrates weakened in 2001. World production of titanium mineral concentrates was estimated to be 4.76 Mt of contained TiO_2, nearly unchanged from that of 2000. 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 2001, numerous mineral sands projects under development had the potential to oversupply the titanium feedstock market.

World TiO_2 pigment production was about 3.8 Mt, nearly unchanged compared with that of 2000. 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, Europe, Japan, Russia, and the United States.

Australia.—Austpac Resources N.L. and Ticor Ltd. announced plans to construct a 10,000-t/yr synthetic rutile plant near Portland, Victoria. The initial plant was expected to demonstrate enhanced roasting and separation (ERMS) and enhanced acid regeneration system (EARS) technology. The ERMS process was known to remove chromite from ilmenite concentrates. A larger scale plant was expected to be constructed in India or the Murray Basin if the ERSM and EARS processes were proven to be technically and economically viable. In August, Austpac and Ticor announced a phased exploration program of the Horsham deposit in the Murray Basin. A low-level airborne geophysical survey was completed in September (Austpac Resources NL, 2001§).

Basin Minerals Ltd. was conducting a final feasibility study at its Douglas project in the Murray Basin, Victoria. According to the company, the resource contained 29.2 Mt of heavy minerals. In December, Basin Minerals filed an environmental effects statement with the Victorian Government. If commissioned in late 2003, production capacity was expected to be approximately 180,000 t/yr of ilmenite, 75,000 t/yr of zircon, 40,000 t/yr of rutile, 6,000 t/yr of leucoxene, and 300 t/yr of tin (cassiterite) (Basin Minerals Ltd., 2002§).

Bemax Resources NL conducted a bankable feasibility study on its Ginko project in the Murray Basin, New South Wales. According to the company, reserves would support a 440,000-t/yr heavy-minerals mine for 14 years. Production could begin in the second half of 2003 (Bemax Resources NL, 2002§).

Doral Mineral Sands made plans to begin mining at its deposit near Dardanup, Western Australia. Although wet separation will be done onsite, dry separation for the operation is expected to be performed at the nearby Picton plant. Doral purchased the Picton mill from ISK Minerals Ltd. The Dardanup operation was expected to produce 120,000 t/yr of titanium minerals (Western Australia Department of Mineral and Petroleum Resources, 2001§).

Iluka Resources announced it had commissioned a new mine and wet concentration plant at its Eneabba, Western Australia, operation. The new plant was expected to supply the Geraldton dry separation plant. Iluka continued its exploration efforts in the Murray Basin but did not expect any production prior to 2006 (Industrial Minerals, 2001c).

Magnetic Minerals Ltd. announced a 6.4 Mt resource estimate of heavy minerals at its Dongara project in Western Australia. Dongara is located in the Perth Basin near Iluka Resources' Eneabba operation. At yearend, a prefeasibility study was close to completion (Magnetic Minerals Ltd., 2001§).

Murray Basin Titanium Joint Venture (Sons of Gwalia Ltd., RZM Pty Ltd., Cable Sands (WA) Pty Ltd.) commissioned the Wemen mineral sands operation in the Murray Basin, Victoria.

When operational, the Wemen operation would produce approximately 30,000 t/yr rutile, 10,000 t/yr zircon, and 30,000 t/yr ilmenite during a mine life of approximately 6 years (Sons of Gwalia Ltd., 2001§).

Southern Titanium Corp. (formerly Murray Basin Minerals NL) acquired the remaining 60% interest in the Mindarie heavy mineral sands project held by its joint venture partner Steiner Holdings Pty Ltd. The Mindarie project is located in the Murray Basin, Western Australia, with proven and probable reserves (as of November 2001) of 1.86 Mt of heavy minerals. A bankable feasibility study was underway in 2001 and was expected to be completed in 2002. Mining was tentatively scheduled to begin in late 2002 (Southern Titanium Corp., 2002§).

Belgium.—Kerr-McGee announced plans to idle its TiO_2 pigment plant in Antwerp by yearend 2001. Kerr McGee is the third largest producer of TiO_2 pigment in the world, with about 600,000 t/yr capacity (Kerr-McGee Corp., 2001§). Capacity at the Antwerp plant was estimated to be 30,000 t/yr.

