



2015 Minerals Yearbook

TITANIUM [ADVANCE RELEASE]

TITANIUM

By George M. Bedinger

Domestic survey data and tables were prepared by Joseph J. Kohler, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2015, there were three producers of titanium mineral concentrates in the United States. The United States was 83% and 61% import reliant, as a percentage of apparent consumption, for titanium mineral concentrates and titanium sponge, respectively. The United States continued to be a net exporter of titanium dioxide (TiO_2) pigment and wrought titanium metal products. The leading sources of imported titanium mineral concentrates were, in decreasing order, Australia, South Africa, and Mozambique (table 11). Domestic production of TiO_2 pigment decreased by 3% compared with that of 2014 (table 5). U.S. consumption of titanium used in steel and other alloys decreased by 3% from 2014 (table 7).

World production of titanium mineral concentrates in 2015 was 10.3 million metric tons (Mt), an increase of 4% from revised totals for 2014. The leading producers of titanium mineral concentrates were, in descending order of production, Australia, South Africa, China, and Mozambique.

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 2015, the USGS annual survey canvassed titanium mineral and pigment producers. The three producers of titanium mineral concentrates responded. In the third quarter, The Chemours Co. announced that it planned to close a pigment manufacturing plant in Edgemoor, DE, by the end of September. Of the five remaining domestic TiO_2 pigment operations, three responded. Production data for the operations that did not respond were estimated on the basis of prior year production levels and industry trends. Production data for titanium ingot and mill products were aggregated from a quarterly survey of producers.

Mineral Concentrates.—Titanium minerals and raw materials of economic importance include ilmenite, leucoxene, rutile, synthetic rutile, and titaniferous slag. Mining of titanium minerals is usually performed using dredging and dry surface mining techniques for the recovery of heavy minerals, including titanium minerals. Spiral separation by gravity is used to isolate the heavy-mineral suite, and magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite and rutile are the two principal minerals for titanium. Ilmenite is the most abundant titanium mineral with a contained TiO_2 content ranging from 35% to 65%. Rutile, naturally occurring TiO_2 , has the highest TiO_2 content but is less abundant. 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.

United States mineral concentrate producers were The Chemours Co. (Wilmington, DE), Iluka Resources, Inc. (a wholly owned subsidiary of the Australian company Iluka Resources Ltd.), and Southern Ionics Inc. (West Point, MS). Chemours produced titanium concentrates from its operation near Starke, FL; Iluka produced titanium concentrates from its operations near Stony Creek, VA; and Southern Ionics produced titanium concentrates from its operation in Charlton County, GA. In December, Iluka idled its Virginia operations owing to market conditions, but continued to hold mineral leases of resources located near the Aurelian Springs and Hickory deposits in North Carolina and Virginia, respectively (Iluka Resources Ltd., 2016, p. 5).

Twin Pines Minerals LLC was developing a project to produce zircon and ilmenite concentrates by reprocessing tailings from former heavy-mineral-sand operations in New Jersey. A mineral sands wet concentration plant was being constructed with a capacity to process 232 metric tons per hour of tailings. Production was expected to begin in the second quarter of 2016 (Mineral Sands Report, 2014, p. 5; Sedgman Ltd., 2015).

TiO_2 Pigment.— TiO_2 pigment is produced from titanium mineral concentrates by either the chloride process or sulfate process. In the chloride process, natural rutile, chloride-grade ilmenite, or slag is converted to titanium tetrachloride (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 during the reaction. Aluminum chloride, added to the TiCl_4 , ensures that virtually all of the titanium is oxidized into the rutile crystal structure, rather than its polymorph anatase. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. Either process may be used to produce pigment; the decision of which process to use is based on numerous factors, including raw material availability and freight and waste disposal costs. In finishing operations, the crude form of the pigment is milled to produce a controlled particle size distribution and surface treated or coated to improve its functional behavior in various media. Some typical surface treatments include alumina, organic compounds, and silica. The TiO_2 pigment produced 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 have significantly different functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO₂ pigment was 1.22 Mt in 2015, a 3% decrease compared with that in 2014 (table 5). U.S. producers of TiO₂ pigment using the chloride process were Cristal Global (a subsidiary of National Titanium Dioxide Company Ltd.), Chemours, Louisiana Pigment Co. L.P. (a joint venture of Kronos Worldwide, Inc. and Huntsman Corp.), and Tronox Ltd. (table 4). TOR Minerals International, Inc. produced a buff TiO₂ pigment from finely ground synthetic rutile.

In August, Chemours announced plans to close its pigment manufacturing plant in Edgemoor, DE, and a TiO₂ line at its facility in New Johnsonville, TN, by the end of September. These reductions were expected to eliminate 150,000 metric tons per year (t/yr) of TiO₂ capacity (Chemours Co., The, 2015).

Metal.—In commercial production of titanium metal, titanium-containing mineral concentrates are chlorinated to produce TiCl₄, which is then reduced with magnesium (Kroll process) or sodium (Hunter process) to produce a commercially pure titanium metal. The metal formed has a porous appearance and is referred to as sponge. Titanium ingot and slab are produced by melting titanium sponge and (or) scrap, usually with other alloying elements such as aluminum and vanadium. Electron beam, plasma arc melt, scull, and vacuum-arc remelting are the commercial methods used to produce ingot and slab. Titanium mill products are formed by 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.

In 2015, 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 Material (Salt Lake City, UT) used the Hunter process to produce titanium sponge as feed for the company's production of electronic-grade titanium. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data.

In June, ATI announced it had received product qualification for premium-quality titanium sponge produced at its Rowley, UT, facility for use in jet engine rotating parts. The qualification included products made using Rowley-produced sponge and melted at ATI's facilities in Bakers, NC, and Albany, OR (Allegheny Technologies Inc., 2015).

There were six U.S. titanium ingot producers with 10 facilities with an estimated capacity of 118,000 t/yr (table 2). In 2015, U.S. production of titanium ingot increased by 11% and mill shipments increased by 5% (table 3).

In March, Alcoa Inc. announced the acquisition of RTI International Metals, Inc. and completed the purchase in July. The acquisition of RTI added melting, ingot casting, bloom, billet, plate, and sheet production to Alcoa's existing titanium investment casting and forging capabilities (Arconic Inc., 2015).

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 grades of ferrotitanium that are normally produced contain 40% or 70% titanium. U.S. producers of ferrotitanium were Alcoa Inc.

