



# 2011 Minerals Yearbook

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## TITANIUM

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The United States was 77% import dependent for titanium mineral concentrates and 64% for titanium sponge, and continued to be a net exporter of titanium dioxide (TiO<sub>2</sub>) pigment and wrought titanium metal products. Domestic production of TiO<sub>2</sub> pigment decreased by 2% compared with that of 2010. U.S. consumption of titanium used in steel and other alloys increased by 6% from that in 2010 (table 7). Increased demand for titanium metal from the commercial aerospace industry resulted in increased domestic production of titanium ingot and mill products.

U.S. production of titanium mineral concentrates in 2011 was unchanged from that of 2010. The leading sources of imports of titanium mineral concentrates were South Africa, Australia, and Canada (table 14). Pigment production capacity in the United States increased by 3% to a total of 1.52 million metric tons per year (Mt/yr) (table 4). World production of titanium mineral concentrates in 2011 was 7.21 million metric tons (Mt), a 3% increase from that in 2010. The leading producers of titanium mineral concentrates were, in descending order of production, Australia, China, Vietnam, Mozambique, and Norway.

## Legislation and Government Programs

The Defense Advanced Research Projects Agency (DARPA) continued to fund work on developing high-volume and low-cost techniques to enable widespread use of titanium and titanium alloys. In fiscal year (FY) 2011, the DARPA program demonstrated a meltless titanium consolidation, and in FY 2012, DARPA planned to demonstrate that meltless titanium alloys exhibited properties equivalent to the same conventionally processed alloys (Defense Advanced Research Projects Agency, 2012, p. 168, 169).

In June 2011, ADMA Products, Inc. received funds from the 2010 Defense Appropriations Act to increase production of hydrogenated titanium powder. During the first half of 2012, a laboratory scale unit capable of producing 5 kilograms per day (kg/d) was constructed. A pilot scale unit with a capacity of 300 kg/d was expected to be built by yearend 2012 (Duz and others, 2012, p. 16).

Title III of the Defense Production Act is a program specifically designed to establish, expand, maintain, or modernize industrial capabilities required for national defense. In 2011, there were three programs funded under Title III to improve the supply of titanium metal. International Titanium Powder (ITP) of Woodridge, IL (a subsidiary of Cristal Global) was working to reduce titanium component costs by producing low-cost metallic titanium powder by sodium reduction via the Armstrong process. ITP was expected to begin production in late 2012 or early 2013 with a capacity of 1,800 metric tons per year (t/yr) of titanium powder (Defense Production Act Committee, undated a).

A second Title III effort was aimed at reducing cost and shortening delivery lead times for nonaerospace titanium used in armor and structures. Gautier Specialty Metals, LLC of Johnstown, PA, installed rolling and finishing equipment and became a new source of titanium for land-based requirements for the Department of Defense (Defense Production Act Committee, undated b).

The third Title III program was the expansion of domestic capacity to produce continuously reinforced titanium metal matrix composites (TMCs) and discontinuously reinforced titanium powder (ETi) components while reducing production costs. FMW Composites Systems of Bridgeport, WV, constructed equipment to expand TMC production capacity from 0.9 to 3.2 t/yr and installed an ETi powder metal production line. Increased stiffness, improved failure modes, and corrosion resistance made TMCs ideal for implementation in aircraft landing gear, engine thrust links, and other tubular aircraft components and rods for space-based structural and support applications. ETi powder offers multiaxial strength improvement and can be consolidated into an array of intermediate forms or into near-net shape parts (Defense Production Act Committee, undated c).

In May, the National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention released Current Intelligence Bulletin 63—Occupational Exposure to Titanium Dioxide, a guidance document on handling TiO<sub>2</sub> powders in the workplace. The NIOSH recommended airborne exposure limits for TiO<sub>2</sub> of fine particle sizes [ $>0.1$  micrometers ( $\mu\text{m}$ )] of 2.4 milligrams/cubic meter ( $\text{mg}/\text{m}^3$ ) and ultrafine sizes ( $<0.1$   $\mu\text{m}$ ) of 0.3  $\text{mg}/\text{m}^3$ . The NIOSH also determined that ultrafine TiO<sub>2</sub> is a potential occupational carcinogen, but there was insufficient data to classify fine TiO<sub>2</sub> as an occupational carcinogen (Centers for Disease Control and Prevention, 2011, p. iii, iv).

## Production

Titanium industry data for this report were collected by the U.S. Geological Survey (USGS) from annual and quarterly surveys of domestic titanium operations. In 2011, the USGS annual survey canvassed titanium mineral and pigment producers. The two producers of titanium mineral concentrates responded. Of the six active domestic TiO<sub>2</sub> 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  $\text{TiO}_2$  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  $\text{TiO}_2$  pigment plants. In 2011, 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. Drilling programs that began in 2010 and completed in 2011 resulted in indicated resource estimates for the Longnose and Titac deposits of 65.3 Mt at 16.4% titanium dioxide and 45.1 Mt at 15.0% titanium dioxide, respectively. These resources did not have a demonstrated economic value (Cardero Resource Corp., 2012).

**Metal.**—Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride ( $\text{TiCl}_4$ ), which is then reduced with magnesium (Kroll process) or sodium (Hunter process) to produce 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 2011, U.S. producers of titanium sponge were Allegheny Technologies Inc. (ATI), Honeywell Electronic Materials Inc., and Titanium Metals Corp. (Timet) (table 2). 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 that was used in the company's production of electronic-grade titanium. Data on domestic production of

titanium sponge were withheld to avoid disclosing company proprietary data. Owing to increased demand from the commercial aerospace industry, U.S. production of titanium ingot and mill products increased in 2011 by 7% and 11%, respectively (table 3). U.S. producers of ferrotitanium were RTI International Metals Inc. (Canton, OH) (7,250 t/yr capacity) and Global Titanium Inc. (Detroit, MI) (<10,000 t/yr capacity). Data on production of ferrotitanium were not available.

RTI International Metals Inc. constructed a new titanium forging and rolling facility in Martinsville, VA, to fulfill mill product supply agreements for the Joint Strike Fighter and the Airbus family of commercial aircraft. The facility began operations in December and had a capacity of 4,800 t/yr of forged titanium products (RTI International Metals Inc., 2012, p. 17, 30).

**$\text{TiO}_2$  Pigment.**— $\text{TiO}_2$  pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the chloride process, rutile is converted to  $\text{TiCl}_4$  by chlorination in the presence of petroleum coke.  $\text{TiCl}_4$  is oxidized with air or oxygen at about 1,000° C, and the resulting  $\text{TiO}_2$  is calcined to remove residual chlorine and any hydrochloric acid that may have formed in the reaction. Aluminum chloride is added to the  $\text{TiCl}_4$  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.  $\text{TiO}_2$  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,  $\text{TiO}_2$  pigment can exhibit a wide range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of  $\text{TiO}_2$  pigment was 1.29 Mt in 2011, a 2% decrease compared with that in 2010 (table 5). U.S. producers of  $\text{TiO}_2$  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  $\text{TiO}_2$  pigment from finely ground synthetic rutile.

In September, Tronox announced its intention to acquire Exxaro Resources Ltd. mineral sand operations in South Africa and Western Australia in exchange for 38.5% of Tronox equity. The acquisition included Exxaro's 50% interest in the Tiwest Joint Venture which was jointly owned with Tronox, along with 74% of Exxaro's KwaZulu-Natal (KZN) sands and 74% of its

Namakawa sands operations in South Africa. This procurement increased Tronox's global TiO<sub>2</sub> pigment capacity to 465,000 t/yr. Tronox had pigment producing operations in Hamilton, MS; Botlek, Netherlands; and Kwinana, Australia. The acquisition was completed by midyear 2012 (Tronox Inc., 2011, 2012).

