



2010 Minerals Yearbook

TITANIUM

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Although import dependent on titanium mineral concentrates and titanium sponge, the United States continued to be a net exporter of titanium dioxide (TiO₂) pigment and wrought titanium metal products. Improving global economic conditions caused domestic production of TiO₂ pigment to increase by 7% compared with that of 2009. After declining in 2009, demand for titanium metal from the commercial aerospace industry rebounded, resulting in increased domestic production of titanium ingot and mill products. U.S. consumption of titanium used in steel and other alloys increased by 25% from that in 2009.

World production of TiO₂ contained in titanium mineral concentrates increased by 13% compared with that of 2009. The leading sources of imports of titanium mineral concentrates were Australia, Canada, and South Africa. Global TiO₂ pigment production capacity was estimated to be 5.7 million metric tons per year (Mt/yr).

Legislation and Government Programs

The Defense Advanced Research Projects Agency (DARPA) continued to fund work on low-cost extraction of titanium metal from oxide ores. DARPA efforts were aimed at producing high-quality titanium at a cost of less than \$8.81 per kilogram. In fiscal year (FY) 2010, the DARPA program demonstrated production of commercially pure titanium at a rate of 500 pounds per day. In FY 2011, DARPA planned to demonstrate consolidation of titanium powder without using conventional melting techniques (Defense Advanced Research Projects Agency, 2011, p. 154).

Oak Ridge National Laboratory (ORNL), a science and technology laboratory managed for the U.S. Department of Energy by UT-Battelle, LLC, was developing methods to consolidate new and conventional titanium powders into net shape components. ORNL hoped to reduce the scrap generation and energy consumption during the fabrication of titanium components (Muth, 2011).

In 2010, two U.S. Department of Defense (DOD) programs were underway to improve the supply of titanium metal. Under a Title III agreement, International Titanium Powder (ITP) (a subsidiary of Cristal Global) was working with DOD to produce low-cost metallic titanium powder. Title III of the Defense Production Act (50 U.S.C. App. 2061 et seq.) is a program specifically designed to establish, expand, maintain, or modernize industrial capabilities required for national defense. Instead of sponge produced by magnesium reduction via the Kroll process, ITP planned to produce titanium metal powder by sodium reduction via the Armstrong process. ITP completed construction of a new 2,000-metric-ton-per-year (t/yr) plant in Ottawa, IL, and was expected to begin production in 2011 (Metal-Pages, 2010b). A second Title III effort was aimed at

reducing cost and shortening delivery lead times for structural titanium and titanium armor. The initial goal of the second program was to direct roll titanium in widths and thicknesses that could be used for armor tiles on military ground vehicles (U.S. Department of Defense, 2011, p. 72).

Production

Titanium industry data for this report are collected by the U.S. Geological Survey (USGS) from annual and quarterly surveys of domestic titanium operations. In 2010, the USGS annual survey canvassed titanium mineral and pigment production operations. The two producers of titanium mineral concentrates responded, but data were withheld to avoid disclosing company proprietary information. Of the six active domestic TiO₂ pigment operations, four responded. Production from the operations that did not respond were estimated on the basis of prior year production levels and industry trends. Production of titanium ingot and mill products was aggregated from a quarterly survey of producers.

Mineral Concentrates.—Titanium mineral concentrates of economic importance include ilmenite, leucoxene, rutile, synthetic rutile, and titaniferous slag. Mining of titanium minerals is usually performed using surface methods. Dredging and dry mining techniques are used for the recovery of heavy minerals. Gravity spirals are used to separate the heavy-mineral suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often processed to produce a 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 TiO₂ content of 75% to 95% is produced commercially using pyrometallurgical processes.

U.S. mineral concentrate producers were DuPont Titanium Technologies [a subsidiary of E.I. du Pont de Nemours and Co. (DuPont)] and Iluka Resources, Inc. (a subsidiary of Iluka Resources Ltd.). 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 TiO₂ pigment plants. In 2010, Iluka produced titanium mineral concentrates from its heavy-mineral operations near Stony Creek, VA.

A drilling program was underway at Cardero Resource Corp.'s Titac and Longnose deposits near Duluth, MN. Longnose and Titac are oxide-bearing ultramafic intrusions that contain disseminated, semimassive, and massive titanium-iron oxide mineralization. The intrusions are primarily composed of dunite, peridotite, and pyroxenite, and contain about 15% to 40% titanium-iron oxides. Drilling was expected to be completed in 2011 along with an updated resource estimate (Cardero Resource Corp., 2010).

DuPont extended the mine life of its Starke operation beyond 2017 through the acquisition of a 788 hectare parcel of timberland in Baker County from the Cummer Land Trust. DuPont has produced heavy-mineral concentrates from deposits along the Trail Ridge ore body since 1949 (Szakonyi, 2010).

Metal.—Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride (TiCl_4), which is reduced with magnesium (Kroll process) or sodium (Hunter process) to form a commercially pure form of titanium metal. As the metal is formed, it has a porous appearance and is referred to as sponge. Titanium ingot and slab are 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 (EB), plasma arc melt (PAM), scull, and vacuum-arc remelting (VAR) are the commercial methods used to produce ingot and slab. Titanium mill products are produced from the drawing, forging, and rolling of titanium 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, but may be produced through the aluminothermic reduction of ilmenite. The two standard grades of ferrotitanium that are normally produced contain 40% and 70% titanium. Domestic ferrotitanium capacity was estimated to be 17,300 t/yr.