(Canton, OH) with a capacity of 7,250 t/yr and Global Titanium Inc. (Detroit, MI) with a capacity of over 10,000 t/yr. Data on production of ferrotitanium were not available.

Consumption

Mineral Concentrates.—On a gross-weight basis, 93% of domestic consumption of titanium mineral concentrates was used to produce TiO₂ pigment. The remaining 7% was used to produce metal and other miscellaneous products, including fluxes and welding rod coatings. Domestic consumption of titanium mineral concentrates was 1.72 Mt, a 4% decrease compared with that of 2014 (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.

TiO₂ Pigment.—Domestic production of TiO₂ pigment in 2015 was 1.22 Mt, a decrease of 3% from that of the previous year (table 1). Apparent gross domestic consumption (not accounting for changes in inventory) decreased slightly from that of 2014 (table 5). The leading uses of TiO₂ pigment, based on TiO₂ pigment shipments in the United States by domestic producers, were paint and coatings (60.3%), plastics and rubber (28.7%), and paper (4.5%). Other uses (6.5%) included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules (table 8).

Metal.—Titanium metal alloys are used for their high strength-to-weight ratio and corrosion resistance. The aerospace industry (75%) was the leading end use for mill products. In general, production of titanium mill products precedes aircraft deliveries by about 1 year. In 2015, mill product shipments increased by 3% from those of 2014 (table 3). Other uses included consumer goods and in 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 was consumed in the steel and nonferrous alloy industries. In the steel industry, titanium is used for deoxidation, grain-size control, and control and stabilization of carbon and nitrogen content. Titanium-intensive steels include interstitial, free-machining, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 11,600 metric tons (t), a decrease of 3% from that of 2014 (table 7).

Stocks

Insufficient data were available to determine yearend consumer inventories of titanium mineral concentrates and TiO₂ pigment producer stocks. Yearend domestic stocks of sponge and ingot increased by 9% and 51%, respectively, from yearend 2014 levels (table 3).

Prices

Yearend titanium mineral concentrate prices are listed in table 9. Prices for bulk ilmenite and rutile concentrates in 2015 continued to decline throughout the year owing to reduced demand. Published prices for titanium slag were not available. Based on U.S. Census Bureau data, the value of slag imports from slag producing countries in December 2015 was within

a range of \$630 to \$751 per metric ton, down from \$690 to \$835 per metric ton in December 2014.

The U.S. Department of Labor, Bureau of Labor Statistics, monthly producer price index (PPI) for TiO₂ pigment (June 1982 = 100) generally decreased during 2015 from 224 in December 2014 to 176 in December 2015. The monthly PPI for titanium mill products began the year at 180 in January, decreased to 166 in February, and ended the year at 171 in December.

Foreign Trade

Mineral Concentrates.—U.S. imports of titanium mineral concentrates included 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. In 2015, domestic imports totaled 1.44 Mt, which included ilmenite (649,000 t), titaniferous slag (399,000 t), rutile (292,000 t), and synthetic rutile (102,000 t), with a TiO₂ content of 36%, 31%, 24%, and 9%, respectively. Australia, South Africa, Mozambique, and Canada were, in descending order of TiO₂ content, the leading import sources. The combined value for all forms of titanium concentrate imports in 2015 was \$669 million (table 11). Imports of titaniferous iron ore from Canada (classified as ilmenite by the U.S. Census Bureau), which totaled 138 t in 2014, increased to 64,700 t in 2015. Exports of titanium concentrates were minor relative to imports (tables 10, 11).

TiO₂ Pigment.—In 2015, the United States continued to be a net exporter of TiO₂ pigment, with exports exceeding imports by a ratio of 2.9 to 1. Exports of TiO₂ pigment were 648,000 t, a 5% decrease compared with those of 2014. About 92% of TiO₂ pigment exports was in the form of finished pigment containing 80% or more TiO₂ content (table 10). During 2015, 222,000 t of TiO₂ pigment was imported, slightly less than that of 2014. The leading import sources of TiO₂ pigment were Canada (32%) and China (24%). Finished pigment containing more than 80% TiO₂ accounted for 76% of pigment imports (table 13).

Metal.—Total imports of titanium metal, excluding ferrotitanium and ferrosilicon titanium, increased by 11% from those in 2014. Imports of titanium metal, excluding ferrotitanium and ferrosilicon titanium, were primarily in the form of waste and scrap (43%), sponge (41%), and wrought products and castings (12%). In descending order, Japan, Kazakhstan, and Ukraine were the leading sources of imported titanium sponge, and the United Kingdom, Germany, Japan, and France were, in descending order, the leading sources of imported scrap. Russia supplied 80% of the imported titanium ingot, and China was the leading source of titanium powder. Russia was the leading source of wrought products and castings. Imports of wrought products and castings were 6,202 t, a slight decrease from the revised 2014 total.

Imports of ferrotitanium were 1,730 t, a 22% decrease compared with those of 2014 (table 12). The leading import sources were, in descending order, Canada and the United Kingdom. Exports of ferrotitanium were 2,140 t, a 29% decrease compared with those of 2014 (table 10).

World Review

Global consumption of TiO₂ in 2015 was estimated to be 5.89 Mt. The leading consumers were China (1.95 Mt), Europe (1.17 Mt), and North America (0.95 Mt); the rest of the world accounted for the remaining 1.82 Mt. The major end-use sectors were, in decreasing order, paints (55%), plastics (26%), and paper (8%). Other uses (11%) included catalysts, textiles, printing ink, and other (Adams, 2016, p. 6, 15).

TZ Minerals International Pty Ltd. (TZMI) estimated that 15% to 20% of the global TiO₂ pigment market was supplied by sulfate-process TiO₂ pigment used for lower quality, price-sensitive applications; applications where a softer pigment was required; or for specialty, nonpigment applications. Another 15% to 20% of the market was supplied by chloride-process pigment for applications requiring durability or certain optical qualities. The remainder of the market (60%–70%) was based on price or value-in-use, where the end-use application was adaptable to either sulfate- or chloride-process-sourced pigments (McCoy, 2016).

Australia.—Iluka Resources produced 137,000 t of rutile and 321,000 t of ilmenite from its operations in Australia, a decrease of 23% and an increase of 18%, respectively, compared with those of 2014. Iluka reactivated a synthetic rutile kiln at its Tutunup South Mine in Western Australia and produced 165,000 t of synthetic rutile in 2015 (Iluka Resources Ltd., 2016, p. 5, 22).