## Consumption

**Mineral Concentrates.**—On a gross weight basis, 93% of the domestic consumption of titanium mineral concentrates was used to produce TiO<sub>2</sub> pigment. The remaining 7% was used to produce metal and miscellaneous other products, including fluxes, and welding rod coatings. Based on TiO<sub>2</sub> content, domestic consumption of titanium mineral concentrates was 1.50 Mt, a slight decrease compared with that of 2010 (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 2011, mill product shipments increased by 19% owing to increased aircraft build rates and growth in inventory levels throughout the titanium products supply chain (table 3). The aerospace industry (67%) was the leading end use for mill products. Other uses included consumer goods, and the 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 interstitialfree, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 12,400 t, a 6% increase compared with that of 2010 (table 7). Increased demand from the specialty steel industry resulted in an increase in ferrotitanium consumption.

**TiO<sub>2</sub> Pigment.**—Domestic production of TiO<sub>2</sub> pigment decreased by 2% while apparent domestic consumption (excluding changes in inventory) decreased by 8% from that of 2010 (table 5). The leading uses of TiO<sub>2</sub> pigment, based on TiO<sub>2</sub> pigment shipments in the United States, were paint and coatings (58.5%), plastics and rubber (27.9%), and paper (8.6%). Other uses (5.0%) 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 TiO<sub>2</sub> pigment producer stocks. Yearend domestic stocks of sponge remained almost constant with yearend levels of 2010. Owing to a continued increase in aerospace consumption, titanium metal producers anticipated a continued increase in aerospace consumption and increased domestic stocks of ingot by 32% in 2011 (table 3).

## Prices

Yearend titanium mineral concentrate prices are listed in table 9. Owing to increased global demand from TiO<sub>2</sub> pigment producers, prices for bulk ilmenite and rutile concentrates were considerably higher compared with prices in 2010. Published prices for titanium slag were not available. Based on U.S. Customs Service data, the value of slag imports in December 2011, ranged from \$468 to \$494 per metric ton compared with \$367 to \$433 per ton in December 2010, owing to rising feedstock prices. The U.S. Department of Labor, Bureau of Labor Statistics, December 2011 producer price index (PPI) for TiO<sub>2</sub> pigment increased to 268, a 38% increase compared with that of December 2010 (U.S. Department of Labor, Bureau of Labor Statistics, 2012).

Prices of titanium mill products remained constant in 2011. In December, the monthly PPI for titanium mill products was 203. Sponge and ingot prices were generally unchanged owing to long-term contracts (U.S. Department of Labor, Bureau of Labor Statistics, 2012).

## 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 and capacity. In 2011, the TiO<sub>2</sub> content of imports was estimated to be 1.03 Mt, primarily in the form of titaniferous slag (42%), rutile (35%), and ilmenite (23%). South Africa, Australia, Canada, and Mozambique were, in descending order of TiO<sub>2</sub> quantity, the leading import sources. The combined value for all forms of titanium concentrate imports in 2011 was \$520 million (table 11). Imports of titaniferous iron ore from Canada (classified as ilmenite by the U.S. Census Bureau), which had totaled 83,000 t in 2010, virtually disappeared in 2011. Exports of titanium concentrates were minor relative to imports (tables 10–11).

**Metal.**—Total imports of titanium metal increased by 37% from those in 2010. Imports of titanium metal were primarily in the form of sponge (61%), waste and scrap (25%), and wrought products and castings (12%). Japan, Kazakhstan, and China were the leading sources of imported titanium sponge, while the United Kingdom, Japan, Germany, and France were, in descending order, the leading sources of imported scrap. Germany and Russia supplied 99% of the imported titanium ingot, and China was the major source of titanium powder. Imports of other unwrought forms of titanium more than doubled compared with those of 2010, yet still constituted less than 2% of titanium metal imports. Imports of titanium wrought products and castings were primarily in the form of plate, sheet, strip, and foil (43%); bar, rod, profiles, and wire (25%); and billets (13%). Russia was the leading source of wrought products and castings. Imports of wrought products and castings decreased by 22% to 6,820 t. Imports of ferrotitanium were 2,070 t, a 24% decrease compared with those of 2010. The leading import sources were, in descending order, the United



Kingdom, Canada, and Russia. Exports of ferrotitanium were 3,210 t, a 25% increase compared with those of 2010.

**TiO<sub>2</sub> Pigment.**—In 2011, the United States continued to be a net exporter of TiO<sub>2</sub> pigment, with exports exceeding imports by a ratio of 3.9 to 1. Exports of TiO<sub>2</sub> pigment were 789,000 t, a 4% increase compared with those of 2010. During 2011, 200,000 t of TiO<sub>2</sub> pigment was imported, a 2% decrease compared with those of 2010. About 94% of TiO<sub>2</sub> pigment exports was in the form of finished pigment with 80% or more TiO<sub>2</sub> content. The leading import sources of TiO<sub>2</sub> pigment were Canada (44%) and China (18%). Seventy percent of pigment imports was in the form of finished pigment with more than 80% TiO<sub>2</sub> content (table 13).

## World Review

An increase in global production of heavy minerals in 2011, accompanied by rising prices for titanium mineral concentrates, encouraged vertical integration within the mineral and pigment industries. Global consumption of resources for heavy-mineral production continued, particularly in sub-Saharan Africa.

Demand of titanium metal from the commercial aerospace and industrial markets resulted in increased consumption and caused metal producers to increase titanium sponge and mill capacity. World production of titanium mineral concentrates in 2011 was 7.21 Mt, a 3% increase from that in 2010. Significant production increases in Australia (14%) and China (10%) were partially offset by production declines in Mozambique (6%) and Norway (10%).

**Australia.**—In July, Iluka Resources Ltd. announced its intention to recommence operations at Eneabba in the Perth Basin after mining operations had ceased in June 2010 owing to declining grades and lower prices. Mining was expected to begin in early 2012 (Iluka Resources Ltd., 2011a). Owing to increased titanium dioxide prices in 2011, Iluka increased its production of rutile in Australia to 282,000 t in 2011 from 250,000 t in 2010. The company's Australian ilmenite production decreased to 172,000 t from 250,000 in 2010. Production of synthetic rutile decreased by 18% to 286,000 t, owing to a 3-month maintenance outage and test work of a new synthetic rutile product from one of its four synthetic rutile kilns in Western Australia (Iluka Resources Ltd., 2011b, p. 3–4, 16–18).

**Canada.**—In March, Titanium Corp. decommissioned its 18-month demonstration pilot program at the Canadian Government's CanmetENERGY facilities. The program demonstrated technologies designed to recover heavy minerals, bitumen, and solvents; to treat and recover process water; and to reduce the environmental impacts associated with froth tailings streams. After decommissioning the pilot program, Titanium Corp. was negotiating with oil sands operators to commercialize the process (Titanium Corp., 2011, p. 3).

Argex Mining announced that following the completion of testing at its La Blache Property, it planned to expand the size of its titanium dioxide pilot plant to 10 metric tons per day (t/d) (Argex Mining Inc., 2011).

Rio Tinto, Fer et Titane (RTFT) planned to invest C\$800 million during 5 years to expand its operations in Quebec. The expansion would extend the life of its Lac Tio ilmenite plant to

2050 and upgrade the Sorel-Tracy processing plant in Quebec (Rio Tinto Fer et Titane, 2011).