Brazil.—Millennium Inorganic Chemicals do Brasil SA was in the process of increasing capacity at its Mataraca mine, Paraiba. At yearend, a new dredge neared completion, increasing capacity by 20,000 t/yr to 120,000 t/yr (Industrial Minerals, 2001h)

Canada.—In March, NAR Resources Ltd. and Titanium Corporation of Canada Ltd. joined to form Titanium Corporation Inc. In December, Titanium Corporation Inc. made plans with the Minerals Engineering Centre at Dalhousie University for a laboratory-scale pilot testing facility in Halifax, Nova Scotia. This pilot facility will process raw material from its Nova Scotia mineral sands project on the Shubenacadie River near Maitland. According to the company, the facility is expected to process bulk samples from its 330-Mt reserve of heavy minerals into concentrates for evaluation by potential consumers (Titanium Corporation Inc., 2001a§, b§).

Finland.—Kemira Pigments announced plans to increase capacity at its TiO_2 pigment facility in Pori. Capacity is expected to be increased to 130,000 t/yr from the current [2001] 120,000 t/yr through process improvements. According to the company, the long-term goal is to increase capacity to 150,000 t/yr. The Pori facility is based on the sulfate process with ilmenite as its primary titanium mineral feedstock (Industrial Minerals, 2001e).

Germany.—In March, a fire disrupted production at Kronos Inc.'s TiO_2 pigment facility at Leverkusen. In April, the chloride-route plant at the facility resumed production. By October, the 35,000-t/yr sulfate-route was fully operational (Industrial Minerals, 2001f).

India.—AustPac Resources NL was conducting engineering and cost studies at its AusRutile synthetic rutile project at Chatrapur, Orissa. The joint venture partners in the project are AustPac (37%), Ticor (37%), and Indian Rare Earths Ltd. (26%). If completed, the project's synthetic rutile plant would be supplied with ilmenite from Indian Rare Earths' adjacent Oscom mining operation. The project was expected to use AusPac's ERMS and EARS technology, and a small-scale facility was being constructed in Australia to demonstrate this technology (Industrial Minerals, 2001a).

Japan.—According to the Japan Titanium Society, sponge production in 2001 was 24,900 t, a 28% increase compared with that of 2000. Toho Titanium Co., one of the two titanium sponge producers in Japan, was proceeding with plans to increase its titanium sponge capacity to 12,000 t/yr (American Metal Market, 2001).

Kenya.—A suit filed by Kenyan citizens with the High Court of Mombasa prevented Tiomin Resources Inc. from proceeding with the development of the Kwale mining project. The plaintiffs claimed that Tiomin commenced mining without a mining permit, destroyed the local environment, and forced the local residents off their land. At yearend, a court order banned Tiomin from pursuing its exploration and development program in the project area and prohibited Tiomin from having any contact with the local residents (Tiomin Resources Inc., 2001§).

Madagascar.—QIT Madagascar Minerals Ltd. was granted an environmental permit by the Government of Madagascar for the proposed mineral sands project near Fort Dauphin. This followed a 3½-year environmental permitting phase. The company expected the project to enter a new phase incorporating market and engineering studies (Rio Tinto plc, 2002§).

Mozambique.—Kenmare Resources plc announced the completion of a definitive feasibility study on its Moma minerals project in northern Mozambique. According to the company, drilling and testwork indicate reserves suitable for supporting a production rate of 625,000 t/yr of titanium minerals for at least 20 years. An environmental impact assessment concluded that the project conformed with leading international environmental standards, and pilot plant operations demonstrated that concentrator and separator plants bought by Kenmare from Broken Hill Pty Ltd. in 2000 were suitable for Moma. In addition, the Government of Mozambique issued a mineral licence agreement and agreed to a concessionary taxation regime (Kenmare Resources plc, 2001§).

A bankable feasibility study was underway at the Corridor Sands project near Chibuto in southern Mozambique. If conditions are favorable, a 375,000-t/yr titanium slag facility could be completed in 2004. Future plans called for capacity to rise to 1 million metric tons per year. Proven and probable reserves at Corridor Sands are estimated to be more than 43 Mt of ilmenite. Corridor Sands is being developed by Southern Mining Corp., WMC Ltd., and Industrial Development Corp. (WMC Ltd., 2002§).

Saudi Arabia.—National Titanium Dioxide Co. Ltd. (Cristal) announced it would increase capacity at its Yanbu facility by 22,000 t/yr to 92,000 t/yr. Cristal is the country's sole producer of TiO_2 pigment (Industrial Minerals, 2001b).