MZI Resources Ltd. completed construction of its Keysbrook project and began mining and processing heavy-mineral concentrates in October. By yearend, Keysbrook had produced more than 4,000 t of leucoxene concentrate and was preparing to export it to North America (MZI Resources Ltd., 2016, p. 3).

China.—China imported 1.88 Mt of titanium mineral concentrates in 2015, down 7% from those of 2014. The leading import countries, in decreasing order, were India, Kenya, and Australia. Exports of titanium pigments totaled 599,000 t and imports were 228,000 t, a decrease of 3% and 7%, respectively, from those of 2014. China exported 3,550 t of titanium sponge in 2015, a decrease of 38% from that of 2014 (Global Trade Information Services Inc., 2016).

In April, Henan Billions Chemicals Co. Ltd. acquired competitor Sichuan Lomon Titanium Industry Co. Ltd. According to market analysis by Guangzhou CCM Information Science & Technology Co., Ltd., the merger would create the world's fourth-largest pigment producer with 520,000 t/yr of capacity and was expected to give Henan Billions access to Lomon's integrated mining operations, guaranteeing a steady stream of raw materials and alleviating price fluctuations (Chen, 2015).

Chloride-process TiO₂ pigment plants in China totaled 220,000 t/yr of capacity, but utilization in 2015 was less than 35% (Adams, 2016, p. 4).

France.—In April, UKAD, a partnership between Aubert & Duval and Ust-Kamenogorsk Titanium Magnesium Plant JSC (UKTMP) (Kazakhstan), began construction on a titanium melt facility in Saint-George-de-Mons. The plant was expected to become operational in 2017 and would source its scrap feedstock independent of United States and Russian aviation industry supply streams (Eramet Group, 2015).

India.—The Indian Space Research Organization announced that the titanium sponge plant owned by Kerala Minerals and Metals Ltd. (KMML), in Chavara, Kollam, was approved for supplying material for use in space applications. The KMML plant currently had a capacity of 500 t/yr with plans to expand to 1,000 t/yr (Sparks, 2015a).

In March, Bharat Forge Ltd. completed its first shipment of titanium flap-track forgings for the Next-Generation 737 and in April announced the award of a contract with the Boeing Co. to supply titanium forgings for the Boeing 777X aircraft (Bharat Forge Ltd., 2016).

Japan.—In 2015, Japan produced 42,000 t of titanium sponge, an increase of 36% from that of 2014 (Gehler, 2016, p. 14). Titanium mill product shipments in 2015 totaled 15,495 t, an increase of 10% from those of 2014. Exports accounted for about 65% of titanium mill shipments and increased by 11% to 10,095 t in 2015. Domestic shipments of mill products rose by 10% to 5,400 t. The leading end-use sector was industrial use at 69% (Roskill's Letter from Japan, 2016, p. 8).

Kazakhstan.—POSK Titanium, a joint venture between the UKTMP and the Republic of Korea's Pohang Iron and Steel Co. Ltd. (POSCO), inaugurated a new titanium slab-ingot plant in eastern Kazakhstan. The plant was expected to deliver its first shipments to POSCO sheet and tube rolling mills by yearend (Sparks, 2015b; Tengri News, 2015).

Kenya.—Base Resources Ltd. (Australia) produced 445,000 t of ilmenite and 78,900 t of rutile from its Kwale operation in 2015, the first full year of production. In 2016, Base Resources planned to produce 450,000 t of ilmenite and 84,000 t of rutile (Base Resources Ltd., 2016, p. 1, 4).

Madagascar.—World Titanium Resources Ltd. (WTR, Australia) completed an alternate mine plan for its Ranobe Mine Project in southwest Madagascar that incorporated a 17-year mine life with an average output of 66,000 t/yr of mixed zircon-rutile concentrate and 670,000 t/yr of ilmenite, which were to be stockpiled adjacent to the wet processing plant (World Titanium Resources Ltd., 2016, p. 1–3).

Mozambique.—Kenmare Resources plc (United Kingdom) produced 763,000 t of ilmenite and 6,000 t of rutile at its Moma Mine in 2015, an increase of 11% and a slight decrease, respectively, from production in 2014 (Kenmare Resources plc, 2016, p. 1).

Norway.—TiZir Ltd.'s ilmenite upgrade facility at Tyssedal produced 107,000 t of titanium slag in 2015, a decrease of 42% from that of 2014. There was no production at the plant in the fourth quarter while the company completed a furnace reline and capacity expansion project. The expansion project would allow the plant to produce a chloride slag, which, according to the company, generally sells at a premium to the sulfate slag previously produced at the plant. Additionally, the roof replacement on the furnace increased smelting capacity by 15%. The Tyssedal facility processes ilmenite from the Grand Côte Project in Senegal (Mineral Deposits Ltd., 2016, p. 6, 19).

Russia.—In 2015, Russia produced 40,000 t of titanium sponge and 65,800 t of ingot at utilization rates of 86% and 87%, respectively. Consumption of mill products in the Russian domestic market was about 12,000 t in 2015. The end uses were

industrial (46%), engine building (29%), and aircraft building (25%) (Metz, 2016, p. 2–4).

The major Russian titanium producer, VSMPO-Avisma, shipped 28,700 t of titanium products in 2015, which included cast (ingot, billet, and slab) and wrought (forged, rolled, and fabricated) products. Shipments decreased slightly from 29,400 t in 2014 (Sparks, 2016).

In March, the Ministry of Economic Development announced that, as of September 1, the 5% tariff on imported titanium scrap and waste would be waived. The move was likely a result of increased scrap purchases by VSMPO and the rising cost of scrap in the Russian market (Sparks, 2015c).

In 2015, IRC Ltd. (Hong Kong) produced 193,000 t of ilmenite at its Kurankh deposit, an increase of 8% from that of 2014. IRC suspended operations and planned to place Kurankh on care-and-maintenance status in March 2016 owing to lower iron ore and ilmenite prices and increased operating expenses (IRC Ltd., 2016, p. 15, 29, 31).

Saudi Arabia.—The National Industrialization Co. announced a delay in the production of titaniferous slag until the second half of 2016 owing to the resolution of technical issues with the furnaces. Construction of a 15,600-t/yr titanium sponge facility, a joint project with Toho Titanium Co. Ltd. of Japan, was ongoing with production expected to begin in the third quarter of 2017 (National Industrialization Co., 2015).