**China.**—Continued demand from the global aviation industry boosted China's titanium metal and mill output in 2011 to record levels. In 2011, exports of sponge and mill products were 8,700 t and 11,000 t, respectively. The 14 leading manufacturers produced 65,000 t of sponge in 2011, an increase of 13% from that of 2010, and 51,000 t of titanium mill products, an increase of 33% from that in 2010 (Metal-Pages, 2011a). Titanium dioxide production in China from 55 producers also reached record levels in 2011 of 1.75 Mt, an increase of 19% from production in 2010 (Metal-Pages, 2011b).

Chinese imports of titanium mineral concentrates increased by 11%, to 2.27 Mt in 2011, and the unit value of imports almost doubled to \$242 per metric ton in 2011 (United Nations Statistics Division, undated).

**France.**—In September, Aubert & Duval [a subsidiary of the Eramet Group, and Ust-Kamenogorsk Titanium-Magnesium Plant (UKTMP) of Kazakhstan] formally inaugurated the UKAD titanium mill in Saint Georges de Mons. The facility was to convert titanium ingot into billets, bars, wire, and sheets primarily for the aerospace market. Financing for the facility was facilitated by the signing of long-term contracts with Airbus and the European Aeronautic Defence and Space Company N.V. (EADS) that guarantee \$1.2 billion in sales through 2022 (Aubert & Duval, 2011).

**India.**—Kerala Minerals & Metals Ltd.'s titanium sponge plant, commissioned in February, produced 3 t of titanium sponge during test runs in September (Hindu Business Line, The, 2011).

**Indonesia.**—Trimex Industries Pvt. Ltd. announced that it had signed a memorandum of understanding (MOU) with the Republic of Indonesia to construct a titanium complex in Indonesia in three phases and planned to invest \$800 million to \$850 million. The first phase to develop the production of titanium dioxide pigment was expected to be complete in December 2013. The second and third phases included the production of titanium slag and titanium metal. The entire project was expected to be completed within 8 to 10 years (Trimex Industries Pvt. Ltd., 2011).

**Japan.**—Owing to increased demand from the aerospace industry, exports of titanium sponge were 25,000 t in 2011, a 68% increase from that of 2010. Annual exports of mill products in 2011 reached their second-highest level in history owing to high demand from desalination plants and the aerospace industry (Roskill's Letters From Japan, 2012, p. 1).

Toho Titanium Co., Ltd. began construction in February to expand its titanium sponge capacity at Wakamatsu, Fukuoka. The project was completed in January 2012 and raised the overall sponge capacity of Toho to 28,800 t/yr (Toho Titanium Co., Ltd., 2012).

OSAKA Titanium technologies Co., Ltd. increased sponge production capacity to 40,000 t/yr near yearend (OSAKA Titanium Technologies Co. Ltd., 2012, p. 15).

**Kazakhstan.**—In October, UKTMP and South Korean Pohang Iron and Steel Company (POSCO) began construction in Ust-Kamenogorsk of a melting operation for the production of titanium slab. UKTMP was to supply titanium sponge for further

processing by POSCO into titanium sheets. The operation was expected to begin production in 2012 (Pohang Iron and Steel Co. Ltd., 2010; Universal Newswire, 2011).

Tioline Ltd. was constructing a heavy-mineral mine and processing operation at the Obukhovskiy deposit in the Akmla province. The operation was expected to start production in 2013 and was expected to reach full capacity in 2014 producing 50,000 t of ilmenite, 12,000 t of rutile, and 50,000 t of zircon (Watts, 2011).

**Kenya.**—In July, Base Resources Ltd. secured \$170 million to develop the Kwale mine in Kenya and began development in October. Mining was expected to commence in July 2013 and was expected to generate 330,000 t/yr of ilmenite, 79,000 t/yr of rutile, and 30,000 t/yr of zircon during the first 7 years of operations (Base Resources Ltd., 2012, p. 5–10).

**Mexico.**—E. I. du Pont de Nemours and Co. announced an expansion of its facilities at Altamira, Tamaulipas, Mexico. The expansion was scheduled for completion by yearend 2014 and was expected to produce approximately 200,000 t/yr of pigment (E. I. du Pont de Nemours and Co., 2011).

**Mozambique.**—At the Kenmare Resources plc Moma operation, an upgrade to the wet concentrator plant was completed in September. In 2011, the Moma operation produced 636,800 t of ilmenite, a 6% decrease compared with that of 2010, and rutile production was 6,500 t, a 38% increase compared with that in 2010. The company planned to increase mine capacity by 50% to approximately 1.2 Mt/yr by 2013 (Kenmare Resources plc, 2012, p. 12–16).

In May, Pathfinder Minerals plc released the results of a scoping study on its Moebase and Naburi deposits which reported that the two sites contained an estimated 71.7 Mt of contained heavy minerals. In July, Pathfinder Minerals was awarded a new mining concession license for its Moebase deposit by the National Directorate of Mines (Pathfinder Minerals plc, 2011a, p. 41, 2011b).

**Norway.**—In July, ERAMET Group established a 50–50 joint venture with Mineral Deposits Ltd. (MDL) to jointly develop the Grand-Cote mineral sands deposit in Senegal to supply ERAMET's titanium slag plant in Tyssedal, Norway. Heavy-mineral sand shipments from Senegal were expected to begin in late 2013. A feasibility study was underway for a second furnace at the Tyssedal plant that could double the current capacity of 200,000 t/yr of heavy-mineral sands. In 2011, the plant processed feedstock from the Tellnes Mine in Norway (ERAMET Group, 2011, p. 18).

**Paraguay.**—At CIC Resources Ltd.'s Parana deposit in the Alto Parana and Canindeyu provinces, the company demonstrated a 5 t/d pilot project to show the feasibility of producing titanium slag and pig iron coproduct. The deposit was estimated to contain 9.1 billion metric tons at 7.6% titanium dioxide and 23.6% iron oxide. Production rates were projected to be 500,000 t/yr of titanium slag and a similar amount of pig (Moodley, 2012).

**Russia.**—At yearend 2011, VSMPO-AVISMA Corp. (VSMPO) completed a new production line for titanium sponge, raising its capacity to 44,000 t/yr. Production at full capacity was to begin in February 2012. In July, VSMPO acquired GPK Titan Ltd. and its license for survey and recovery of mineral

sand deposits in the northern part of the Centralnoye deposit in the Tambov Region of Russia (VSMPO-AVISMA Corp., 2012, p. 14, 135).

**Saudi Arabia.**—Cristal Global announced the construction of an ilmenite-processing plant in Yanbu. The plant was to have two ilmenite smelting furnaces and require 800,000 t/yr of ilmenite to produce 500,000 t/yr of 85% titanium slag and 235,000 t/yr of pig iron as a coproduct. Site preparation was to begin in early 2012 and the plant was expected to become operational in the fourth quarter 2013 (Cristal Global, 2011).

**Senegal.**—In July, ERAMET established a 50–50 joint venture with MDL to develop the Grand-Cote mineral sands deposit in Senegal, which would supply ERAMET's titanium slag plant in Tyssedal, Norway. Production was to begin in late 2013 at an average rate of 575,000 t/yr of ilmenite, 85,000 t/yr of zircon, 11,000 t/yr of leucogene, and 6,000 t/yr of rutile (Mineral Deposits Ltd., 2011, p. 11).