In 2010, U.S. producers of titanium sponge were Allegheny Technologies Inc. (ATI), Honeywell Electronic Materials Inc., and Titanium Metals Corp. (Timet). ATI's Rowley, UT, plant and Timet's Henderson, NV, plant produced titanium sponge using the Kroll process. Honeywell Electronic Materials' plant in Salt Lake City, UT, produced titanium sponge using the Hunter process and supported the company's production of electronic-grade titanium. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data (table 2). Owing to increased demand from the commercial aerospace industry, U.S. production of titanium ingot and mill products increased significantly in 2010 (table 3). U.S. producers of ferrotitanium were RTI International Metals Inc. (Canton, OH) and Global Titanium Inc. (Detroit, MI). 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 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. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. Although either process may be used to produce pigment, the decision of which process to use 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 pigment is less reactive with the binders in paint when exposed to sunlight than is the anatase pigment and is preferred for use in outdoor paints. Anatase pigment has a bluer tone than rutile, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which it is produced and subsequently finished, TiO_2 pigment can exhibit a wide range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO_2 pigment was 1.32 million metric tons (Mt) in 2010, a 7% increase compared with that in 2009 (table 5). U.S. producers of TiO_2 pigment by the chloride process were Cristal Global, DuPont, Louisiana Pigment Co. L.P. (a joint venture of NL Industries, Inc. and Huntsman Corp.), and Tronox Inc. (table 4). TOR Minerals International, Inc. produced a buff TiO_2 pigment from finely ground synthetic rutile.

Consumption

Mineral Concentrates.—On a gross weight basis, 95% of the domestic consumption of titanium mineral concentrates was used to produce TiO_2 pigment. The remaining 5% was used to produce miscellaneous other products, including fluxes, metal, and welding rod coatings. Based on TiO_2 content, domestic consumption of titanium mineral concentrates was 1.46 Mt, an 8% increase compared with that of 2009 (table 6). Consumption data for titanium concentrates were estimated by the USGS owing to insufficient response by industry to the voluntary survey for consumption data.

Metal.—Titanium metal alloys are used for their high strength-to-weight ratio and corrosion resistance. In general, production of titanium mill products precede aircraft deliveries by about 1 year. In 2010, mill product shipments increased by 62% because of increased aircraft build rates and higher inventory levels throughout the titanium supply chain (table 3). The aerospace industry (67%) was the leading end use for mill products. Other uses included those in the consumer goods, marine, medical, oil and gas, pulp and paper, and specialty chemical industries.

A significant quantity of titanium in the form of ferrotitanium, scrap, and sponge is consumed in the steel and nonferrous alloy industries. In the steel industry, titanium is used for deoxidation, grain-size control, and controlling and stabilizing carbon and nitrogen content. Titanium-intensive steels include interstitial-free, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 11,700 t, a 25% increase compared with that of 2009 (table 7). Increased demand from the specialty steel industry resulted in an increase in ferrotitanium consumption.

TiO_2 Pigment.—Owing to increased global consumption, domestic production of TiO_2 pigment increased by 7% while domestic consumption increased slightly compared with that of 2009 (table 5). The leading uses of TiO_2 pigment, based on TiO_2 pigment shipments in the United States, were paint and coatings

(57.1%), plastics and rubber (27.4%), and paper (9.7%). Other uses (5.8%) included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules (table 8).

Stocks

Insufficient data were available to determine yearend consumer inventories of titanium mineral concentrates and TiO₂ pigment producer stocks. Owing to increased consumption by the aerospace and steel industries, yearend domestic stocks of sponge decreased by 32% compared with those in 2009. Because titanium metal producers anticipated increased consumption, domestic stocks of ingot increased by 9% in 2010 (table 3).

Prices

Yearend titanium mineral concentrate prices are listed in table 9. Owing to increased demand from TiO₂ pigment producers, prices for bulk ilmenite and rutile concentrates were higher compared with prices in 2009. Published prices for titanium slag were not available. Based on U.S. Customs Service data, the yearend unit value of slag imports ranged from \$367 to \$433 per metric ton in 2010 compared with \$401 to \$439 per ton in 2009.

The U.S. Department of Labor, Bureau of Labor Statistics, yearend producer price index (PPI) for TiO₂ pigment increased by 18% compared with that of 2009. The monthly PPI started the year at 165, was nearly unchanged at midyear, and then rose to 194 by yearend (U.S. Department of Labor, Bureau of Labor Statistics, 2011).

A resurgence in demand from aircraft programs and an improving global economy caused prices of titanium mill products to rise. At yearend, the monthly PPI for titanium mill products reached a high of 203. Sponge and ingot prices were less affected by short-term demand because of long-term contracts (U.S. Department of Labor, Bureau of Labor Statistics, 2011).

Foreign Trade

Mineral Concentrates.—Imports of titanium mineral concentrates include ilmenite, rutile, synthetic rutile, and titaniferous slag. The United States was heavily reliant on imports of titanium mineral concentrates because domestic consumption of titanium minerals greatly exceeded domestic production capacity. In 2010, the TiO₂ content of imports was estimated to be 966,000 t, primarily in the form of titaniferous slag (42%) and ilmenite (24%). South Africa, Australia, Canada, and Mozambique were, in descending order of TiO₂ quantity, the leading import sources. The combined value for all forms of titanium concentrate imports in 2010 was \$442 million (table 11). Because of increased steel production, imports of titaniferous iron ore from Canada, classified as ilmenite by the U.S. Census Bureau, increased significantly. Exports of titanium concentrates were minor relative to imports (tables 10–11).

Metal.—Total imports of titanium metal increased significantly in 2010. Imports of titanium metal were primarily in the form of sponge (51%), waste and scrap (27%), and wrought products and castings (22%). Japan and Kazakhstan

were the leading sources of imported titanium sponge, while Germany, the United Kingdom, Japan, and France were, in descending order, the leading sources of imported scrap. Germany supplied two-thirds of the imported titanium ingot, and China was the major source of titanium powder. Imports of powder and other unwrought forms of titanium increased significantly compared with those of 2009.

Imports of titanium wrought products and castings were primarily in the form of plate, sheet, strip, and foil (38%); bar, rod, profiles, and wire (29%); and billets (23%). Russia was the leading source of wrought products and castings. Imports of wrought products and castings increased to a record high 8,710 t. Owing to increased consumption of titanium for steel and other alloys, imports of ferrotitanium were 2,740 t, an 8% increase compared with those of 2009. The leading import sources were, in descending order, the United Kingdom, Russia, and Canada. Exports of ferrotitanium were 2,570 t, a 27% increase compared with those of 2009.