Senegal.—TiZir produced 428,000 t of ilmenite and 5,300 t of rutile and leucoxene at its Grand Côte Project (GCP) in 2015, the first full year of production. GCP supplied chloride-grade ilmenite feedstock to the Tyssedal slag plant in Norway and external customers. Australia's Mineral Deposits Ltd. and France's Eramet Group jointly owned the TiZir joint venture, which included GCP and the Tyssedal operation (Mineral Deposits Ltd., 2016, p. 19).

Sierra Leone.—Sierra Rutile Ltd. produced 126,000 t of rutile and 37,600 t of ilmenite in 2015, an increase of 10% and 5%, respectively, from 2014. Sierra Rutile slowed production in December in order to align production with planned shipments in 2016. The rutile production plan for 2016 was set at 120,000 to 135,000 t. Construction activity at the Gangama Mine remained on schedule for commissioning in the second quarter of 2016 (Sierra Rutile Ltd., 2016, p. 22).

South Africa.—At yearend, Tronox Ltd. (Stamford, CT) began production at its Fairbreeze Mine in KwaZulu-Natal. The Fairbreeze Mine was the mining portion of the KZN Sands operations that also included a mineral separation plant and slag operation at Empangeni. The Fairbreeze Mine was expected to produce 220,000 t/yr of titanium slag and 25,000 t/yr of rutile over a 12-year mine life (Tronox Ltd., 2016, p. 2, 5).

Mineral Commodities Ltd. (Australia) produced 44,500 t of zircon-rutile concentrate, containing about 73% zircon and 13% rutile, at its Tormin mining operation in 2015, a production increase of 4% from that of 2014. Production of ilmenite was 110,000 t in 2015, an increase of 9% from 2014 (Mineral Commodities Ltd., 2016, p. 1).

Ukraine.—In 2015, the Zaporozhye Titanium Magnesium Plant (ZTMP) produced 7,700 t of titanium sponge, an increase of 7% from that of 2014. Owing to the repair and upgrade of

one of three titanium slag furnaces, production of titanium slag was 27,100 t in 2015, a decrease of 17% from that of 2014. The company also reported it had received EN 9100 certification, an internationally recognized quality system standard specific to the aerospace industry (Group DF, 2016).

Vietnam.—In October, PHI Group Inc. (Las Vegas, NV) signed an agreement with Hung Thinh Minerals Investment Co., Ltd. (HTMI) to assist in the upgrading of HTMI's titanium slag production facility in Binh Thuan Province to a capacity of 150,000 t/yr (PHI Group Inc., 2015, p. 18).

Outlook

Worldwide, consumption of titanium mineral concentrates is estimated to increase by more than 4% per year through 2025. Global consumption of TiO₂ pigment is forecast to rise by 4% per year through 2025 to 8.83 million metric tons per year (Mt/yr), with China as the world's largest consumer at 3.6 Mt/yr. Paints are expected to remain the leading end-use sector (Adams, 2016, p. 28, 32, 36).

Aerospace applications continued to lead demand for titanium metal. The global aircraft fleet is expected to double over the next 20 years (Leach, 2016, p. 13), and titanium consumption by the jet engine market is forecast to increase to more than 18,000 t/yr in 2022 from about 15,000 t/yr in 2015 (Seiner, 2016, p. 21). Consumption in industrial uses of titanium metal is expected to increase to about 30,000 t/yr in 2020 from about 23,000 t in 2015. Industrial end-use sectors are expected to be, in decreasing order, chemical processing, power generation, automotive, and desalination (Bruneau, 2016, p. 25).