**Sierra Leone.**—In September, Titanium Sierra Rutile Ltd. (SRL) announced two projects to increase rutile production by up to 60,000 t/yr of rutile and up to 12,000 t/yr of ilmenite. A dry mining project was to focus on high-grade pockets of ore in the Lanti deposit that the existing dredge was unable to mine and was expected to produce an additional 30,000 to 35,000 t/yr of rutile and 6,000 to 9,000 t/yr of ilmenite by 2013. The tailings project dredge mined Mogbwemo mine tailings that still contained high grades of rutile (22 Mt at 1.13% rutile) and was expected to produce an additional 20,000 t/yr of rutile and 3,000 t/yr of ilmenite in 2014 (Sierra Rutile Ltd., 2011, p. 6–7). In 2011, production of rutile was 67,916 t and 15,946 t of ilmenite (Sierra Rutile Ltd., 2012, p. 1).

**South Africa.**—In September, Tronox Inc. announced its intention to acquire Exxaro's 74% interest in the KZN and Namakwa mining operations (Tronox Inc., 2011). Owing to the projected end of production in 2012 at the KZN Hillendale Mine, production of ilmenite in 2011 was 168,000 t, a decrease of 40% from that of 2010, and production of rutile was unchanged at 17,000 t. The Fairbreeze Mine at the KZN operation was to replace the Hillendale Mine and was projected to begin production in 2014. Production for the Namakwa operation was 377,000 t of ilmenite, an increase of 50% from that of 2010 and production of rutile was 31 t, an increase of 11% from that of 2010 (Exxaro Resources Ltd., 2012, p. 5, 104).

**Sri Lanka.**—Lanka Mineral Sands Ltd. planned to refurbish its Pulmoddai Mine to pre-war levels of 100,000 to 125,000 t/yr. The current annual production was 90,000 t of ilmenite, 9,000 t of rutile, and 4,000 t of hi-titanium ilmenite (Gunasekera, 2011).

**Ukraine.**—Velta LLC was on schedule to commission its Birzulovsky ilmenite mine and processing operation in the Kirovohrad region. Velta LLC expected the mine to produce 185,000 t/yr after the first 3 months of production and anticipated that shipments from the mine would begin in the first quarter 2012 (Metal-Pages, 2011c).

## Outlook

For the foreseeable future, the market for titanium minerals was expected to be driven by the production of TiO<sub>2</sub> pigment. Unless new domestic 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 TiO<sub>2</sub> was expected to trend with economic growth and the production of paint, paper, and plastics.

Aerospace, defense, and industrial uses were expected to strongly influence consumption of titanium metal for the foreseeable future. Commercial aircraft production was expected to remain the dominant consumer of titanium metal. The growth of the global airplane fleet was projected to average 3.5% per year from 2012 to 2031 (Boeing Co., The, 2011, p. 3). According to one industry estimate, consumption of titanium metal by the aerospace industry was expected to climb to 41,200 t by 2016 from 21,300 t in 2011 (Hickton, 2012, p. 20). Government and private industry programs may commercialize lower cost methods of producing titanium metal, further increasing its demand.