TiO₂ Pigment.—The United States continued to be a net exporter of TiO₂ pigment. In 2010, exports exceeded imports by a ratio of 3.7 to 1. Exports of TiO₂ pigment were 758,000 t, a 17% increase compared with those of 2009. About 95% of TiO₂ pigment exports was in the form of finished pigment with 80% or more TiO₂ content.

During 2010, 204,000 t of TiO₂ pigment was imported, a 17% increase compared with that in 2009. The leading import sources of TiO₂ pigment were Canada (39%) and China (12%). About 71% of pigment imports was in the form of finished pigment with more than 80% TiO₂ (table 13).

In November, the United States Bankruptcy Court for the Southern District of New York approved a reorganization plan for Tronox Inc. that would allow the company to emerge from Chapter 11 of the U.S. Bankruptcy Code. Under the plan, Tronox agreed to pay \$270 million to settle certain environmental liabilities as well as 88% of proceeds from pending litigation. Global TiO₂ production capacity for Tronox was 390,000 t/yr with operations in Hamilton, MS; Botlek, Netherlands; and Kwinana, Australia (50% ownership) (PRNewswire-FirstCall, 2010). In 2009, Tronox had idled its 110,000-t/yr TiO₂ operation in Savannah, GA.

World Review

Australia.—In August, the mining license for Astron Ltd.'s Donald mining project was approved by the Department of Primary Industries, Victoria, and mine and plant designs were completed during the year. Ore reserves were estimated to be 305 Mt, with 6.3% heavy minerals containing 32% ilmenite, 19% leucoxene, and 4.4% rutile (Astron Ltd., 2010a, b).

Diatreme Resources Ltd. was conducting exploration and prefeasibility studies on its heavy-mineral deposits in the Eucla Basin, Western Australia. The resource estimated for its Cyclone deposit was 3.1 Mt of heavy minerals with 1.32 Mt classified as measured and 1.59 Mt classified as indicated (Diatreme Resources Ltd., 2011, p. 6).

Gunson Resources Ltd. completed a definitive feasibility study for its Coburn heavy-minerals project in Western Australia. Reserves of heavy minerals including ilmenite, leucoxene, rutile, and zircon in the Coburn deposit were estimated to be 3.7 Mt

supporting a mine life of 17 years, with a production rate of 146,000 t/yr (Gunson Resources Ltd., 2010, p. 5–9).

Owing to increased demand for titanium minerals, Iluka significantly increased its production of ilmenite and rutile in Australia (250,000 t in 2010 compared with 141,000 t in 2009). The company's Australian ilmenite production also increased (218,000 t in 2010 compared with 159,000 t in 2009). Synthetic rutile production declined significantly (348,000 t in 2010 compared with 405,000 t in 2009) following Iluka's decision to idle two of four synthetic rutile kilns in Western Australia. The increases were largely because of the ramp up of its new operations in the Eucla Basin, South Australia, and the Murray Basin, Victoria. In 2010, Iluka's exploration and development efforts focused on the Eucla and Murray Basins and increased Iluka's mineral resource estimate of heavy minerals by 7.3 Mt (Iluka Resources Ltd., 2011, p. 3–4, 17–18).

Matilda Zircon Ltd. continued to develop heavy-minerals deposits in the Northern Territory and Western Australia. In 2010, Matilda Zircon formed an agreement with China-based Tricoastal Minerals Co. to take all heavy-mineral concentrate from the Tiwi Islands operations and supply \$2.5 million in loans and share placements to assist in development of the Lethbridge Mine, which began production in June. At yearend, the company expected approval from the Western Australian Minister of the Environment to proceed with the development of the Keysbrook deposit, 70 kilometers south of Perth. Mining at Keysbrook was expected to begin in 2012, with an 8-year mine life (Matilda Zircon Ltd., 2010, p. 8–11).

Owing to increasing demand for TiO₂ pigment, the Western Australia-based joint venture, Tiwest Pty Ltd., commissioned a 40,000-t/yr expansion project at its Kwinana TiO₂ pigment plant, raising production capacity to 150,000 t/yr. Tiwest operated the joint venture between Tronox Western Australia Pty Ltd. (50%) and subsidiaries of Exxaro Australia Sands Pty Ltd. (50%) (Exxaro Resources Ltd., 2011, p. 53).

Canada.—Titanium Corp. continued its research into the recovery of bitumen, volatile organic compounds, and heavy minerals, including ilmenite and leucoxene, from mined oil sand tailings. In 2010, Titanium Corp. commissioned a demonstration pilot plant at the Canadian Government's Canmet testing facilities in Devon, Alberta. Pilot studies were conducted during June through September, with additional studies planned for 2011 (Titanium Corp., 2010, p. 4).

In Quebec, Argex Mining Inc. was proceeding with exploration and development of its La Blache titaniferous magnetite project near Bai-Comeau. In 2010, Argex contracted with Met-Chem Canada Inc. to complete a resource estimate and with Process Research Ortech Inc. to develop a commercial process for the recovery of TiO₂. Argex contracted with Groupe BBA Inc. in preparation for a scoping study to evaluate the requirements for mining and milling operations, metallurgical processing facilities, and infrastructure. In 2010, a total of 20,300 meters were drilled on the La Blache Property (Argex Mining Inc., 2011, p. 2–3).

Chile.—White Mountain Titanium Corp. (WMT) was proceeding with the exploration and development of its Cerro Blanco rutile deposit. In 2010, WMT conducted drilling and pilot-plant feasibility studies. In 2011, WMT was scheduled

to conduct a final engineering feasibility study to support the development of a 5 to 6 Mt/yr mining operation for 20 years (White Mountain Titanium Corp., 2010).