References Cited

- Adams, Reg, 2016, Drivers of demand for TiO₂ feedstocks: Informa Australia Pty. Ltd., Mineral Sands Conference, Melbourne, Victoria, Australia, March 15–16, 2016, presentation, 38 p.
- Allegheny Technologies Inc., 2015, ATI achieves PQ titanium product and process qualification: Pittsburgh, PA, Allegheny Technologies Inc. news release, June 15. (Accessed December 22, 2016, at https://www.atimetals.com/news/Pages/NA_2059073.aspx.)
- Arconic Inc., 2015, Alcoa completes acquisition of RTI International Metals, growing multi-material aerospace portfolio: New York, NY, Arconic Inc. press release, July 23. (Accessed December 26, 2016, at https://www.arconic.com/global/en/news/news_detail.asp?pageID=20150723000284en&newsYear=2015.)
- Base Resources Ltd., 2016, Quarterly activities report December 2015: West Perth, Western Australia, Australia, Base Resources Ltd., 8 p. (Accessed December 23, 2016, at http://www.baseresources.com.au/wp-content/files/160120_BSE_ASX_December_Quarterly_Activities_Report.pdf.)
- Bharat Forge Ltd., 2016, Boeing awards 777X titanium forging contract to Bharat Forge: Pune, India, Bharat Forge Ltd. press release, April 26. (Accessed December 23, 2016, at <http://bharatforge.com/images/PDFs/press-release/2016/Boeing%20Contract%20for%20777X%20titanium%20forging%20260416.pdf>.)
- Bruneau, Albert, 2016, Global trends in industrial markets: International Titanium Association, Titanium Europe 2016 Conference and Exhibition, Paris, France, April 18–20, 2016, presentation, 26 p.
- Chemours Co., The, 2015, Chemours consolidates and strengthens TiO₂ business as part of five-point transformation plan: Wilmington, DE, The Chemours Co. press release, August 20. (Accessed December 23, 2016, at <https://investors.chemours.com/investor-relations/investor-news/press-release-details/2015/Chemours-Consolidates-and-Strengthens-TiO2-Business-as-Part-of-Five-Point-Transformation-Plan/default.aspx>.)
- Chen, Sophie, 2015, Henan Billions-Lomon deal to trigger a new flood of M&A in China's TiO₂ industry: Guangzhou CCM Information Science & Technology Co., Ltd., May 7. (Accessed December 23, 2016, via <https://www.linkedin.com/pulse/ccm-henan-billions-lomon-deal-trigger-new-flood-ma-chinas-sophie-chan-6001967092054634496>.)
- Eramet Group, 2015, Launch of EcoTitanium project: Paris, France, Eramet Group press release, January 9, 3 p. (Accessed March 1, 2017, at http://www.eramet.com/sites/default/files/20150109_cp_ecotitanium_va.pdf.)
- Gehler, Sylvain, 2016, Overview of world titanium sponge supply: International Titanium Association, Titanium Europe 2016 Conference and Exhibition, Paris, France, April 18–20, 2016, presentation, 22 p.
- Global Trade Information Services Inc., 2016, Global trade atlas: Global Trade Information Services Inc. (Accessed December 27, 2016, via <http://www.gtis.com/gta/>.)
- Group DF, 2016, ZTMC increased the production of titanium sponge by 7% in 2015: Kiev, Ukraine, Group DF news release, March 2. (Accessed December 23, 2016, at <https://groupdf.com/en/press-center/news/ztmc-increased-the-production-of-titanium-sponge-by-7-in-2015/>.)
- Iluka Resources Ltd., 2016, Annual review 2015: Perth, Western Australia, Australia, Iluka Resources Ltd., 169 p. (Accessed December 23, 2016, at <http://www.iluka.com/docs/default-source/annual-reports/iluka-review-2015.pdf?sfvrsn=6>.)
- IRC Ltd., 2016, IRC—2015 annual results: Hong Kong, China, IRC Ltd., 38 p. (Accessed December 23, 2016, at http://www.irgroup.com.hk/attachment/2016033107170100002469001_en.pdf.)
- Kenmare Resources plc, 2016, Q4 2015 trading update: Dublin, Ireland, Kenmare Resources plc, 4 p. (Accessed December 23, 2016, at http://www.kenmareresources.com/~/_media/Files/K/Kenmare-Resources-PLC/pdf/press-releases/2016/2016-02-01%20KMR%20Q4%20Trading%20Update.pdf.)
- Leach, Wade, 2016, Titanium demand and trends in the airframe market: International Titanium Association, Titanium Europe 2016 Conference and Exhibition, Paris, France, April 18–20, 2016, presentation, 17 p.
- McCoy, David, 2016, Global titanium dioxide pigment suffers worst year on record in 2015: TZ Minerals International Pty Ltd., July 19. (Accessed December 23, 2016, at <https://www.linkedin.com/pulse/global-titanium-dioxide-pigment-market-suffers-worst-year-david-mccoy?trk=mp-reader-card>.)
- Metz, Michael, 2016, Russian titanium market: International Titanium Association, Titanium Europe 2016 Conference and Exhibition, Paris, France, April 18–20, 2016, presentation, 7 p.
- Mineral Commodities Ltd., 2016, Quarterly activities report for the period ended 31 December 2015: Welshpool, Western Australia, Australia, Mineral Commodities Ltd., 13 p. (Accessed December 23, 2016, at <http://www.mineralcommodities.com/wp-content/sharelink/20160127-quarterly-activities-report-47b91403f110ac8a5c0b3604c9bc4c17.pdf>.)
- Mineral Deposits Ltd., 2016, Annual report 2015: Melbourne, Victoria, Australia, Mineral Deposits Ltd., 79 p. (Accessed December 23, 2016, at <http://www.mineraldeposits.com.au/wp-content/uploads/2016/02/MDLAnnualReport2015.pdf>.)
- Mineral Sands Report, 2014, Twin Pines Minerals appoints Wogen Pacific: Mineral Sands Report, no. 229, November, 37 p.
- MZI Resources Ltd., 2016, Half-year account: Subiaco East, Western Australia, Australia, MZI Resources Ltd., 22 p. (Accessed December 23, 2016, at <http://www.mzi.com.au/index.php/investor-relations/asx-announcements/509-half-year-accounts-31-december-2015/download>.)
- National Industrialization Co., 2015, Investment update August 2015: Riyadh, Saudi Arabia, National Industrialization Co., 3 p. (Accessed December 23, 2016, at http://www.aljziracapital.com.sa/report_file/company/FUN-916.pdf.)
- PHI Group Inc., 2015, Form 10–Q quarterly report: Las Vegas, NV, PHI Group Inc., 36 p. (Accessed August 16, 2016, at <https://www.sec.gov/Archives/edgar/data/704172/000149315216007442/form10-q.htm>.)
- Roskill's Letter from Japan, 2016, Titanium mill products—10% rise in Japanese shipments: Roskill's Letter from Japan, no. 476, April, p. 7–10.
- Sedgman Ltd., 2015, Twin Pines project: Brisbane, Queensland, Australia, Sedgman Ltd. news release, May 5. (Accessed December 23, 2016, at http://sedgman.com/files/documents/Sedgman%20Project%20Profiles_Twin%20Pines.pdf.)
- Seiner, H.S., 2016, Development in jet engines, a titanium perspective: International Titanium Association, Titanium Europe 2016 Conference and Exhibition, Paris, France, April 18–20, 2016, presentation, 22 p.
- Sierra Rutile Ltd., 2016, Annual report and accounts 2015: Freetown, Sierra Leone, Sierra Rutile Ltd., 97 p. (Accessed December 23, 2016, at <http://www.sierra-rutile.com/media/63527/sierrarutile2015ar.pdf>.)

Sparks, Polina, 2015a, Indian titanium sponge plant starts commercial space grade metal production: Metal-Pages, August 11. (Accessed January 19, 2016, via <http://www.metal-pages.com/>.)

Sparks, Polina, 2015b, Kazakhstan inaugurates new titanium slab-rolling plant: Metal-Pages, January 5. (Accessed January 19, 2016, via <http://www.metal-pages.com/>.)

Sparks, Polina, 2015c, Russia to remove import duty on titanium scrap, review 4,000 others: Metal-Pages, March 13. (Accessed July 8, 2016, via <http://www.metal-pages.com/>.)

Sparks, Polina, 2016, VSMPO-AVISMA ships more value-added Ti in 2015: Argus Media group Metal-Pages, May 20. (Accessed August 16, 2016, via <http://www.metal-pages.com/>.)

Tengri News, 2015, Nazarbayev launches titanium plant in eastern Kazakhstan: Almaty, Kazakhstan, Tengri News Web site. (Accessed December 23, 2016, at http://en.tengrinews.kz/industry_infrastructure/Nazarbayev-launches-titanium-plant-in-eastern-Kazakhstan-258115/.)

Tronox Ltd., 2016, 2015 annual report and corporate responsibility report: Stamford, CT, Tronox Ltd., 121 p. (Accessed December 23, 2016, at http://investor.tronox.com/common/download/download.cfm?companyid=TRX&fileid=885104&filekey=6E176A7B-EA2C-4730-AD46-9B5385EC20BD&filename=TRONOX_2015.pdf.)