## References Cited

- Argex Mining Inc., 2011, Argex announces 3000% scale up of TiO<sub>2</sub> pilot-plant: Montreal, Quebec, Canada, Argex Mining Inc. news release, 1 p. (Accessed August 15, 2012, at <http://argex.ca/documents/argexnrengdecember52011finalnr.pdf>.)
- Aubert & Duval, 2011, Aubert & Duval and UKTMP open their new UKAD unit: Paris, France, Aubert & Duval news release, September 19. (Accessed September 10, 2012, at [http://www.aubertduval.com/news/detailed-news/article/aubert-duval-and-uktmp-open-their-new-ukad-unit.html?x\\_ttnews%5BbackPid%5D=135&cHash=b74ed01476](http://www.aubertduval.com/news/detailed-news/article/aubert-duval-and-uktmp-open-their-new-ukad-unit.html?x_ttnews%5BbackPid%5D=135&cHash=b74ed01476).)
- Base Resources Ltd., 2012, Annual report 2012: West Perth, Western Australia, Australia, Base Resources Ltd., October 27, 69 p. (Accessed December 5, 2012, at <http://www.baseresources.com.au/investor-centre/reports/annual/>.)
- Boeing Co., The, 2012, Current market outlook 2012–2031: Seattle, WA, The Boeing Co., 35 p. (Accessed December 26, 2012, at [http://www.boeing.com/commercial/cmo/pdf/Boeing\\_Current\\_Market\\_Outlook\\_2012.pdf](http://www.boeing.com/commercial/cmo/pdf/Boeing_Current_Market_Outlook_2012.pdf).)
- Cardero Resource Corp., 2012, Cardero receives 43–101 resource estimates for Longnose and TiTac ferro-titanium deposits, Minnesota, USA: Vancouver, British Columbia, Canada, Cardero Resource Corp. news release, January 31. (Accessed August 8, 2012, at [http://www.cardero.com/s/news\\_releases.asp?ReportID=504583](http://www.cardero.com/s/news_releases.asp?ReportID=504583).)
- Centers for Disease Control and Prevention, 2011, Current Intelligence Bulletin 63—Occupational exposure to titanium dioxide: Centers for Disease Control and Prevention, April. (Accessed August 29, 2012, at <http://www.cdc.gov/niosh/docs/2011-160/pdfs/2011-160.pdf>.)
- Cristal Global, 2011, Cristal Global announces a groundbreaking TiO<sub>2</sub> industry partnership with Outotec: Jeddah, Saudi Arabia, Cristal Global press release, November 10. (Accessed January 31, 2013, at [http://www.cristalglobal.com/news-room/news/Pages/Cristal-Global-announces-a-groundbreaking-TiO<sub>2</sub>-industry-partnership-with-Outotec.aspx](http://www.cristalglobal.com/news-room/news/Pages/Cristal-Global-announces-a-groundbreaking-TiO2-industry-partnership-with-Outotec.aspx).)
- Defense Advanced Research Projects Agency, 2012, Department of Defense fiscal year (FY) 2013 budget estimates: Defense Advanced Research Projects Agency, 336 p. (Accessed August 10, 2012, at <http://www.darpa.mil/WorkArea/DownloadAsset.aspx?id=2147484865>.)
- Defense Production Act Committee, [undated]a, Armstrong titanium production: Defense Production Act Committee. (Accessed December 27, 2012, at [http://www.dpatitle3.com/dpa\\_db/project.php?id=189](http://www.dpatitle3.com/dpa_db/project.php?id=189).)
- Defense Production Act Committee, [undated]b, Non-aerospace titanium for armor and structures transformation project: Defense Production Act Committee. (Accessed December 27, 2012, at [http://www.dpatitle3.com/dpa\\_db/project.php?id=74](http://www.dpatitle3.com/dpa_db/project.php?id=74).)
- Defense Production Act Committee, [undated]c, Titanium metal matrix composites: Defense Production Act Committee. (Accessed December 27, 2012, at [http://www.dpatitle3.com/dpa\\_db/project.php?id=84](http://www.dpatitle3.com/dpa_db/project.php?id=84).)
- Duz, V.A., Moxson, V.S., Abakumov, G.I., Ivasishin, O.M., and Kletsov, A., 2012, Transformational non-Kroll process hydrogenated titanium powder production: International Titanium Association, Titanium 2012 Conference and Exhibition, Atlanta, GA, October 8–10, 2012, presentation, 17 p.
- E. I. du Pont de Nemours and Co., 2011, DuPont announces global plans to expand titanium dioxide capabilities: Wilmington, DE, E.I. du Pont de Nemours and Co. news release, May 11. (Accessed August 8, 2012, at [http://us.vocuspr.com/Newsroom/Query.aspx?SiteName=DupontPreview&Entity=PRAAsset&SF\\_PRAAsset\\_PRAAssetID\\_EQ=120622&XSL=PressRelease&Cache=](http://us.vocuspr.com/Newsroom/Query.aspx?SiteName=DupontPreview&Entity=PRAAsset&SF_PRAAsset_PRAAssetID_EQ=120622&XSL=PressRelease&Cache=).)
- ERAMET Group, 2011, Creation of a vertically integrated player in the mineral sands sector: Paris, France, ERAMET Group, October 26, 25 p. (Accessed September 10, 2012, at <http://www.eramet.fr/us/Site/Template/Presentations.aspx?SELECTID=182&ID=68>.)
- Exxaro Resources Ltd., 2012, Exxaro annual review 2011: Pretoria, South Africa, Exxaro Resources Ltd., March 27, 305 p. (Accessed December 14, 2012, at <http://www.exxaro.com/content/investor/finreport.asp>.)
- Gunasekera, Rohan, 2011, Lanka Mineral Sands ramps up and seeks partners: Industrial Minerals, no. 530, November, p. 21.
- Hickton, Dawne, 2012, Commercial aerospace demand: International Titanium Association, Titanium 2012 Conference and Exhibition, Atlanta, GA, October 8–10, presentation, 21 p.
- Hindu Business Line, The, 2011, KMML test-run produces titanium sponge: Chennai, India, The Hindu Business Line. (Accessed August 27, 2012, at <http://www.thehindubusinessline.com/todays-paper/tp-others/tp-states/article2468698.ece>.)
- Iluka Resources Ltd., 2011a, Eneabba rutile sand: Perth, Western Australia, Australia, Iluka Resources Ltd. (Accessed September 10, 2012, at <http://www.iluka.com/products/natural-rutile/eneabba-rutile-sand>.)
- Iluka Resources Ltd., 2011b, Iluka review 2011: Perth, Western Australia, Australia, Iluka Resources Ltd., 51 p. (Accessed August 17, 2012, at [http://www.iluka.com/annualreport2011/content/pdf/Iluka\\_Review2011\\_FA02\\_Links.pdf](http://www.iluka.com/annualreport2011/content/pdf/Iluka_Review2011_FA02_Links.pdf).)
- Kenmare Resources plc, 2012, Annual report and accounts 2011: Dublin, Ireland, Kenmare Resources plc, 92 p. (Accessed December 12, 2012, at <http://www.kenmare.annualreport11.com/>.)
- Metal-Pages, 2011a, Interview, Chinese titanium output to continue to rise in 2012, Baoji Titanium: Metal-Pages, February 29. (Accessed June 19, 2012, via <http://www.metal-pages.com/>.)
- Metal-Pages, 2011b, China 2011 titanium dioxide output exceeds 1.75 million tons: Metal-Pages, February 24. (Accessed August 14, 2012, via <http://www.metal-pages.com/>.)
- Metal-Pages, 2011c, Ukraine's new ilmenite mine on tract for November start-up: Metal-Pages, October 20. (Accessed September 30, 2011, via <http://www.metal-pages.com/>.)
- Mineral Deposits Ltd., 2011, Annual general meeting presentation: Melbourne, Victoria, Australia, Mineral Deposits Ltd., 20 p. (Accessed September 7, 2012, at <http://www.mineraldeposits.com.au/wp-content/uploads/2012/05/MDL-AGM-18-November-2011.pdf>.)
- Moodley, Sashnee, 2012, US company begins test on world's largest titanium deposit: Mining Weekly, March 16. (Accessed August 21, 2012, at <http://www.miningweekly.com/article/us-company-begins-tests-on-worlds-largest-titanium-deposit-2012-03-16>.)
- OSAKA Titanium Technologies Co. Ltd., 2012, Annual report 2012: Amagasaki, Japan, OSAKA Titanium Technologies Co. Ltd., August, 54 p. (Accessed December 5, 2012, via [http://www.osaka-ti.co.jp/e\\_e\\_ir/index.html](http://www.osaka-ti.co.jp/e_e_ir/index.html).)
- Pathfinder Minerals plc, 2011a, Scoping study report on the Moebase and Naburi mineral sands deposits, Mozambique: London, United Kingdom, Pathfinder Minerals plc, 102 p. (Accessed December 12, 2012, at <http://www.pathfinderminerals.com/operations/technical-information/technical-reports/2011.aspx>.)
- Pathfinder Minerals plc, 2011b, New mining license issued: London, United Kingdom, Pathfinder Minerals plc news release, July 21. (Accessed December 12, 2012, at <http://otp.investis.com/clients/uk/pathfinder/rns/regulatory-story.aspx?cid=195&newsid=213489>.)
- Pohang Iron and Steel Co., Ltd., 2010, Agreement on the establishment of the titanium slab joint venture: Pohang, South Korea, Pohang Iron and Steel Co., Ltd. press release, April 30. (Accessed December 18, 2012, at <http://www.posco.com/homepage/docs/eng/jsp/prcenter/news/s91c1010025v.jsp>.)
- Rio Tinto, Fer et Titane, 2011, Rio Tinto to extend life of titanium dioxide operations in Quebec in response to growing global demand: Sorel-Tracy, Quebec, Canada, Rio Tinto, Fer et Titane press release, 2 p. (Accessed September 7, 2012, at [http://www.rft.com/documents/Rio\\_Tinto\\_to\\_extend\\_life\\_of\\_titanium\\_dioxide\\_operations\\_in\\_Quebec\\_26May11.pdf](http://www.rft.com/documents/Rio_Tinto_to_extend_life_of_titanium_dioxide_operations_in_Quebec_26May11.pdf).)



- Roskill's Letters from Japan, 2012, Titanium sponge—Japanese producers operate close to capacity: Roskill's Letters from Japan, no. 430, June, p. 1.
- RTI International Metals Inc., 2012, 2011 annual report: Pittsburgh, PA, RTI International Metals Inc., 106 p. (Accessed December 17, 2012, at <http://rtiintl.com/en-us/investorrelations/Pages/Annual-Reports.aspx#archive>.)
- Sierra Rutile Ltd., 2011, Sierra Rutile to expand production: Sierra Leone, West Africa, Sierra Rutile Ltd. press release, October 24. (Accessed December 12, 2012, at <http://www.sierra-rutile.com/press-releases.aspx>.)
- Sierra Rutile Ltd., 2012, Annual report 2011: Sierra Leone, West Africa, Sierra Rutile Ltd., 72 p. (Accessed December 12, 2012, at <http://www.sierra-rutile.com/financial-reports.aspx>.)
- Titanium Corp., 2011, Annual report 2011: Edmonton, Alberta, Canada, Titanium Corp., 17 p. (Accessed August 15, 2012, at <http://www.titaniumcorporation.com/i/pdf/AIF.PDF>.)
- Toho Titanium Co., Ltd., 2012, Regarding the completion of the work to expand the capacity of titanium sponge production line in Wakamatsu plant: Chigasaki, Japan, Toho Titanium Co., Ltd. press release, February 23. (Accessed August 29, 2012, at [http://v4.eir-parts.net/v4Contents/View.aspx?template=ir\\_material&sid=14715&code=5727](http://v4.eir-parts.net/v4Contents/View.aspx?template=ir_material&sid=14715&code=5727).)
- Trimex Industries Pvt. Ltd., 2011, Trimex Sands signs Memorandum of Understanding with Government of Indonesia to establish an integrated titanium industrial complex: Chennai, India, Trimex Industries Pvt. Ltd. news release, January 25. (Accessed August 15, 2012, at [http://www.trimexgroup.com/p\\_201101\\_trimex\\_mou.asp](http://www.trimexgroup.com/p_201101_trimex_mou.asp).)
- Tronox Inc., 2011, Tronox to acquire Exxaro's mineral sands operations creating leading vertically integrated titanium dioxide pigment producer: Oklahoma City, OK, Tronox Inc. press release, September 26, 3 p. (Accessed September 13, 2012, at <http://investor.tronox.com/releasedetail.cfm?ReleaseID=607992>.)
- Tronox Inc., 2012, Tronox announces closing of Exxaro mineral sands acquisition: Oklahoma City, OK, Tronox Inc. press release, June 15. (Accessed February 22, 2013, at <http://investor.tronox.com/releasedetail.cfm?ReleaseID=683427>.)
- United Nations Statistics Division, [undated], Titanium ores and concentrates: United Nations Comtrade Database. (Accessed December 17, 2012, at <http://comtrade.un.org/db/>.)
- Universal Newswire, 2011, New titanium factory to be built in Kazakhstan: Washington, DC, Universal Newswires Ltd., October 18. (Accessed December 18, 2012, at <http://www.universalnewswires.com/centralasia/kazakhstan/viewstory.aspx?id=10460>.)
- U.S. Department of Labor, Bureau of Labor Statistics, 2012, Producer price index—Commodities: U.S. Department of Labor, Bureau of Labor Statistics. (Accessed August 8, 2012, at <http://data.bls.gov/>.)
- VSMPO-AVISMA Corp., 2012, Quarterly report for first quarter 2012: Sverdlovsk, Russia, VSMPO-AVISMA Corp. quarterly report, May 15, 204 p. (Accessed December 18, 2012, at [http://www.vsm-po.ru/en/pages/Ezhekvtarnie\\_otcheti](http://www.vsm-po.ru/en/pages/Ezhekvtarnie_otcheti).)
- Watts, Mark, 2011, Tioline targets full scale minsands plant in Kazakhstan by 2013: Industrial Minerals, October 10. (Accessed December 10, 2012, at <http://www.indmin.com>)