China.—China's titanium metal and pigment production capacity continued to rise. According to the Chinese Titanium Association, the top 14 sponge producers increased sponge production capacity to 103,500 t/yr in 2010 and sponge production reached 57,800 t, up 42% from that in 2009. China's ingot (89,200 t/yr) and mill product (38,300 t/yr) production capacity also increased substantially (Zou, 2011). China's TiO₂ production and consumption was reported to have reached record levels in 2010. Production was 1.47 Mt, compared with 1.05 Mt in 2009, and domestic consumption was more than 1.4 Mt (Paint & Coatings Industry, 2011).

Although the development of domestic mine production was ongoing, increased consumption of titanium concentrates was met through increased imports of titanium mineral concentrates. In 2010, Chinese imports of titanium mineral concentrates nearly doubled to 2.04 Mt from 1.07 Mt in 2009. The unit value of imports was \$126 per metric ton compared with \$110 per metric ton in 2011 (United Nations Statistics Division, undated).

China's National Development and Reform Commission approved Panzhihua Iron Steel Group to develop vanadium and titanium resources and increasing processing titanium sponge and pigment capacity in Sichuan Province. Panzhihua planned to increase production capacity of titanium mineral concentrates to 500,000 t/yr, TiO₂ pigment to 200,000 t/yr, and titanium sponge to 15,000 t/yr (Steelguru.com, 2011).

Germany.—In May, Tronox Pigments GmbH changed its name to crenox GmbH. Sulfate-route TiO₂ production capacity at the Krefeld-Uerdingen operation was 107,000 t/yr (crenox GmbH, 2010).

India.—In June, Kerala Minerals & Metals Ltd. (KMML) produced the first batch of titanium from its new 500-t/yr sponge plant, the country's first commercial sponge plant. TiCl₄ was supplied to the plant from KMML's Chavara TiO₂ pigment plant. KMML also reported it had commissioned the country's first commercial nano-TiO₂ plant and a titanium oxychloride pilot plant (Kerala Minerals & Metals Ltd., undated).

Trimex Group continued its plan to produce up to 200,000 t/yr of ilmenite and 6,000 t/yr of rutile in the Srikurmam District, Andhra Pradesh. In 2010, Trimex completed the first phase of the Srikurmam project, including detailed engineering plans and finalizing the mining license agreement with the Government of India and private land owners (Trimex Sands Pvt. Ltd., 2010). Proven reserves were estimated to be 5.5 Mt of ilmenite (Industrial Minerals, 2008).

Japan.—Toho Titanium Co., Ltd. raised its overall sponge production capacity to 25,200 t/yr. Toho completed construction of a new 12,000-t/yr plant at Wakamatsu, Fukuoka Prefecture (Toho Titanium Co., Ltd., 2010). At its Chigasaki plant, Toho dismantled a portion of its production capacity that was deemed inefficient and reduced capacity to 13,200 t/yr from 16,000 t/yr (Toho Titanium Co., Ltd., 2011).

In August, OSAKA Titanium technologies Co., Ltd. resumed plans to increase capacity at its Amagasaki sponge plant to 38,000 t/yr (Japan Metal Bulletin, 2010). The expansion

plan followed a series of capacity increases. In 2008, sponge production capacity had been raised to 32,000 t/yr from 24,000 t/yr at Amagasaki, and ingot capacity had been increased at its Kishiwada plant to 10,000 t/yr from 7,000 t/yr in 2009 (OSAKA Titanium technologies Co. Ltd., 2010).

Kazakhstan.—Ust-Kamenogorsk Titanium-Magnesium Plant (UKTMP), the sole producer of titanium sponge in Kazakhstan, commissioned new VAR ingot production capacity in eastern Kazakhstan. A 16,000-t/yr ingot plant producing both commercially pure and alloy ingot was commissioned in 2010. In 2008 and 2009, UKTMP formed joint ventures in Europe and Asia to produce titanium mill products for industrial and aerospace markets (Metal-Pages, 2010a).

Kenya.—In July, Base Resources Ltd. acquired the Kwale mineral sands project from Vaaldiam Mining Inc. and began updating a definitive feasibility study completed by Vaaldiam in 2006. The feasibility study, drilling program, and process design review were completed by yearend. By 2014, Base Resources planned to begin production of heavy-mineral concentrates with production capacity for 330,000 t/yr of ilmenite, 79,000 t/yr of rutile, and 30,000 t/yr of zircon (Base Resources Ltd., 2011, p. 10–12).

Madagascar.—QIT Madagascar Minerals SA (QMM) was ramping up production at its 700,000-t/yr mineral sands project near Mutamba. QMM was a joint venture between Rio Tinto plc (80%) and the Government of Madagascar (20%). In 2010, QMM produced 287,000 t of ilmenite and planned to produce 473,000 t in 2011 (McNeish, 2011).

Mozambique.—Kenmare Resources plc was increasing heavy-minerals production at its Moma operation to design capacity. In 2010, the Moma operation produced 678,000 t of ilmenite, a 44% increase compared with that of 2009, and rutile production was 4,700 t, a 161% increase compared with that in 2009. In October, a breach of a settling pond allowed water to flood into a nearby village, causing one fatality. The mine was idled for 4 weeks while repairs and new safety measures were implemented. At yearend, Kenmare was proceeding with an expansion plan that would increase production capacity by about 50% (Kenmare Resources plc, 2011, p. 13).

Norway.—Nordic Mining ASA was developing an rutile-bearing eclogite deposit at Engebøfjellet in Sogn and Fjordane County. In 2010, Nordic Mining received approval from the Norwegian Climate and Pollution Agency to sell tailings from its proposed Engebøfjellet operation as capping material for contaminated sediments (Nordic Mining ASA, 2010).

Russia.—ARZM Uranium Holding Co. continued to develop the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. By 2014, the company planned to begin production of heavy-mineral concentrates including up to 35,000 t/yr of ilmenite, and 5,000 t/yr of rutile (ARZM Uranium Holding Co., 2010, p. 40).

Owing to improving market conditions, VSMPO-AVISMA Corp. resumed plans to increase its titanium sponge production capacity to 44,000 t/yr by 2015. VSMPO also was proceeding with plans to increase its capacity to produce forged and mill products to 45,000 to 46,000 t/yr by 2015 (Interfax, 2010).

