



# 2016 Minerals Yearbook

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## TITANIUM [ADVANCE RELEASE]

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In 2016, there were two producers of titanium mineral concentrates in the United States. The United States was 91% and 45% 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<sub>2</sub>) pigment and wrought titanium metal products. The leading sources of imported titanium mineral concentrates were, in decreasing order, South Africa, Australia, and Mozambique (table 11). Domestic production of TiO<sub>2</sub> pigment increased by 2% compared with that of 2015 (table 5). U.S. consumption of titanium used in steel and other alloys increased by 2% from that in 2015 (table 7). World production of titanium mineral concentrates in 2016 was 9.62 million metric tons (Mt), an increase of 2% from revised totals for 2015.

Titanium is the ninth most abundant element in the earth's crust and can be found in nearly all rocks and sediments. Owing to its strong affinity for oxygen, it is not found as a pure metal in nature. Titanium was first isolated as a pure metal in 1910, but it was not until 1948 that metal was produced commercially using the Kroll process (named after its developer, William Kroll) to reduce titanium tetrachloride with magnesium to produce titanium metal.

## 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 2016, the USGS annual survey canvassed titanium mineral and pigment producers. The two producers of titanium mineral concentrates responded. Of the five active domestic TiO<sub>2</sub> 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 of economic importance include ilmenite, leucoxene, and rutile. For this report, titanium mineral concentrates include ilmenite, leucoxene, and rutile, as well as beneficiated materials produced from ilmenite—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 and other heavy 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 titanium minerals. Ilmenite is the most abundant titanium mineral with a contained TiO<sub>2</sub> content ranging from 35% to 65%. Rutile, naturally occurring TiO<sub>2</sub>, has the highest TiO<sub>2</sub> 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. Titaniferous slag is produced from ilmenite by pyrometallurgical processing.

U.S. mineral concentrate producers were The Chemours Co. (Wilmington, DE) and Southern Ionics Minerals LLC (Offerman, GA). Chemours' mining operations near Starke, FL, produced a mixed product containing ilmenite, leucoxene, and rutile which was used as a feedstock in Chemours's TiO<sub>2</sub> pigment plants. Southern Ionics' operations included its Mission Mine and a mineral-sands processing plant in Charlton County, GA. Iluka Resources Ltd. (Perth, West Australia, Australia) idled its mining operations near Stony Creek, VA, in December 2015 (Iluka Resources Ltd., 2016, p. 5).

**TiO<sub>2</sub> Pigment.**—TiO<sub>2</sub> pigment is produced from titanium mineral concentrates, including ilmenite, rutile, synthetic rutile, and titaniferous slag, by using either the chloride process or the sulfate process. In the chloride process, natural rutile, chloride-grade ilmenite, or titanium slag is converted to titanium tetrachloride (TiCl<sub>4</sub>) by chlorination in the presence of petroleum coke. TiCl<sub>4</sub> is oxidized with air or oxygen at about 1,000 °C, and the resulting TiO<sub>2</sub> is calcined to remove residual chlorine and any hydrochloric acid that may have formed during the reaction. Aluminum chloride, added to the TiCl<sub>4</sub>, 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<sub>2</sub> 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<sub>2</sub> pigment can have significantly different functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO<sub>2</sub> pigment was 1.24 Mt in 2016, a slight increase compared with that in 2015 (table 5). U.S. producers of TiO<sub>2</sub> pigment using the chloride process were Cristal Global (a subsidiary of National Titanium Dioxide Co. 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 TiO<sub>2</sub> pigment from finely ground synthetic rutile.

**Metal.**—In commercial production of titanium metal, titanium mineral concentrates are chlorinated to produce  $TiCl_4$ , 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, 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 2016, 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 Inc. (Spokane Valley, WA) used the Hunter process to produce titanium sponge as feed for the company's production of electronic-grade titanium at its plant in Salt Lake City, UT. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data. In August, ATI announced it would idle its titanium sponge facility in Rowley, UT, by the end of 2016 owing to global overcapacity and its ability to secure aerospace quality sponge under long-term supply agreements at prices less than its production costs at Rowley. The facility was to be idled so that it could be restarted if supported by market conditions (Allegheny Technologies Inc., 2016).

In 2016, U.S. production of titanium ingot increased by 7%, and mill shipments were almost unchanged from those of 2015 (table 3). Producers of titanium ingot included ATI, Honeywell, and Timet. Other producers were Alcoa Inc., with facilities in Whitehall, MI, and Niles, OH; Alloy Works LLC (Greensboro, NC); and Perryman Co. (Houston, PA).