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Recycling—Metals. Ch. in Minerals Yearbook, annual.
- Titanium and Titanium Dioxide. Ch. in Mineral Commodity Summaries, annual.
- Titanium Mineral Concentrates. Ch. in Mineral Commodity Summaries, annual.
- Titanium Mineral Resources of the United States—Definitions and documentation—Contributions to the Geology of Mineral Deposits. Bulletin 1558-B, 1984.
- Titanium. Ch. in Metal Prices in the United States Through 1998, 1999.
- Titanium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Titanium. International Strategic Minerals Inventory Summary Report, Circular 930-G, 1988.
- Titanium. Mineral Industry Surveys, quarterly.

### Other

- Geology of Titanium-Mineral Deposits. Geological Society of America Special Paper 259, 1991.
- Industrial Minerals, monthly.
- Japan Titanium Society.
- Titanium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
- Titanium Metal—Market outlook to 2015 (5th ed.). Roskill Information Services Ltd., 2010.
- Titanium Newsletter. International Titanium Association, quarterly.



TABLE 1  
SALIENT TITANIUM STATISTICS<sup>1</sup>

		2007	2008	2009	2010	2011
United States:						
Mineral concentrate:						
Imports for consumption	metric tons	1,460,000	1,380,000	943,000	1,200,000	1,270,000
Consumption <sup>e,2</sup>	do.	1,950,000	1,780,000	1,700,000	1,850,000 <sup>r</sup>	1,830,000
Sponge metal:						
Imports for consumption	do.	25,900	23,900	16,600	20,500	33,800
Consumption	do.	33,700	W	W	34,900	48,400
Price, yearend <sup>3</sup>	dollars per pound	6.33–7.06	6.16–8.02	4.50–7.07	3.50–6.24	3.27–6.74
Titanium dioxide pigment:						
Production	metric tons	1,440,000	1,350,000	1,230,000	1,320,000	1,290,000
Imports for consumption	do.	221,000	183,000	175,000	204,000	200,000
Consumption, apparent <sup>4</sup>	do.	979,000	800,000	757,000	767,000	706,000
Producer price index, yearend <sup>5</sup>	(1982=100)	162	170	164	194	268
World, production:						
Ilmenite concentrate <sup>6</sup>	metric tons	7,140,000	7,060,000 <sup>r</sup>	6,120,000 <sup>r</sup>	6,220,000 <sup>r</sup>	6,450,000
Rutile concentrate, natural <sup>7</sup>	do.	608,000 <sup>r</sup>	634,000	571,000	739,000 <sup>r</sup>	789,000
Titaniferous slag <sup>e</sup>	do.	2,230,000	2,230,000	2,000,000	2,210,000	2,180,000

<sup>e</sup>Estimated. <sup>r</sup>Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Data are rounded to no more than three significant digits, except prices.

<sup>2</sup>Excludes consumption used to produce synthetic rutile.

<sup>3</sup>Landed duty-paid unit based on U.S. imports for consumption.

<sup>4</sup>Production plus imports minus exports. Excludes stock changes.

<sup>5</sup>Source: U.S. Department of Labor, Bureau of Labor Statistics.

<sup>6</sup>Includes U.S. production of ilmenite, leucoxene, and rutile rounded to one significant digit to avoid disclosing company proprietary data.

<sup>7</sup>U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2  
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2011<sup>1,2</sup>

(Metric tons per year)

Company	Plant location	Yearend capacity <sup>c</sup>	
		Sponge	Ingot <sup>3</sup>
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

<sup>c</sup>Estimated. Do. Ditto. -- Zero.

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

<sup>2</sup>Estimated operating capacity based on 7-day-per-week full production.

<sup>3</sup>Includes electron-beam, plasma, and vacuum-arc-remelting capacity.

<sup>4</sup>In July 2009, sponge capacity of 9,980 metric tons per year was temporarily idled and did not operate in 2011.

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

(Metric tons)

Component	2010	2011
<b>Production:</b>		
Ingot	56,400	60,300
Mill products	36,300	40,500
<b>Exports:</b>		
Waste and scrap	3,480	5,150
Sponge	293	256
Other unwrought	3,040	1,180
Wrought products and castings	14,800	24,700
Total	21,600	31,300
<b>Imports:</b>		
Waste and scrap	10,700	13,900
Sponge	20,500	33,800
Other unwrought	444	915
Wrought products and castings	8,710 <sup>r</sup>	6,820
Total	40,300 <sup>r</sup>	55,400
<b>Stocks, industry, yearend:</b>		
Sponge	10,500	10,800
Scrap	7,900	12,900
Ingot	2,920	3,850
<b>Consumption, reported:</b>		
Sponge	34,900	48,400
Scrap	29,200	30,900
Ingot	40,900	55,900
<b>Shipments:</b>		
Ingot	13,700	15,400
<b>Mill products (net shipments):</b>		
Forging and extrusion billet	19,700	16,800
Other	18,500	28,700
Total	38,300	45,500
Castings (shipments)	W	W
<b>Receipts, scrap:</b>		
Home	9,770	12,300
Purchased	23,400	21,200
Total	33,200	33,600

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Data 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 2011<sup>1,2,3</sup>

(Metric tons per year)

Company	Plant location	Yearend capacity <sup>4</sup>
Cristal Global	Ashtabula, OH	220,000
Du Pont Titanium Technologies	De Lisle, MS	340,000
Do.	Edgemoor, DE	190,000
Do.	New Johnsonville, TN	400,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	146,000
Tronox Inc.	Hamilton, MS	225,000
Do.	Savannah, GA	( <sup>5</sup> )
Total		1,520,000

Do. Ditto.

<sup>1</sup>Estimated operating capacity based on 7-day-per-week full production.

<sup>2</sup>Table 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 TiO<sub>2</sub> pigment that is produced by refining and fine grinding of synthetic rutile.

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

<sup>4</sup>All plants use the chloride process to manufacture TiO<sub>2</sub> pigment.