World Titanium Resources Ltd., 2016, Quarterly report period ending 31 December 2015: Mount Claremont, Western Australia, Australia, World Titanium Resources Ltd., 11 p. (Accessed December 23, 2016, at <http://www.worldtitaniumresources.com/files/160121-Quarterly-Activities-and-Cashflow-Report.pdf>.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.

Recycling—Metals. Ch. in *Minerals Yearbook*, annual.

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.

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 (Ti). Ch. in *Metal Prices in the United States Through 2010*, *Scientific Investigations Report 2012–5188*, 2013.

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 STATISTICS¹

		2011	2012	2013	2014	2015
United States:						
Mineral concentrate:						
Production ^{e,2}	metric tons	400,000	300,000	300,000	200,000	300,000
Imports for consumption	do.	1,270,000	1,380,000	1,480,000	1,380,000	1,440,000
Consumption ^{e,3}	do.	1,830,000	1,940,000	1,820,000	1,790,000	1,720,000
Sponge metal:						
Imports for consumption	do.	33,800	33,600	19,900	17,700 ^r	20,700
Consumption	do.	48,400	35,100	26,500	26,400	31,200
Price, yearend ⁴	dollars per pound	3.27–6.74	3.53–6.95	3.20–6.23	4.07–5.96	3.32–5.36
Titanium dioxide pigment:						
Production	metric tons	1,290,000	1,140,000	1,280,000	1,260,000	1,220,000
Imports for consumption	do.	200,000	203,000	213,000	224,000	222,000
Consumption, apparent ⁵	do.	706,000	722,000	826,000	802,000	793,000
Producer price index, yearend ⁶	(June 1982=100)	268	268	236	224	176
World, production:						
Ilmenite concentrate ⁷	metric tons	7,330,000 ^r	7,340,000 ^r	7,690,000 ^r	7,400,000 ^r	7,270,000 ^c
Rutile concentrate, natural ⁸	do.	800,000 ^r	791,000 ^r	631,000 ^r	553,000 ^r	850,000 ^c
Titaniferous slag ^e	do.	2,250,000	2,200,000	2,200,000 ^r	2,000,000 ^r	2,200,000

^eEstimated. ^rRevised. do. ditto.

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

²Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

³Does not include consumption used to produce synthetic rutile.

⁴Landed duty-paid unit based on U.S. imports for consumption.

⁵Production plus imports minus exports. Does not include 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
ESTIMATED U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2015^{1,2}

(Metric tons per year)

Company	Plant location	Yearend capacity	
		Sponge	Ingot ³
Alcoa Inc.	Niles, OH	--	13,600
Alcoa Howmet	Whitehall, MI	--	3,200
Allegheny Technologies Inc.	Albany, OR	--	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
Titanium Metals Corp.	Henderson, NV	12,600	12,300
Do.	Morgantown, PA	--	40,700
Do.	Vallejo, CA	--	800
Total		24,000	118,000

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.

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

(Metric tons)

Component	2014	2015
Production:		
Sponge	W	W
Ingot	55,800	61,800
Mill products	37,000 ^r	38,100
Exports:		
Waste and scrap	4,610	6,860
Sponge	2,210 ^r	1,650
Other unwrought	7,260 ^r	1,730
Wrought products and castings	19,400	24,700
Total	33,500 ^r	35,000
Imports:		
Waste and scrap	19,300	22,000
Sponge	17,700 ^r	20,700
Other unwrought	2,330 ^r	2,710
Wrought products and castings	6,260	6,040
Total	45,500 ^r	51,400
Stocks, industry, yearend:		
Sponge	22,900	25,000
Scrap	17,500	20,700
Ingot	6,350	9,610
Consumption, reported:		
Sponge	26,400	31,200
Scrap	44,300	52,200
Ingot	55,000 ^r	57,200
Shipments:		
Ingot	25,600 ^r	18,700
Mill products (net shipments):		
Forging and extrusion billet	25,100 ^r	24,100
Other	11,900 ^r	13,900
Total	37,000 ^r	38,000
Castings (shipments)	W	W
Receipts, scrap:		
Home	18,700	21,000
Purchased	34,800	43,800
Total	53,600	64,700

^rRevised. 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 2015^{1, 2, 3}

(Metric tons per year)

Company	Plant location	Yearend capacity ⁴
Cristal Global	Ashtabula, OH	220,000
The Chemours Co.	De Lisle, MS	340,000
Do.	New Johnsonville, TN	400,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	150,000
Tronox Ltd.	Hamilton, MS	230,000
Total		1,340,000

Do. Ditto.

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

²Does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of about 26,400 metric tons per year of buff titanium dioxide (TiO₂) pigment that was 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.

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

		2014		2015	
		Gross weight	TiO ₂ content	Gross weight	TiO ₂ content
Production ^{c, 2}	metric tons	1,260,000	1,190,000	1,220,000	1,150,000
Shipments: ³					
Quantity	do.	1,270,000	1,190,000	1,260,000	1,190,000
Value	thousands	\$3,450,000	XX	\$2,910,000	XX
Exports	metric tons	685,000 ^r	644,000 ^r	648,000	610,000
Imports for consumption	do.	224,000 ^r	211,000 ^r	222,000	208,000
Consumption, apparent ^{c, 4}	do.	802,000 ^r	754,000 ^r	793,000	745,000

^cEstimated. ^rRevised. do. Ditto. XX Not applicable.

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

²Does not include production of buff pigment.

³Includes interplant transfers.

⁴Production plus imports minus exports. Does not include 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)

Use	2014		2015	
	Gross weight	TiO ₂ content	Gross weight	TiO ₂ content
Pigment	1,660,000	NA	1,600,000	NA
Miscellaneous ³	128,000	NA	120,000	NA
Total	1,790,000	1,430,000	1,720,000	1,380,000

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)

	2014	2015
Steel:		
Carbon steel	5,790	5,380
Stainless and heat-resisting steel	3,580	3,590
Other alloy steel ³	838	793
Total steel	10,200	9,770
Cast irons	11	8
Superalloys	523	528
Alloys, other than above	1,120	1,180
Miscellaneous and unspecified	38	87
Grand total	11,900	11,600

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

(Percent)

Industry	2014	2015
Paint, varnish, and lacquer	59.5	60.3
Paper	11.8	4.5
Plastics and rubber	19.6	28.7
Other ²	9.1	6.5
Total	100.0	100.0

¹Does not include exports.