Norsk Titanium US Inc. (Plattsburgh, NY) planned to open a production and training facility in Plattsburgh, NY, to produce aerospace components using additive manufacturing technologies. Construction of the facility was expected to be completed in 2017 (Lavigne, 2016).

In July, Alcoa opened a metal powder facility near Pittsburgh, PA. The company was expecting to produce titanium, nickel, and aluminum metal powders optimized for printing aerospace parts using additive manufacturing techniques (Fitzgerald, 2016).

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 Arconic Inc. (Canton, OH) with a capacity of 7,250 metric tons per year (t/yr) and Global Titanium Inc. (Detroit, MI) with a capacity of more than 10,000 t/yr. Data on production of ferrotitanium were not available.

**Mergers, Acquisitions, and Divestitures.**—In 2015, Alcoa Inc. announced that it would split into two separate companies in a transaction expected to be completed in the second half

of 2016. On November 1, 2016, the separation of Alcoa Inc. into two separate companies was completed. One company retained the Alcoa name and included the company's bauxite mines, alumina refineries, aluminum smelters, casthouses, and powerplants. The other company, named Arconic Inc., received the downstream assets focused on value-added products for the aerospace and automobile industries. The equipment included rolling mills and specialty metal assets for production of aluminum-lithium alloys, nickel alloys, and titanium products (Alcoa Inc., 2015; Arconic Inc., 2016).

## Consumption

**Mineral Concentrates.**—On a gross-weight basis, 94% of domestic consumption of titanium mineral concentrates was used to produce  $TiO_2$  pigment. The remaining 6% was used to produce metal and other miscellaneous products, including fluxes and welding rod coatings. On the basis of  $TiO_2$  content, domestic consumption of titanium mineral concentrates was 1.74 Mt, a slight increase compared with that of 2015 (table 6). Consumption data for titanium mineral concentrates were estimated by the USGS owing to insufficient response by industry to the voluntary survey for consumption data.

**$TiO_2$  Pigment.**—Domestic production of  $TiO_2$  pigment increased by 2%, and apparent domestic consumption (not accounting for changes in inventory) increased by 6% from that of 2015 (table 5). The leading uses of  $TiO_2$  pigment, based on  $TiO_2$  pigment shipments in the United States by domestic producers, were paint and coatings (67.5%), plastics and rubber (25.0%), and paper (3.0%). Other uses (4.5%) 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 (76%) was the leading end use for mill products. In general, the production of titanium mill products precedes aircraft deliveries by about 12 months. In 2016, mill product shipments were unchanged from those of 2015 (table 3). Other uses included consumer goods and goods or materials for 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 was used for deoxidation, grain-size control, and control and stabilization of carbon and nitrogen content. Titanium-intensive steels include interstitial, free, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 11,000 metric tons (t), a slight decrease from that of 2015 (table 7).

## Stocks

Insufficient data were available to determine yearend consumer inventories of titanium mineral concentrates and  $TiO_2$  pigment producer stocks. Reported yearend 2016 domestic stocks of sponge were almost unchanged from those of 2015, ingot stocks decreased slightly, and scrap stocks decreased by 20% (table 3).

## Prices

Yearend titanium mineral concentrate prices are listed in table 9. In 2016, average yearend prices for ilmenite and rutile concentrates decreased from those in 2015. Published prices for titanium slag were not available. On the basis of U.S. Census Bureau data, the value of slag imports from slag-producing countries in December 2016 ranged from \$674 to \$676 per metric ton, down from \$630 to \$751 per metric ton in December 2015.

The U.S. Department of Labor, Bureau of Labor Statistics, producer price index (PPI) for TiO<sub>2</sub> pigment (June 1982 = 100) was 176 in January, and then increased to as high as 192 before ending at 175 in December. The monthly PPI for titanium mill products was 171 in January, increased to an annual high of 175 in April, and ended the year at 163 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 and capacity. In 2016, domestic imports consisted of ilmenite (592,000 t), titaniferous slag (402,000 t), rutile (267,000 t), and synthetic rutile (82,700 t) of gross production. TiO<sub>2</sub> content of this production was 35%, 33%, 24%, and 8%, respectively. South Africa, Australia, Canada, and Mozambique were, in descending order of TiO<sub>2</sub> content, the leading import sources. The combined value for all forms of titanium concentrate imports in 2016 was \$569 million (table 11). Imports of titaniferous iron ore from Canada (classified as ilmenite), which were 64,700 t in 2015, decreased to 15,200 t in 2016. Exports of titanium concentrates were minor relative to imports (tables 10, 11).