South Africa.—Ticor acquired Iscor Ltd.'s 40% interest in the heavy-minerals mining and smelting project in KwaZulu Natal near Richards Bay. The remaining 60% interest is owned by Kumba Resources Ltd. The project was renamed Ticor South Africa. In 2001, Ticor South Africa commissioned the Hillendale mine and separation plant. Construction of the project's 250,000-t/yr smelter was underway, and the first production of slag was scheduled for 2003 (Ticor Ltd., 2002§).

Spain.—In September, Huntsman announced plans to increase capacity at its TiO_2 pigment plant near Huelva by 17,000 t/yr (Huntsman Corp., 2001§). In 2001, capacity at Huelva was 65,000 t/yr.

Outlook

Global demand for TiO_2 pigment is expected to remain near its current level in the coming year. 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 is consumed to produce TiO_2 pigment, consumption of titanium minerals is expected to continue to follow a similar trend in the future.

Over the next 1 to 2 years, a slowing of the global economy and the terrorist actions in September 2001 are expected to depress demand for titanium metal, particularly in the aerospace and chemical process industries. However, long-term growth in passenger traffic and nonaerospace markets is expected to result in a 5% per year demand growth during the next decade.

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TABLE 1
SALIENT TITANIUM STATISTICS 1/

(Metric tons, unless otherwise specified)

	1997	1998	1999	2000	2001
United States:					
Ilmenite and titanium slag:					
Imports for consumption	952,000	1,010,000	1,070,000	918,000	1,060,000
Consumption	1,520,000 2/	1,300,000 3/	1,280,000 3/	1,250,000 3/	1,180,000 e/ 3/
Rutile concentrate, natural and synthetic:					
Imports for consumption	336,000	387,000	344,000	438,000	325,000
Consumption	489,000	421,000	494,000	537,000	483,000 e/
Sponge metal:					
Imports for consumption	16,100	10,900	6,000	7,240	13,300
Consumption	32,000	28,200	18,100	18,200	26,200
Price, yearend, dollars per pound	$3.69 r/	$4.54 r/	$3.58 r/	$3.95 r/	$3.58
Titanium dioxide pigment:					
Production	1,340,000	1,330,000	1,350,000	1,400,000	1,330,000
Imports for consumption	194,000	200,000	225,000	218,000	209,000
Consumption, apparent 4/	1,130,000	1,140,000	1,160,000	1,150,000	1,100,000
Price, December 31, dollars per pound:					
Anatase	$1.01-$1.03	$.96-$.98	$.92-$.94	$.92-$.94	$.92-$.94
Rutile	$1.04-$1.06	$.97-$.99	$.99-$1.02	$.99-$1.02	$1.00-$1.09
World, production					
Ilmenite concentrate	4,470,000	4,560,000 r/	4,150,000 r/	5,010,000 r/ 5/	5,060,000 e/ 5/
Rutile concentrate, natural	425,000 r/	438,000 r/	348,000 r/	387,000 r/ 6/	378,000 e/ 6/
Titaniferous slag	1,950,000	2,050,000	2,050,000	2,070,000	2,050,000 e/

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

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2001 1/ 2/

		Yearend capacity (metric tons)	
Company	Plant location	Sponge	Ingot 3/
Allegheny Technologies Inc.	Albany, OR	-- 4/	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	--	15,400
Titanium Metals Corp.	Henderson, NV	8,600 5/	12,300
Do.	Morgantown, PA	--	25,000
Do.	Vallejo, CA	--	800
Total		8,940	90,800

-- 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.
4/ Sponge plant idled in the first half of 2001.
5/ Excludes idle magnesium reduced/acid leach sponge plant.

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

(Metric tons)

Component	2000	2001
Production:		
Ingot	39,600	44,600
Mill products	25,500 r/	27,900
Exports:		
Sponge	1,930	2,170
Waste and scrap	5,060	7,500
Other unwrought 2/	3,200	3,840
Wrought products and castings 3/	5,380	6,700
Total	15,600	20,200
Imports:		
Sponge	7,240	13,300
Waste and scrap	7,550	11,600
Other unwrought 2/	1,810 r/	3,040
Wrought products and castings 3/	2,900	3,170
Total	19,500	31,100
Stocks, yearend:		
Government, sponge (total inventory)	26,300	18,600
Industry:		
Sponge	5,010	6,340
Scrap	5,150	4,920
Ingot	6,910	6,180
Consumption, reported		
Sponge	18,200	26,200
Scrap	18,500	17,000
Ingot	27,400	30,900
Shipments:		
Mill products (net shipments):	25,500 r/	23,000
Forging and extrusion billet	12,700 r/	11,000
Plate, sheet, strip	8,790 r/	6,600
Rod, bar, fastner stock, wire	3,290 r/	4,560
Other 4/	735 r/	837
Castings (shipments)	658	704
Receipts, scrap:		
Home	5,820	5,760
Purchased	15,600	16,800

r/ Revised.