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

TABLE 9
YEAREND PRICES OF TITANIUM PRODUCTS

		2014	2015
Concentrate:			
Ilmenite, free on board (f.o.b.) Australian ports ¹	dollars per metric ton	150–165	100–120
Rutile, bagged, f.o.b. Australian ports ¹	do.	840–1,000	800–840
Rutile, bulk, f.o.b. Australian ports ¹	do.	820–950	790–890
Titaniferous slag, import, 80% to 95% TiO ₂ ²	do.	690–835	630–751
Metal:			
Sponge import ²	dollars per pound	4.07–5.96	3.32–5.36
Scrap, turnings, unprocessed ³	do.	1.45–1.55	0.75–0.80
Ferrotitanium, 70% Ti ³	do.	2.90–3.10	1.90–2.10
Mill products ⁴	producer price index	180	171
Titanium dioxide pigment ⁴	do.	224	176
do. Ditto.			

¹Source: Industrial Minerals.

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

³Source: Platts Metals Week.

⁴June 1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 10
U.S. EXPORTS OF TITANIUM BY CLASS¹

Class	HTS ² code	2014		2015	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:					
Scrap	8108.30.0000	4,610	\$18,200	6,860	\$25,900
Unwrought:					
Sponge	8108.20.0010	2,590 [†]	29,900	1,700	17,300
Ingot	8108.20.0030	4,970 [†]	78,000	5,610	86,900
Wrought:					
Bloom, sheet bar, slab	8108.90.6020	2,440 [†]	78,900 [†]	2,590	85,000
Bar, rod, profile, wire	8108.90.6031	5,470 [†]	252,000 [†]	6,160	285,000
Other	8108.90.8000	11,500	1,030,000	10,400	963,000
Total		19,400 [†]	1,360,000 [†]	19,100	1,330,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	3,020 [†]	12,400	2,140	9,070
Ores and concentrates	2614.00.0000	2,240	5,400	2,040	3,500
Pigment:					
80% or more titanium dioxide	3206.11.0000	659,000 [†]	1,640,000	625,000	1,340,000
Other titanium dioxide	3206.19.0000	22,600 [†]	136,000	20,100	108,000
Unfinished titanium dioxide ³	2823.00.0000	4,150 [†]	9,810 [†]	3,680	7,980
Total		685,000	1,790,000	648,000	1,460,000

[†]Revised.

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 CONCENTRATES, BY COUNTRY¹

Concentrate and country	HTS ² code	2014		2015	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:	2614.00.6020				
Australia		118,000	\$19,800	327,000	\$54,300
Mozambique		217,000	38,600	217,000	41,200
Other		20,200 ^r	2,670 ^r	105,000	11,500
Total		355,000 ^r	61,100 ^r	649,000	107,000
Titaniferous slag:	2620.99.5000				
Australia		108,000	63,300	56,400	7,280
Canada		213,000	162,000	102,000	75,600
Madagascar		26,600	5,640	--	--
South Africa		331,000	225,000	241,000	166,000
Other		4	8	--	--
Total		678,000	455,000	399,000	248,000
Rutile, natural:	2614.00.6040				
Australia		64,100	47,300	68,000	47,600
Sierra Leone		20,200	16,200	35,200	27,600
South Africa		144,000	109,000	167,000	113,000
Other ³		27,300 ^r	23,700 ^r	21,700	18,600
Total		255,000	196,000 ^r	292,000	207,000
Rutile, synthetic:	2614.00.3000				
Australia		84,400	66,400	98,800	71,500
Other ³		3,100 ^r	4,540 ^r	2,850	3,480
Total		87,500	71,000 ^r	102,000	75,000
Titaniferous iron ore, Canada⁴	2614.00.6020	138	62	64,700	32,400

^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 code	2014		2015	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		970	\$3,760	1,160	\$4,400
China		437	3,540	635	5,120
France		1,900	10,500 ^r	2,530	15,600
Germany		3,320 ^r	21,400	3,400	23,400
Israel		692	4,020	596	3,130
Italy		1,300	5,840	1,130	5,360
Japan		2,140 ^r	11,500 ^r	3,300	18,200
Korea, Republic of		1,950	10,500	1,870	11,000
Mexico		825	2,690	773	2,920
Taiwan		563	2,890	554	3,030
United Kingdom		3,030	11,600	4,150	20,600
Other		2,130 ^r	12,200 ^r	1,890	10,800
Total		19,300 ^r	100,000 ^r	22,000	123,000
Unwrought:					
Sponge:	8108.20.0010				
China		1,530	11,800	890	6,690
Japan		13,300	155,000	15,500	161,000
Kazakhstan ^c		660	6,640	2,600	21,400
Ukraine		1,910	16,200	1,310	10,300
Other		298 ^r	2,830 ^r	413	3,990
Total		17,700 ^r	193,000 ^r	20,700	203,000
Ingot:	8108.20.0030				
Japan		35	3,390	39	3,580
Russia		665	12,200	453	9,470
Other		--	--	25	408
Total		700	15,600	517	13,500
Powder:	8108.20.0015				
Canada		7	2,230	14	3,430
China		102	1,780	100	1,750
Germany		3 ^r	1,110	7	1,840
Other		8 ^r	1,560 ^r	9	1,260
Total		120	6,670	130	8,280
Other:	8108.20.0091, 8108.20.0095				
France		54	2,250	112	4,530
Germany		349	7,830	279	6,140
Russia		808	20,900	1,060	24,900
United Kingdom		288	12,800	54	3,550
Other		7	218	54	938
Total		1,510	44,000	1,560	40,100
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				
Canada		111	9,010 ^r	140	9,130
China		1,050 ^r	40,000 ^r	953	35,800
Japan		429 ^r	17,900	484	15,500
Russia		3,040	124,000	2,730	103,000
United Kingdom		373	42,600 ^r	382	42,800
Other		1,260 ^r	91,800 ^r	1,840	116,000
Total		6,260 ^r	326,000 ^r	6,530	321,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,210	9,290	1,730	6,260

⁰Estimated. ¹Revised. -- 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.

Source: U.S. Census Bureau.