<sup>5</sup>Tronox Inc. idled its 110,000-t/yr plant in the fourth quarter of 2009 and did not operate the plant in 2011.

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

		2010		2011	
		Gross weight	TiO <sub>2</sub> content	Gross weight	TiO <sub>2</sub> content
Production <sup>2</sup>	metric tons	1,320,000	1,240,000	1,290,000	1,220,000
Shipments: <sup>3</sup>					
Quantity	do.	1,360,000	1,270,000	1,320,000	1,220,000
Value	thousands	\$3,170,000	XX	\$4,400,000	XX
Exports	metric tons	758,000	713,000 <sup>c</sup>	789,000	741,000
Imports for consumption	do.	204,000	192,000 <sup>c</sup>	200,000	188,000
Consumption, apparent <sup>e, 4</sup>	do.	767,000	719,000	706,000	464,000

<sup>c</sup>Estimated. do. Ditto. XX Not applicable.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Excludes production of buff pigment.

<sup>3</sup>Includes interplant transfers.

<sup>4</sup>Production 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<sup>1,2</sup>

(Metric tons)

	2010		2011	
	Gross weight <sup>r</sup>	TiO <sub>2</sub> content	Gross weight	TiO <sub>2</sub> content
Pigment	1,740,000	NA	1,700,000	NA
Miscellaneous <sup>3</sup>	113,000	NA	131,000	NA
Total	1,850,000	1,520,000 <sup>r</sup>	1,830,000	1,500,000

<sup>r</sup>Revised. NA Not available.

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

<sup>2</sup>Includes a mixed product containing altered ilmenite, leucoxene, and rutile.

<sup>3</sup>Includes 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<sup>1,2</sup>

(Metric tons)

	2010	2011
Steel:		
Carbon steel	6,110	6,580
Stainless and heat-resisting steel	3,300	3,120
Other alloy steel <sup>3</sup>	649	737
Total steel	10,100	10,400
Cast irons	16	16
Superalloys	522	686
Alloys, other than above	1,020	1,240
Miscellaneous and unspecified	42	41
Grand total	11,700	12,400

<sup>1</sup>Includes ferrotitanium, scrap, sponge, and other titanium additives.

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

<sup>3</sup>Includes high-strength low-alloy and tool steel.

TABLE 8  
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS,  
TITANIUM DIOXIDE CONTENT, BY INDUSTRY<sup>1</sup>

(Percent)

Industry	2010 <sup>e</sup>	2011 <sup>e</sup>
Paint, varnish, lacquer	57.1	58.5
Paper	9.7	8.6
Plastics and rubber	27.4	27.9
Other <sup>2</sup>	5.8	5.0
Total	100.0	100.0

<sup>e</sup>Estimated.

<sup>1</sup>Excludes exports.

<sup>2</sup>Includes 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

		2010	2011
<b>Concentrate:</b>			
Ilmenite, free on board (f.o.b.) Australian ports <sup>1</sup>	dollars per metric ton	65–85	140–250
Rutile, bagged, f.o.b. Australian ports <sup>1</sup>	do.	760–805	1,348–1,600
Rutile, bulk, f.o.b. Australian ports <sup>1</sup>	do.	530–550	1,300–1,400
Titaniferous slag, import, 80% to 95% TiO <sub>2</sub> <sup>2</sup>	do.	367–433	468–494
<b>Metal:</b>			
Sponge import <sup>2</sup>	dollars per pound	3.50–6.24	3.27–6.74
Scrap, turnings, unprocessed <sup>3</sup>	do.	2.00–2.10	2.00–2.20
Ferrotitanium, 70% Ti <sup>3</sup>	do.	3.18–3.25	3.45–3.55
Mill products <sup>4</sup>	producer price index	203	203
Titanium dioxide pigment <sup>4</sup>	do.	194	268

do. Ditto.

<sup>1</sup>Source: Industrial Minerals.

<sup>2</sup>Landed duty-paid unit value based on U.S. imports for consumption.

<sup>3</sup>Source: Platts Metals Week.

<sup>4</sup>1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 10  
U.S. EXPORTS OF TITANIUM BY CLASS<sup>1</sup>

Class	HTS <sup>2</sup>	2010		2011	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
<b>Metal:</b>					
Scrap	8108.30.0000	3,480	\$19,200	5,150	\$33,300
<b>Unwrought:</b>					
Sponge	8108.20.0010	293	2,330	256	1,860
Ingot	8108.20.0030	467	9,530	252	6,000
Other	8108.20.0090	2,570	31,900	923	16,500
<b>Wrought:</b>					
Billet	8108.90.6010	2,240	77,600	3,500	131,000
Bloom, sheet bar, slab	8108.90.6020	1,240	35,500	1,560	49,400
Bar, rod, profile, wire	8108.90.6031	2,830	149,000	4,060	224,000
Other	8108.90.8000	8,450	531,000	15,600	863,000
Total		21,600	856,000	31,300	1,320,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,570	12,200	3,210	17,600
Ores and concentrates	2614.00.0000	18,900	11,800	26,600	11,000
<b>Pigment:</b>					
80% or more titanium dioxide pigment	3206.11.0000	717,000	1,570,000	741,000	2,110,000
Other titanium dioxide pigment	3206.19.0000	36,700	102,000	40,000	104,000
Unfinished titanium dioxide <sup>3</sup>	2823.00.0000	4,160	11,000	7,160	19,700
Total		758,000	1,690,000	789,000	2,230,000

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

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 11  
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATE, BY COUNTRY<sup>1</sup>

Concentrate and country	HTS <sup>2</sup>	2010		2011	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:	2614.00.6020				
Australia		98,200	\$9,680	244,000	\$26,800
Mozambique		199,000	14,800	114,000	8,980
Ukraine		57,500	10,100	10,000	2,220
Other		22,300	3,070	9,340	1,540
Total		377,000	37,600	377,000	39,600
Titaniferous slag:	2620.99.5000				
Canada		150,000	64,700	191,000	90,600
South Africa		325,000	135,000	323,000	144,000
Total		475,000	200,000	513,000	235,000
Rutile, natural:	2614.00.6040				
Australia		83,500	55,000	106,000	62,100
Sierra Leone		29,800	17,300	10,100	9,030
South Africa		96,500	51,700	133,000	76,600
Other <sup>3</sup>		19,100	21,200	13,500	9,900
Total		229,000	145,000	262,000	158,000
Rutile, synthetic:	2614.00.3000				
Australia		109,000	45,500	112,000	80,300
Malaysia		4,460	2,620	--	--
Other <sup>3</sup>		9,170	4,310	6,960	7,730
Total		122,000	52,400	119,000	88,000
Titaniferous iron ore, Canada <sup>4</sup>	2614.00.6020	83,100	6,760	96	23

-- Zero.

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

<sup>2</sup>Harmonized Tariff Schedule of the United States.