Senegal.—A feasibility study of Mineral Deposits Ltd.'s Grande Cote heavy-minerals deposit was completed in 2010, allowing the company to secure financing to develop the project. Construction of the mine and separation plants was expected to begin in 2011, and initial production was scheduled for 2013. Once the mine and separation plants are fully commissioned, the company expected to produce an average of 575,000 t/yr of ilmenite, 80,000 t/yr of zircon, 11,000 t/yr of leucoxene, and 6,000 t/yr of rutile (Mineral Deposits Ltd., 2010, p. 16).

Sierra Leone.—A strategic review of Titanium Resources Group Ltd. (TRG) plans to optimize and expand its production was underway and expected to be completed in 2011. In 2010, production was hindered by a fire on its dredge, downtime following a move of the wet separation plant, and problems with slimes in the dredge pond. In 2011, TRG expected its ilmenite and rutile production to be similar to that in 2010 (18,200 t of ilmenite and 63,900 t of rutile), but a significant increase in production was expected in 2012 following the completion of process improvements. Subsequent to yearend, TRG changed its name to Sierra Rutile Ltd. (Sierra Rutile Ltd., 2011, p. 6–7).

South Africa.—In October, a burn-through caused both slag furnaces at Exxaro Resources Ltd.'s KZN Sands operation to be idle for 2 months. Despite production lost to maintenance and repair, total slag production from Exxaro's KZN Sands and Namakwa Sands operation increased by 16% to 284,000 t. Exxaro's Hillendale Mine neared the end of its life; however, plans were underway to develop the Fairbreeze deposit as a substitute for the waning production from the Hillendale Mine (Exxaro Resources Ltd., 2011, p. 45, 53).

Rio Tinto invested \$158 million in a tailings treatment facility at its Richards Bay Minerals heavy-minerals operation. At yearend, the treatment facility neared completion and was scheduled to begin production in the first quarter of 2011. Heavy-mineral concentrates, including ilmenite and rutile, were to be recovered from about 30 years accumulation of mine tailings (Industrial Minerals, 2010).

Ukraine.—Rutile-Ilmenite Co. (RICO) was planning to mine and process heavy-mineral sands at its deposit in Tarasovka. RICO planned to produce 51,000 t of heavy-mineral concentrates including ilmenite (6,000 t), leucoxene (20,000 t), rutile (15,000 t), and zircon (10,000 t) (Industrial Minerals, 2009).

Velta LLC announced plans to begin production at the Birzulvovske mining operation near Korobchino, Kirovograd Oblast in 2012. Initial capacity of the operation was expected to be 180,000 t/yr of ilmenite (Mineral Sands Report, 2010).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam continued to suspend a ban on exports of titanium and zirconium mineral concentrates designed to encourage the production of value-added products. Producers were permitted to export through the end of 2010 (Mineral Sands Report, 2009).

Outlook

For the foreseeable future, the market for titanium minerals is expected to be driven by the production of TiO₂ pigment. Unless new mines are developed, the U.S. reliance on imports

of titanium mineral concentrates is likely to increase as existing mines are expected to be depleted by 2020.

Global demand growth for TiO₂ is expected to track with the total global gross domestic product and the production of paint, paper, and plastics. Through 2020, higher-than-average growth is expected to continue in Asia. China, in particular, is expected to lead world growth in production and consumption of TiO₂. The International Monetary Fund (IMF) projected that world economic growth would be about 4.3% in 2011 and 4.5% in 2012. The IMF expected China to lead global economic growth with 9.6% in 2011 and 9.5% growth expected in 2012. China's continued growth was expected to significantly increase titanium mineral, pigment, and metal consumption during the long term. In the United States, the economy was projected to increase by 2.2% in 2011 and 2.6% in 2012 (International Monetary Fund, 2011). The U.S. Congressional Budget Office projected the long-term U.S. gross domestic product growth to average 3.6% per year from 2013 to 2016 (U.S. Congressional Budget Office, 2011).

Aerospace, defense, and industrial uses are expected to strongly influence consumption of titanium metal for the foreseeable future. Commercial aircraft production is expected to remain the dominant consumer of titanium metal. The growth of the global airplane fleet was projected to average 3.6% per year from 2010 to 2030 (Boeing Co., The, 2011, p. 4). According to one industry estimate, global consumption of titanium metal by the defense industry was expected to climb to 19,100 t by 2015 from 14,500 t in 2010 (Hickton, 2011, p. 20). Within the next 3 years, global titanium metal production was expected to increase in line with the construction of new aircraft and increased industrial output. Government and private industry programs may commercialize lower cost methods of producing titanium metal.

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TABLE 1
SALIENT TITANIUM STATISTICS¹

		2006	2007	2008	2009	2010
United States:						
Mineral concentrate:						
Imports for consumption	metric tons	1,230,000	1,460,000	1,380,000	943,000	1,200,000
Consumption ^{e, 2}	do.	1,870,000	1,950,000	1,780,000	1,700,000	1,820,000
Sponge metal:						
Imports for consumption	do.	24,400	25,900	23,900	16,600	20,500
Consumption	do.	28,400	33,700	W	W	34,900
Price, yearend ³	dollars per pound	5.87–12.84	6.33–7.06	6.16–8.02	4.50–7.07	3.50–6.24
Titanium dioxide pigment:						
Production	metric tons	1,370,000	1,440,000	1,350,000	1,230,000	1,320,000
Imports for consumption	do.	288,000	221,000	183,000	175,000	204,000
Consumption, apparent	do.	1,080,000 ⁴	979,000 ⁵	800,000 ⁵	757,000 ⁵	767,000 ⁵
Producer price index, yearend ⁶	(1982=100)	165	162	170	164	194
World, production:						
Ilmenite concentrate ⁷	metric tons	6,860,000 ^r	7,140,000 ^r	6,970,000 ^r	6,090,000 ^r	6,870,000
Rutile concentrate, natural ⁸	do.	516,000 ^r	607,000 ^r	634,000 ^r	571,000 ^r	710,000
Titaniferous slag ^e	do.	2,160,000	2,230,000	2,230,000	2,000,000	2,210,000

^eEstimated. ^rRevised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits, except prices.