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

Country	HTS ² code	2014		2015	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
80% or more titanium dioxide:	3206.11.0000				
Australia		6,850	\$17,600	7,520	\$17,500
Belgium		2,540	7,350	--	--
Brazil		100	207	--	--
Canada		60,600	183,000	60,600	155,000
China		33,500	71,800	35,200	66,900
Czech Republic		2,150	5,230	--	--
Finland		6,810	17,400	6,000	14,900
France		2,350	6,350	--	--
Germany		22,500	63,400	13,000	30,600
India		786	1,620	--	--
Italy		1,850	4,790	--	--
Japan		5,330	25,100	4,740	22,400
Malaysia		242	441	--	--
Mexico		4,640	12,300	6,420	20,900
Netherlands		1,760	5,440	--	--
Norway		5,610	14,600	4,970	10,500
Slovenia		318	700	--	--
Spain		4,840	11,600	8,780	20,100
Ukraine		6,490	12,100	2,900	4,830
United Kingdom		353	964	--	--
Other		581	518	17,800	38,800
Total		170,000	462,000	168,000	403,000
Other titanium dioxide:	3206.19.0000				
Canada		8,030	25,200	9,530	25,200
China		2,030	6,150 ^r	1,130	3,620
Colombia		201	663	--	--
France		12	190	--	--
Germany		1,140	6,760 ^r	900	5,390
India		525	2,190	--	--
Israel		--	36	--	--
Italy		377	1,580	937	3,080
Japan		246 ^r	5,830 ^r	--	--
Korea, Republic of		12	483	--	--
Mexico		233	932	--	--
Spain		13	277	--	--
United Kingdom		59	2,160	--	--
Other		118 ^r	743 ^r	1,280	12,700
Total		13,000	53,200	13,800	50,000
Unfinished titanium dioxide: ³	2823.00.0000				
China		17,100 ^r	37,400 ^r	16,000	30,700
Czech Republic		2,550	6,660	2,550	5,920
Finland		3,030	10,700	3,000	9,800
France		4,300 ^r	17,800 ^r	4,710	14,600
Germany		3,470 ^r	10,500	3,930	11,000
India		2,050	4,290	--	--
Italy		1,410	3,820	2,640	5,880
Japan		513 ^r	4,910 ^r	--	--
Korea, Republic of		4,730	9,040	2,660	4,860
Other		1,620 ^r	6,580 ^r	4,270	12,300
Total		40,800 ^r	112,000 ^r	39,700	95,000
Grand total		224,000	627,000 ^r	222,000	548,000

^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.

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	2011	2012	2013	2014	2015 ^c
Ilmenite and leucoxene:^{3,4}					
Australia	1,501,000	1,572,000	1,342,000	1,000,000 ^r	1,200,000
Brazil ⁵	114,673 ^r	115,118 ^r	130,440 ^r	135,463 ^r	131,000
China ^c	1,420,000 ^r	1,340,000 ^r	1,420,000 ^r	1,420,000 ^r	1,400,000
India ^c	550,000	340,000	436,000	320,000	300,000
Indonesia	18,000	20,000	23,000	23,000 ^e	23,000
Kazakhstan ^c	25,000	25,000	20,000	20,000	20,000
Kenya	--	--	5,539	368,239 ^r	444,999 ⁶
Madagascar	521,627 ^r	620,700 ^r	530,421 ^r	500,000 ^r	233,000
Malaysia	28,782	22,275	16,043 ^r	8,159 ^r	5,814 ⁶
Mozambique	636,800	574,500	720,100	854,600	854,600 ⁶
Norway	869,000 ^r	831,000	826,000 ^r	864,000 ^r	429,800 ⁶
Russia	63,490	125,095	150,458	178,426 ^r	193,236 ⁶
Senegal	--	--	--	100,590 ^r	427,690 ⁶
Sierra Leone	15,946	22,590	32,349	35,838 ^r	37,633 ⁶
Sri Lanka	68,085	44,707 ^r	42,685 ^r	32,971 ^r	42,000
Ukraine	260,700 ^r	246,800 ^r	670,000 ^e	411,300 ^r	625,000
United States ^{e,5,7}	400,000	300,000	300,000	200,000	300,000
Vietnam ⁸	840,600	1,143,800	1,025,779	929,400 ^r	600,000
Total ⁹	7,330,000 ^r	7,340,000 ^r	7,690,000 ^r	7,400,000 ^r	7,270,000
Rutile:⁴					
Australia	474,000	425,000	232,000	212,000	429,000
Brazil ⁵	2,474 ^r	1,980 ^r	2,127 ^r	1,931 ^r	2,110
India ^c	18,800	24,000	26,000	19,100	20,000
Kenya	--	--	152	59,348 ^r	78,947 ⁶
Madagascar ^c	9,000 ^r	12,000 ^r	11,000 ^r	6,000 ^r	6,000
Malaysia	10,810	20,008	5,983	3,069 ^r	198 ⁶
Mozambique	6,455	4,000	5,100	6,100 ^{r,e}	6,000
Senegal	--	--	--	663	5,311 ⁶
Sierra Leone	67,916	94,493	120,349	114,163 ^r	126,021 ⁶
South Africa ^c	149,000 ⁶	150,000	65,000	58,500	74,400
Sri Lanka ^c	1,970	1,590	1,406 ^{r,6}	2,111 ^{r,6}	2,000
Ukraine ^c	60,000	58,000	162,000	70,000	100,000
United States	(10)	(10)	(10)	(10)	(10)
Total	800,000 ^r	791,000 ^r	631,000 ^r	553,000 ^r	850,000
Titaniferous slag:^{c,11}					
Canada	878,000	900,000	900,000	800,000	700,000
South Africa	1,367,000 ⁶	1,300,000	1,300,000 ^r	1,200,000 ^r	1,500,000
Total	2,250,000	2,200,000	2,200,000 ^r	2,000,000 ^r	2,200,000

^cEstimated. ^rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

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

²Includes data available through December 5, 2017.

³Ilmenite was also produced in Canada and South Africa, but this output was not included here because most of it is duplicative of output reported under "Titaniferous slag," and the rest was 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, was inadequate to make reliable estimates of output.

⁵Does not include production of unbeneficiated anatase ore.

⁶Reported figure.

⁷Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

⁸Estimate based on import statistics from trading partners (primarily China and Japan).

⁹Includes U.S. production, rounded to one significant digit, of ilmenite, leucoxene, and rutile to avoid disclosing company proprietary data.

¹⁰Included with ilmenite to avoid disclosing company proprietary data.

¹¹Slag was also produced in China, Kazakhstan, Norway, Russia, and Vietnam, but this output was not included under "Titaniferous slag" to avoid duplicative reporting.