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

<sup>4</sup>Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux. Titaniferous iron ore from Canada is classified as ilmenite under the 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 COUNTRY<sup>1</sup>

Class and country	HTS <sup>2</sup>	2010		2011	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		682	\$3,130	738	\$4,920
France		1,480	10,700	1,790	16,100
Germany		2,050	15,000	1,930	17,900
Israel		256	2,060	523	4,490
Italy		398	3,580	329	2,610
Japan		1,550	11,000	2,260	20,100
Korea, Republic of		416	2,820	655	5,960
Mexico		151	519	369	1,770
Russia		243	1,860	158	1,240
Spain		134	961	220	2,040
Taiwan		692	3,870	813	6,880
United Kingdom		1,720	13,200	2,820	20,600
Other		943	6,780 <sup>r</sup>	1,320	10,900
Total		10,700	75,500	13,900	116,000
Unwrought:					
Sponge:	8108.20.0010				
China		868	7,660	5,860	62,900
Japan		9,790	110,000	16,100	176,000
Kazakhstan <sup>c</sup>		8,550	69,700	8,610	81,800
Russia		918	6,630	1,260	7,710
Other		331 <sup>r</sup>	2,680 <sup>r</sup>	1,990	20,500
Total		20,500	196,000	33,800	349,000
Ingot:	8108.20.0030				
China		48	631	--	--
Germany		156	2,640	344	6,310
Russia		12	154	302	5,830
Other		21	447	9	325
Total		237	3,880	655	12,500
Powder:	8108.20.0015				
Canada		7	759	4	905
China		96	1,830	33	602
Japan		6	1,380	8	1,480
Other		10 <sup>r</sup>	1,450 <sup>r</sup>	6	498
Total		119	5,420	51	3,490
Other:	8108.20.0091				
China		15	104	40	663
France		7	794	22	750
Germany		26	554	64	1,270
Russia		--	--	31	804
United Kingdom		21	2,230	48	3,440
Other		19 <sup>r</sup>	296 <sup>r</sup>	4	568
Total		88	3,980	209	7,500
Wrought products and castings: <sup>3</sup>	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		537	17,400	958	31,400
Germany		266	10,600	311	10,500
Japan		181	12,700	468	23,400
Russia		7,130	211,000	3,920	146,000
United Kingdom		140	15,600	351	28,700
Other		455 <sup>r</sup>	31,800 <sup>r</sup>	812	48,000
Total		8,710	299,000	6,820	288,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,740	11,500	2,070	11,700

<sup>c</sup>Estimated. <sup>r</sup>Revised. -- Zero.

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

<sup>2</sup>Harmonized Tariff Schedule of the United States.

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

Source: U.S. Census Bureau.

TABLE 13  
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENT, BY COUNTRY<sup>1</sup>

Country	HTS <sup>2</sup>	2010		2011	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Canada		83,400	\$183,000	79,000	\$226,000
China		8,120	15,800	10,300	29,100
Finland		7,970	16,000	6,790	17,200
France		4,200	8,990	4,910	14,500
Germany		5,720	13,300	6,450	17,400
Italy		2,890	6,170	3,460	10,100
Japan		4,350	18,600	4,180	20,800
Netherlands		4,730	9,790	1,800	4,390
Ukraine		9,890	15,900	11,700	25,600
Other		13,700 <sup>r</sup>	26,800 <sup>r</sup>	11,900	32,700
Total		145,000	314,000	140,000	397,000
Other titanium dioxide:	3206.19.0000				
Canada		7,230	18,600	8,820	25,900
China		1,550	4,510	1,110	4,040
Germany		1,440	5,230	666	2,720
Japan		836	7,910	552	6,670
Other		1,060	8,870	1,030	8,200
Total		12,100	45,100	12,200	47,500
Unfinished titanium dioxide: <sup>3</sup>	2823.00.0000				
China		22,400	41,300	24,200	70,800
Czech Republic		2,400	4,610	2,460	6,390
Finland		2,960	6,960	2,910	9,590
France		4,910	16,400	5,720	18,200
Germany		4,920	10,700	4,270	9,580
Italy		2,220	4,800	3,120	8,930
Korea, Republic of		4,450	7,600	2,630	5,890
Other		2,930 <sup>r</sup>	11,000 <sup>r</sup>	2,430	11,100
Total		47,200	103,000	47,700	141,000
Grand total		204,000	462,000	200,000	585,000

<sup>r</sup>Revised.

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

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Unmixed and not surface treated.

Source: U.S. Census Bureau.



TABLE 14  
TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY<sup>1,2</sup>

(Metric tons)

Concentrate type and country	2007	2008	2009	2010	2011
<b>Ilmenite and leucoxene:<sup>3,4</sup></b>					
Australia	2,503,000	2,230,000	1,611,000	1,313,000 <sup>r</sup>	1,501,000
Brazil <sup>5</sup>	100,364	175,076	71,122	75,000	75,000 <sup>e</sup>
China <sup>e</sup>	1,100,000	1,100,000	900,000	1,000,000	1,100,000
India <sup>c</sup>	700,000	610,000	700,000	540,000 <sup>r</sup>	550,000
Kazakhstan <sup>e</sup>	25,000	25,000	25,000	25,000	25,000
Malaysia	60,250	36,779	15,983	19,036 <sup>r</sup>	28,782
Mozambique	140,515	328,875	471,524	678,400 <sup>r</sup>	636,800
Norway <sup>e</sup>	882,000	915,000	671,000	670,000	600,000
Sierra Leone	15,750	17,528	15,161 <sup>r</sup>	18,206	15,946
Sri Lanka	70,728	22,159	122,424	52,637	52,000
Ukraine	500,000	520,000	500,000 <sup>e</sup>	500,000 <sup>e</sup>	500,000 <sup>e</sup>
United States <sup>5,6</sup>	400,000	400,000 <sup>r</sup>	300,000	400,000	400,000
Vietnam <sup>7</sup>	653,500 <sup>r</sup>	709,500 <sup>r</sup>	698,700 <sup>r</sup>	912,000 <sup>r</sup>	915,000 <sup>e</sup>
<b>Total<sup>8</sup></b>	<b>7,140,000</b>	<b>7,060,000<sup>r</sup></b>	<b>6,120,000<sup>r</sup></b>	<b>6,220,000<sup>r</sup></b>	<b>6,450,000</b>
<b>Rutile:<sup>4</sup></b>					
Australia	312,000	325,000	281,000	429,000 <sup>r</sup>	474,000
Brazil <sup>5</sup>	3,000	2,309 <sup>r</sup>	2,737 <sup>r</sup>	2,519 <sup>r</sup>	2,550 <sup>p</sup>
India <sup>c</sup>	21,000	21,000	21,000	24,000 <sup>r</sup>	25,000
Madagascar	--	--	3,200 <sup>e</sup>	5,700 <sup>e</sup>	9,500 <sup>e</sup>
Malaysia	1,450	1,834	1,502	7,567	10,810
Mozambique	8,782	6,552	1,697	4,656	6,500
Sierra Leone	82,805 <sup>r</sup>	78,908	63,864	68,198	67,916
South Africa <sup>e</sup>	114,000	127,000	134,000	135,000 <sup>r</sup>	130,000
Sri Lanka	4,607 <sup>r</sup>	11,335	2,276	2,568	2,700
Ukraine <sup>e</sup>	60,000	60,000	60,000	60,000	60,000
United States	(9)	(9)	(9)	(9)	(9)
<b>Total</b>	<b>608,000<sup>r</sup></b>	<b>634,000</b>	<b>571,000</b>	<b>739,000<sup>r</sup></b>	<b>789,000</b>
<b>Titaniferous slag:<sup>e,10</sup></b>					
Canada	960,000	1,000,000	765,000	1,090,000	878,000
South Africa	1,270,000	1,230,000	1,230,000	1,120,000	1,300,000
<b>Total</b>	<b>2,230,000</b>	<b>2,230,000</b>	<b>2,000,000</b>	<b>2,210,000</b>	<b>2,180,000</b>

<sup>e</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

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

<sup>2</sup>Table includes data available through July 20, 2012.

<sup>3</sup>Ilmenite 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.

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

<sup>5</sup>Excludes production of unbeneficiated anatase ore.

<sup>6</sup>Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

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

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

<sup>9</sup>Included with ilmenite to avoid disclosing company proprietary data.

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