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, 2001 1/ 2/ 3/

Company	Plant location	Yearend capactiy (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	-- 4/	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.
4/ Sulfate plant with a capacity of 44,000 metric tons per year was idled in September 2001.

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

(Metric tons, unless otherwise specified)

	2000		2001	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production 2/	1,400,000	1,320,000 e/	1,330,000	1,250,000 e/
Shipments: 3/				
Quantity	1,470,000	1,380,000	1,370,000	1,290,000
Value thousands	$2,760,000	$2,760,000	$2,590,000	$2,590,000
Exports	464,000	436,000 e/	415,000	391,000 e/
Imports for consumption	218,000	205,000 e/	209,000	197,000 e/
Stocks, yearend e/	141,000 e/	133,000 e/	159,000	150,000 e/
Consumption, apparent 4/ e/	1,150,000	1,090,000	1,100,000	1,040,000

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)

	2000		2001	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Ilmenite and titanium slag: 2/ 3/				
Pigments	1,240,000	NA	1,160,000	NA
Miscellaneous 4/	13,900	NA	15,400	NA
Total	1,250,000	919,000	1,180,000	856,000
Rutile, natural and synthetic:				
Pigments	513,000	NA	455,000	NA
Miscellaneous 4/	24,100	NA	28,500	NA
Total	537,000	497,000	483,000	448,000
Total concentrates:				
Pigments	1,750,000	NA	1,620,000	NA
Miscellaneous 4/	38,000	NA	43,900	NA
Total	1,790,000	1,420,000	1,660,000	1,300,000

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, welding-rod coatings and fluxes, ceramics, chemicals, glass fibers, and titanium metal.

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

(Metric tons)

	2000 r/	2001
Carbon steel	3,580	3,170
Stainless and heat-resisting steel	2,570	2,950
Other alloy steel (includes HSLA and tool steel)	787	754
Total steel	6,940	6,870
Superalloys	918	827
Alloys, other than above	794	303
Miscellaneous and unspecified	21	18
Total consumption	8,670	8,020

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	2000	2001
Coated fabrics and textiles	0.2	0.1
Paint, varnish, lacquer	49.5	49.3
Paper	20.4	15.6
Plastics	21.3	25.0
Rubber	1.0	1.0
Other 2/	7.6 r/	9.0
Total	100.0	100.0

r/ Revised.
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)

	2000		2001	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Concentrates: 2/				
Ilmenite and titanium slag	337,000	262,000	286,000	221,000
Rutile, natural and synthetic	109,000	101,000	127,000	118,000
Titanium pigment 3/	141,000	133,000 e/	159,000	150,000 e/

e/ Estimated.
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

		2000	2001
Concentrates:			
Ilmenite, free on board (f.o.b.) Australian ports 1/	per metric ton	$83.00-$105.00	$90.00-$110.00
Rutile, bagged, f.o.b. Australian ports 1/	do.	480.00-570.00	475.00-565.00
Rutile, bulk, f.o.b. Australian ports 1/	do.	470.00-500.00	450.00-500.00
Titanium slag, Canada 80% TiO_2 2/	do.	362	335
Titanium slag, Canada 95% TiO_2 2/	do.	547	518
Titanium slag, South Africa, 85% TiO_2 2/	do.	425 r/	419
Metal:			
Sponge 2/	per pound	3.95 r/	3.58
Scrap, turnings, unproccessed 3/	do.	.75-.80	.68-.70
Ferrotitanium, 70% Ti 3/	do.	1.55-1.63	1.60-1.70
Pigment:			
TiO_2 pigment, f.o.b. U.S. plants, anatase 4/	do.	.92-.94	.92-.94
TiO_2 pigment, f.o.b. U.S. plants, rutile 4/	do.	.99-1.02	1.00-1.09

r/ Revised.
1/ Source: Industral Minerals.
2/ Landed duty-payed 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/