²Excludes consumption used to produce synthetic rutile.

³Landed duty-paid unit based on U.S. imports for consumption.

⁴Production plus imports minus exports plus stock decrease or minus stock increase.

⁵Production plus imports minus exports. Excludes stock changes.

⁶Source: U.S. Department of Labor, Bureau of Labor Statistics.

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

⁸U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2010^{1, 2}

(Metric tons per year)

Company	Plant location	Yearend capacity ^c	
		Sponge	Ingot ³
Alcoa Howmet	Whitehall, MI	--	3,200
Allegheny Technologies Inc.	Albany, OR	(4)	10,900
Do.	Monroe, NC	--	23,200
Do.	Richland, WA	--	10,000
Do.	Rowley, UT	10,900	--
Alloy Works LLC	Greensboro, NC	--	1,800
Honeywell Electronic Materials Inc.	Salt Lake City, UT	500	--
Perryman Co.	Houston, PA	--	1,800
RTI International Metals, Inc.	Niles, OH	--	13,600
Titanium Metals Corp.	Henderson, NV	12,600	12,300
Do.	Morgantown, PA	--	40,700
Do.	Vallejo, CA	--	800
Total		24,000	118,000

^cEstimated. Do. Ditto. -- Zero.

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

²Estimated operating capacity based on 7-day-per-week full production.

³Includes electron-beam, plasma, and vacuum-arc-remelting capacity.

⁴In July 2009, sponge capacity of 9,980 metric tons per year was temporarily idled, and did not operate in 2010.

TABLE 3
COMPONENTS OF U.S. TITANIUM METAL SUPPLY AND DEMAND¹

(Metric tons)

Component	2009	2010
Production:		
Ingot	35,600	56,400
Mill products	31,900	36,300
Exports:		
Waste and scrap	4,200	3,480
Sponge	820	293
Other unwrought	3,790	3,040
Wrought products and castings	12,500	14,800
Total	21,300	21,600
Imports:		
Waste and scrap	4,770	10,700
Sponge	16,600	20,500
Other unwrought	573	444
Wrought products and castings	6,930	8,720
Total	28,900	40,300
Stocks, industry, yearend:		
Sponge	15,300	10,500
Scrap	9,880	7,900
Ingot	2,680	2,920
Consumption, reported:		
Sponge	W	34,900
Scrap	25,700	29,200
Ingot	30,100	40,900
Shipments:		
Ingot	10,600	13,700
Mill products (net shipments):		
Forging and extrusion billet	9,520	19,700
Other	14,100 [†]	18,500
Total	23,700	38,300
Castings (shipments)	W	W
Receipts, scrap:		
Home	10,600	9,770
Purchased	17,700	23,400
Total	28,300	33,200

[†]Revised. W Withheld to avoid disclosing company proprietary data.

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

TABLE 4
U.S. PRODUCERS OF TITANIUM DIOXIDE PIGMENT IN 2010^{1,2,3}

(Metric tons per year)

Company	Plant location	Yearend capacity ⁴
Cristal Global	Ashtabula, OH	220,000
Du Pont Titanium Technologies	De Lisle, MS	340,000
Do.	Edgemoor, DE	154,000
Do.	New Johnsonville, TN	380,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	146,000
Tronox Inc.	Hamilton, MS	225,000
Do.	Savannah, GA	(s)
Total		1,470,000

Do. Ditto.

¹Estimated operating capacity based on 7-day-per-week full production.

²Table does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of about 26,400 metric tons per year (t/yr) of buff TiO₂ pigment that is produced by refining and fine grinding of synthetic rutile.

³Data are rounded to no more than three significant digits; may not add to total shown.

⁴All plants use the chloride process to manufacture TiO₂ pigment.

⁵Tronox Inc. idled its 110,000-t/yr plant in the fourth quarter of 2009, and did not operate the plant in 2010.

TABLE 5
COMPONENTS OF U.S. TITANIUM DIOXIDE PIGMENT SUPPLY AND DEMAND¹

		2009		2010	
		Gross weight	TiO ₂ content	Gross weight	TiO ₂ content
Production ²	metric tons	1,230,000	1,150,000 ^e	1,320,000	1,240,000
Shipments: ³					
Quantity	do.	1,280,000	1,200,000 ^e	1,360,000	1,270,000
Value	thousands	\$2,830,000	XX	\$3,170,000	XX
Exports	metric tons	649,000	609,000 ^e	758,000	713,000 ^e
Imports for consumption	do.	175,000	165,000 ^e	204,000	192,000 ^e
Consumption, apparent ^{e, 4}	do.	757,000	710,000	767,000	719,000

^eEstimated. do. Ditto. XX Not applicable.

¹Data are rounded to no more than three significant digits.

²Excludes production of buff pigment.

³Includes interplant transfers.

⁴Production plus imports minus exports. Excludes stock changes.

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

TABLE 6
ESTIMATED U.S. CONSUMPTION OF TITANIUM CONCENTRATE^{1,2}

(Metric tons)

	2009		2010	
	Gross weight	TiO ₂ content	Gross weight	TiO ₂ content
Pigment	1,620,000	NA	1,730,000	NA
Miscellaneous ³	78,400	NA	90,000	NA
Total	1,700,000	1,360,000	1,820,000	1,460,000

NA Not available.

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

²Includes a mixed product containing altered ilmenite, leucoxene, and rutile.

³Includes alloys, carbide, ceramics, chemicals, glass fibers, titanium metal, and welding-rod coatings and fluxes.

TABLE 7
U.S. CONSUMPTION OF TITANIUM IN STEEL AND OTHER ALLOYS^{1,2}

(Metric tons)

	2009	2010
Steel:		
Carbon steel	4,660	6,110
Stainless and heat-resisting steel	2,600	3,300
Other alloy steel ³	524 ^r	649
Total steel	7,790 ^r	10,100
Cast irons	12	16
Superalloys	462	522
Alloys, other than above	994 ^r	1,020
Miscellaneous and unspecified	42 ^r	42
Grand total	9,300 ^r	11,700

^rRevised.

¹Includes ferrotitanium, scrap, sponge, and other titanium additives.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Includes high-strength low-alloy and tool steel.

TABLE 8
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS,
TITANIUM DIOXIDE CONTENT, BY INDUSTRY¹

(Percent)

Industry	2009	2010 ^c
Paint, varnish, lacquer	59.2	57.1
Paper	10.1	9.7
Plastics and rubber	24.5	27.4
Other ²	6.2	5.8
Total	100.0	100.0

^cEstimated.

¹Excludes exports.

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

TABLE 9
YEAREND PRICES OF TITANIUM PRODUCTS

	2009	2010	
Concentrate:			
Ilmenite, free on board (f.o.b.) Australian ports ¹	dollars per metric ton	60–85	65–85
Rutile, bagged, f.o.b. Australian ports ¹	do.	700–800	760–805
Rutile, bulk, f.o.b. Australian ports ¹	do.	525–540	530–550
Titaniferous slag, import, 80% to 95% TiO ₂ ²	do.	401–439	367–433
Metal:			
Sponge import ²	dollars per pound	4.50–7.07	3.50–6.24
Scrap, turnings, unprocessed ³	do.	0.90–1.00	2.00–2.10
Ferrotitanium, 70% Ti ³	do.	2.12–2.20	3.18–3.25
Mill products ⁴	producer price index	197	203
Titanium dioxide pigment ⁴	do.	164	194
do. Ditto.			

¹Source: Industrial Minerals.

²Landed duty-paid unit value based on U.S. imports for consumption.

³Source: Platts Metals Week.

⁴1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 10
U.S. EXPORTS OF TITANIUM BY CLASS¹

Class	HTS ²	2009		2010	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:					
Scrap	8108.30.0000	4,200	\$14,000	3,480	\$19,200
Unwrought:					
Sponge	8108.20.0010	820	8,560	293	2,330
Ingot	8108.20.0030	776	19,800	467	9,530
Other	8108.20.0090	3,020	41,300	2,570	31,900
Wrought:					
Billet	8108.90.6010	2,010	75,200	2,240	77,600
Bloom, sheet bar, slab	8108.90.6020	913	26,900	1,240	35,500
Bar, rod, profile, wire	8108.90.6031	2,300	130,000	2,830	149,000
Other	8108.90.8000	7,240	476,000	8,450	531,000
Total		21,300	792,000	21,600	856,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,020	7,360	2,570	12,200
Ores and concentrates	2614.00.0000	14,800	8,230	18,900	11,800
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	617,000	1,230,000	717,000	1,570,000
Other titanium dioxide pigment	3206.19.0000	28,000	67,000	36,700	102,000
Unfinished titanium dioxide ³	2823.00.0000	3,500	7,720	4,160	11,000
Total		649,000	1,310,000	758,000	1,690,000

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

²Harmonized Tariff Schedule of the United States.

³Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATE, BY COUNTRY¹

Concentrate and country	HTS ²	2009		2010	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:	2614.00.6020				
Australia		105,000	\$10,200	98,200	\$9,680
Mozambique		120,000	8,840	199,000	14,800
Ukraine		14,800	1,850	57,500	10,100
Other		10,200 ^r	917 ^r	22,300	3,070
Total		250,000	21,800	377,000	37,600
Titaniferous slag:	2620.99.5000				
Canada		109,000	44,600	150,000	64,700
South Africa		305,000	123,000	325,000	135,000
Other ³		91	32	--	--
Total		414,000	168,000	475,000	200,000
Rutile, natural:	2614.00.6040				
Australia		122,000	70,700	83,500	55,000
Sierra Leone		10,800	5,970	29,800	17,300
South Africa		75,700	37,100	96,500	51,700
Other ³		15,300 ^r	9,030 ^r	19,100	21,200
Total		224,000	123,000	229,000	145,000
Rutile, synthetic:	2614.00.3000				
Australia		48,000	14,000	109,000	45,500
Malaysia		4,790	2,920	4,460	2,620
Other ³		2,810	848	9,170	4,310
Total		55,600	17,700	122,000	52,400
Titaniferous iron ore, Canada ⁴	2614.00.6020	10,000	532	83,100	6,760

^rRevised. -- Zero.

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

²Harmonized Tariff Schedule of the United States.

³All or part of these data have been referred to the U.S. Census Bureau for verification.

⁴Includes 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 HTS.

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

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY¹

Class and country	HTS ²	2009		2010	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		341	\$563	682	\$3,130
France		1,220	5,500	1,480	10,700
Germany		903	3,940	2,050	15,000
Israel		6	6	256	2,060
Italy		93	311	398	3,580
Japan		505	1,700	1,550	11,000
Korea, Republic of		100	683	416	2,820
Russia		68 ^r	615 ^r	243	1,860
Taiwan		133	516	692	3,870
United Kingdom		1,140	3,190	1,720	13,200
Other		264 ^r	613 ^r	1,230	8,260
Total		4,770	17,600	10,700	75,500
Unwrought:					
Sponge:	8108.20.0010				
Japan		5,870	81,600	9,790	110,000
Kazakhstan ^c		9,930	88,800	8,550	69,700
Other		806 ^r	7,600 ^r	2,120	17,000
Total		16,600	178,000	20,500	196,000
Ingot:	8108.20.0030				
China		--	--	48	631
Germany		364	10,300	156	2,640
Russia		155	2,830	12	154
Other		12	223	21	447
Total		531	13,300	237	3,880
Powder:	8108.20.0015				
China		17	385	96	1,830
Germany		2	468	6	1,180
Japan		4	1,070	6	1,380
Other		1 ^r	468 ^r	11	1,030
Total		24	2,390	119	5,420
Other:	8108.20.0091				
Canada		1	275	16	48
China		(4)	6	15	104
France		--	--	7	794
Germany		10	202	26	554
United Kingdom		4	572	21	2,230
Other		3 ^r	165 ^r	2	248
Total		18 ^r	1,220	88	3,980
Wrought products and castings: ³	8108.90.3030, 8108.90.3060, 8108.90.6010, 8108.90.6020, 8108.90.6031, 8108.90.6045, 8108.90.6060, 8108.90.6075				
China		470	18,700	537	17,400
Japan		229	16,500	181	12,700
Russia		5,260	171,000	7,130	211,000
United Kingdom		309	32,800	140	15,600
Other		657 ^r	52,900 ^r	721	42,400
Total		6,930	292,000	8,710	299,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,540	6,750	2,740	11,500

^cEstimated. ^rRevised. -- Zero.