	2000		2001	
Class	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:				
Unwrought:				
Sponge	1,930	$11,400	2,170	$13,800
Waste and scrap	5,060	12,700	7,500	18,300
Other unwrought:				
Billet	263	6,320	210	5,020
Blooms and sheet bars	1,460	51,700	1,620	47,700
Ingot	829	11,900	1,510	21,600
Other	649	12,600	492	17,400
Wrought products and castings:				
Bars and rods	2,400	81,000	3,440	108,000
Other	2,980	172,000	3,260	156,000
Total metal	15,600	360,000	20,200	387,000
Ores and concentrates	18,900	7,920	7,800	3,130
Pigment and oxides:				
80% or more titanium dioxide and other titanium dioxide pigments	423,000	703,000	379,000	602,000
Titanium oxides	41,000	80,500	36,700	65,800
Total	464,000	784,000	415,000	667,000

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

Source: U.S. Census Bureau.

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

	2000		2001	
Concentrate and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:				
Australia	209,000	$23,100	261,000	$20,100
India	29,400	2,560	25,300	2,430
Malaysia	26,000	1,240	74,200	4,780
Ukraine	121,000	10,300	107,000	10,100
Total	386,000	37,200	467,000	37,400
Titanium slag:				
Canada	123,000	52,600	258,000	98,900
Norway	10,000	3,800	--	--
South Africa	400,000	162,000	336,000	140,000
Other	30	27	--	--
Total	533,000	219,000	594,000	239,000
Rutile, natural:				
Australia	113,000	47,600	56,000	29,700
Canada	1,080	724	382	160
Korea, Republic of	172	223	--	--
South Africa	140,000	58,500	141,000	58,600
Ukraine	10,000	3,920	--	--
Other 2/	4	8	40	70
Total	265,000	111,000	197,000	88,500
Rutile, synthetic:				
Australia	159,000	51,600	103,000	30,000
India	9,050	3,750	--	--
Malaysia	5,700	3,080	3,040	1,780
Other	45	61	21,600	7,250
Total	173,000	58,400	127,000	39,000
Titaniferous iron ore, Canada 3/	88,200	4,890	55,500	6,500

-- 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-furance flux. Titaniferous iron ore from Canada is classified as ilmenite under the Harmonized Tariff Schedule.

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	2000 Quantity (metric tons)	2000 Value (thousands)	2001 Quantity (metric tons)	2001 Value (thousands)
Unwrought:				
Sponge:				
Japan	3,790	$29,200	4,900	$38,600
Kazakhstan	2,170	13,500	5,690	34,400
Russia	1,200	6,780	2,220	11,800
Other	77	381	450	1,430
Total	7,240	49,900	13,300	86,200
Waste and scrap:				
Canada	155	373	427	1,160
France	1,220	3,910	1,590	6,730
Germany	693	2,350	1,310	6,000
Italy	491	1,550	537	1,810
Japan	1,760	5,760	3,000	10,200
Mexico	73	196 r/	423	1,300
Russia	692	2,280	445	1,520
Sweden	251	881	212	901
Taiwan	81	225	367	1,040
United Kingdom	1,360	4,670	2,440	8,240
Other	774 r/	1,900 r/	834	2,280
Total	7,550	24,100	11,600	41,200
Ingot and billet:				
Germany	63	530	269	2,450
Japan	105	3,570	35	3,650
Russia	1,240	14,800	1,790	22,900
United Kingdom	76	3,710	165	5,580
Other	53 r/	634 r/	95	933
Total	1,540	23,200	2,360	35,500
Powder	250	2,610	160	1,840
Other: 2/				
Canada	17	102	6	8
France	--	--	194	1,100
Japan	(3/)	130	163	1,150
Russia	--	--	50	654
United Kingdom	4	87	66	401
Other	2	79	43	263
Total	23	398	522	3,580
Wrought products and castings: 4/				
Belgium	27	1,180	18	1,450
Canada	123	3,170	179	4,590
China	59	1,220	164	4,550
France	20	1,480	22	1,720
Germany	73	2,360	68	1,310
Italy	113	2,010	141	2,670
Japan	643	15,700	590	14,300
Russia	1,510	24,800	1,780	37,000
Sweden	71	1,370	18	307
United Kingdom	152	4,800	52	2,710
Other	109 r/	2,560 r/	137	2,170
Total	2,900	60,600	3,170	72,800
Ferrotitanium and ferrosilicon-titanium	6,050	15,900 r/	4,120	10,800

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/ Less than 1/2 unit.

4/ 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	2000 Quantity (metric tons)	2000 Value (thousands)	2001 Quantity (metric tons)	2001 Value (thousands)
80% or more titanium dioxide:				
Belgium	3,030	$5,410	1,970	$3,630
Canada	64,000	111,000	58,600	101,000
China	5,910	7,450	4,880	6,330
Finland	1,870	4,230	3,340	6,650
France	5,760	9,290	6,940	10,400
Germany	24,100	50,300	18,400	38,600
Italy	8,400	13,900	11,500	17,900
Japan	6,920	18,900	5,840	16,900
Korea, Republic of	3,480	4,680	5,390	7,130
Mexico	8,200	14,400	6,530	10,800
Netherlands	738	1,180	42	122
Norway	6,290	11,000	4,770	8,110
Singapore	3,010	5,300	3,980	6,830
Slovenia	2,730	5,040	2,480	4,260
South Africa	7,690	13,800	8,020	13,200
Spain	15,700	27,300	14,000	22,500
Ukraine	7,330	9,020	10,500	13,200
United Kingdom	3,980	6,770	3,370	5,530
Other	1,260 r/	1,870 r/	1,240	1,630
Total	180,000	320,000	172,000	294,000
Other titanium dioxide:				
Austria	19	304	226	4,560
Belgium	2,610	6,110	807	1,750
Canada	3,110	5,560	2,380	5,510
Germany	1,670	4,930	943	2,740
United Kingdom	81	256	231	3,580
Other	1,260 r/	3,570 r/	1,820	10,700
Total	8,760	20,700	6,410	28,900
Titanium oxide:				
Belgium	1,440	2,400	635	1,010
Canada	--	--	39	79
China	6,350	7,040	5,900	6,630
Czech Republic	2,030	3,660	2,270	3,780
France	7,180	10,900	12,100	18,500
Germany	935	2,140	1,510	2,480
Japan	630	6,640	419	4,090
Korea, Republic of	570	781	3,650	4,880
Poland	2,520	4,540	2,120	3,640
Ukraine	7,050	8,800	1,060	1,340
Other	260 r/	599 r/	1,040	1,740
Total	29,000	47,500	30,700	48,200
Grand total	218,000	389,000	209,000	367,000

r/ Revised. -- Zero.

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	1997	1998	1999	2000	2001 e/
Ilmenite and leucoxene: 3/					
Australia:					
Ilmenite	2,233,000	2,413,000 r/	1,976,000 r/	2,146,000 r/	2,017,000 4/
Leucoxene	32,000	30,000	32,000	27,000	30,000 4/
Brazil 5/	97,174	103,000	96,000 e/	123,000 r/ e/	125,000
China e/	170,000	175,000	180,000	185,000	185,000
Egypt	125,000	125,000	130,000	125,000	125,000
India e/	332,000	378,000	378,000	380,000	430,000
Malaysia	167,504	124,689	127,695	124,801 r/	122,462 4/
Norway e/	750,000	590,000	600,000	750,000 r/	750,000
Sri Lanka	17,970	34,118	--	--	--
Ukraine	500,000 e/	507,435	536,542	576,749	600,000
United States	W	W	W	400,000 e/ 6/	500,000 6/
Vietnam e/	50,000	80,000	91,000	174,000 r/	180,000
Total	4,470,000	4,560,000 r/	4,150,000 r/	5,010,000 r/ 7/	5,060,000 7/
Rutile:					
Australia	233,000 r/	238,000 r/	179,000 r/	208,000 r/	206,000 4/
Brazil	1,742	1,800 e/	4,300 e/	3,162 r/	3,200
India e/	14,000	16,000	16,000	17,000	19,000
South Africa e/	123,000	130,000	100,000	100,000	90,000
Sri Lanka	2,970	1,930	--	--	--
Ukraine e/	50,000	50,000	49,000	58,600	60,000
United States	W	W	W	(8/) e/	(8/)
Total	425,000 r/	438,000 r/	348,000 r/	387,000 r/	378,000
Titaniferous slag: e/ 9/					
Canada	850,000	950,000	950,000	950,000	950,000
South Africa	1,100,000	1,100,000	1,100,000	1,120,000	1,100,000
Total	1,950,000	2,050,000	2,050,000	2,070,000	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, 2002.

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/ Reported figure.

5/ Excludes production of unbeneficiated anatase ore.

6/ Includes rutile to avoid revealing company proprietary data. Rounded to one significant digit.

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

8/ Included with ilmenite to avoid revealing company proprietary data; not included in "Total."

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