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

²Harmonized Tariff Schedule of the United States.

³Includes bar, billet, bloom, castings, foil, pipe, plate, profile, rod, sheet, sheet bar, slab, strip, tube, wire, and other.

TABLE 12—Continued
 U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY¹

⁴Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
 U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENT, BY COUNTRY¹

Country	HTS ²	2009		2010	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Australia		2,660	\$4,400	2,000	\$3,930
Canada		59,600	130,000	83,400	183,000
China		9,910	15,600	8,120	15,800
Finland		8,290	19,100	7,970	16,000
France		3,150	5,980	4,200	8,990
Germany		6,970	14,900	5,720	13,300
Italy		4,870	9,120	2,890	6,170
Japan		3,300	12,800	4,350	18,600
Netherlands		3,620	6,880	4,730	9,790
South Africa		10,300	21,300	2	4
Ukraine		6,150	9,560	9,890	15,900
Other		11,400 ^r	21,300 ^r	11,700	22,900
Total		130,000	271,000	145,000	314,000
Other titanium dioxide:	3206.19.0000				
Canada		8,160	20,700	7,230	18,600
China		766	2,880	1,550	4,510
Germany		2,500	7,800	1,440	5,230
Japan		509	5,450	836	7,910
Other		1,020 ^r	7,020 ^r	1,060	8,870
Total		13,000	43,900	12,100	45,100
Unfinished titanium dioxide: ³	2823.00.0000				
China		9,880	14,200	22,400	41,300
Czech Republic		1,920	3,480	2,400	4,610
Finland		1,800	4,450	2,960	6,960
France		4,350	14,500	4,910	16,400
Germany		3,570	7,750	4,920	10,700
Japan		5,240	16,900	1,110	7,020
Korea, Republic of		2,980	3,890	4,450	7,600
Other		2,180 ^r	4,940 ^r	4,030	8,810
Total		31,900	70,100	47,200	103,000
Grand total		175,000	385,000	204,000	462,000

^rRevised.

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

²Harmonized Tariff Schedule of the United States.

³Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 14
TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY^{1,2}

(Metric tons)

Concentrate type and country	2006	2007	2008	2009	2010
Ilmenite and leucoxene:^{3,4}					
Australia	2,508,000	2,503,000	2,230,000 ^r	1,611,000 ^r	1,651,000
Brazil ⁵	94,909 ^r	100,364 ^r	175,076 ^r	71,122 ^r	75,000
China ^e	1,000,000	1,100,000	1,100,000	900,000 ^r	1,000,000
India ^e	690,000	700,000	610,000 ^r	700,000 ^r	900,000
Kazakhstan ^e	25,000	25,000	25,000	25,000	25,000
Malaysia	45,649	60,250	36,779	15,983 ^r	19,064 ^e
Mozambique	--	140,515	328,875	471,524 ^r	678,000
Norway ^e	850,000	882,000	915,000 ^r	671,000 ^r	670,000
Sierra Leone	13,819	15,750	17,528	15,164 ^r	18,206 ^e
Sri Lanka	57,033 ^r	70,728 ^r	22,159 ^r	122,424 ^r	52,637
Ukraine	470,000	500,000	520,000 ^r	500,000 ^e	500,000 ^e
United States ^{e,6}	500,000	400,000	300,000	300,000	400,000
Vietnam ⁷	604,700 ^r	643,400 ^r	692,700 ^r	686,800 ^r	881,000 ^e
Total⁸	6,860,000^r	7,140,000^r	6,970,000^r	6,090,000^r	6,870,000
Rutile:⁴					
Australia	232,000	312,000	325,000	281,000 ^r	380,000
Brazil ⁵	2,100	3,000	2,431	2,881	2,900
India ^e	21,000	21,000	21,000	21,000	25,000
Madagascar	--	--	--	3,200 ^{r,e}	5,700 ^e
Malaysia	1,450	1,450	1,834	1,502	7,567
Mozambique	--	8,782	6,552	1,697	4,656
Sierra Leone	73,802	82,527	78,908	63,864	68,198
South Africa ^e	123,000	114,000	127,000	134,000	153,000
Sri Lanka	2,280 ^r	4,607 ^r	11,335 ^r	2,276 ^r	2,568
Ukraine ^e	60,000	60,000	60,000	60,000	60,000
United States	(9)	(9)	(9)	(9)	(9)
Total	516,000^r	607,000^r	634,000^r	571,000^r	710,000
Titaniferous slag:^{e,10}					
Canada	930,000	960,000	1,000,000	765,000	1,090,000
South Africa	1,230,000	1,270,000	1,230,000	1,230,000	1,120,000
Total	2,160,000	2,230,000	2,230,000	2,000,000	2,210,000

^eEstimated. ^rRevised. -- Zero.

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

²Table includes data available through July 11, 2011.

³Ilmenite is also produced in Canada, Madagascar, 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.

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

⁵Excludes production of unbeneficiated anatase ore.

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

⁷Estimate based on import statistics from trading partners (primarily China and Japan).

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

⁹Included with ilmenite to avoid disclosing company proprietary data.

¹⁰Slag is also produced in China, Norway, Kazakhstan, Russia, and Vietnam, but this output is not included under "Titaniferous slag" to avoid duplicative reporting.