**TiO<sub>2</sub> Pigment.**—In 2016, the United States continued to be a net exporter of TiO<sub>2</sub> pigment, with exports exceeding imports by a ratio of 2.7 to 1. Exports of TiO<sub>2</sub> pigment were 651,000 t, a slight increase compared with those of 2015. About 97% of TiO<sub>2</sub> pigment exports was in the form of finished pigment containing 80% or more TiO<sub>2</sub> (table 10). During 2016, 247,000 t of TiO<sub>2</sub> pigment was imported, an increase of 12% compared with that of 2015. The leading import sources of TiO<sub>2</sub> pigment were Canada (31%) and China (28%). Seventy-five percent of pigment imports was in the form of finished pigment containing 80% or more TiO<sub>2</sub> (table 13).

**Metal.**—Imports for consumption of titanium metal decreased by 14% in 2016 from those in 2015. Imports of titanium metal were primarily in the form of waste and scrap (42%), sponge (37%), and wrought products and castings (16%). Japan supplied 98% of imported titanium sponge; Russia supplied 90% of imported titanium ingot; and the United Kingdom, Germany, Japan, and France were, in descending order, the leading sources of imported scrap. China was the major source of titanium powder at 71%. Russia (45%) was the leading source of wrought products and castings. Imports of wrought products and castings were 7,190 t, an increase of 15% from revised 2015 totals.

Imports for consumption of ferrotitanium were 3,140 t, almost double those of 2015 (table 12). Exports of ferrotitanium were 2,020 t, a slight decrease compared with those of 2015 (table 10).

## World Review

World production of titanium mineral concentrates in 2016 was 9.62 Mt, an increase of 2% from revised totals for 2015.

**Australia.**—Iluka Resources Ltd. produced 108,800 t of rutile and 326,200 t of ilmenite from its operations in Australia, a decrease of 20% and an increase of 2%, respectively, from those of 2015. Production of synthetic rutile at its Tutunup South Mine in Western Australia increased by 28% to 210,900 t in 2016 (Iluka Resources Ltd., 2017, p. 16, 17).

At other operations in Western Australia, Tronox produced 32,000 t of rutile at its Cooljarloo Mine and 233,000 t of synthetic rutile at its Chandala processing plant (Tronox Ltd., 2017, p. 35–36). MZI Resources Ltd.'s Keysbrook operation in Western Australia completed its first full year of production in 2016, producing 40,113 t of leucoxene concentrate (MZI Resources Ltd., 2017, p. 3).

**China.**—Imports of titanium mineral concentrates totaled 2.55 Mt in 2016, an increase of 36% from those of 2015. The leading import countries, in decreasing order, were India, Mozambique, and Kenya (Global Trade Information Services, Inc., 2017).

China imported 3,182 t of titanium sponge in 2016, an increase from 82 t in 2015 owing to steep increases in imports from Russia and Ukraine. Exports of titanium sponge in 2016 decreased by 50% from those of 2015; the leading destination was the Republic of Korea at 62% (Global Trade Information Series Inc., 2017).

The China Nonferrous Metals Industry Association announced goals to coincide with the end of the Government's 13th Five-Year Plan in 2020. The goals included a production target of 120,000 t for titanium sponge, reductions in energy use and emissions by the titanium industry, new research and development centers, and support of China's aerospace industry by domestically produced titanium sponge (Mineral Sands Report, 2016, p. 26).

Henan Billions Chemicals Co., Ltd. completed its acquisition of Sichuan Lomon Titanium Industry Co., Ltd. The acquisition gave Henan Billions access to Lomon's integrated mining operations and raw materials, making it the world's fourth-leading TiO<sub>2</sub> pigment producer with a capacity of 600,000 t/yr (Metal-Pages, 2016c). In 2016, China's TiO<sub>2</sub> pigment production capacity was slightly less than 3.0 million metric tons per year (Mt/yr), with more than 2.5 Mt/yr of sulfate-process production (Adams, 2017, p. 20).

**India.**—In late 2016, Saraf Agencies Pvt. Ltd. was commissioning a titanium slag plant in Ganjam. The plant had a design capacity of 36,000 t/yr. Saraf also expected to begin construction of a TiO<sub>2</sub> pigment plant in 2017 with a planned capacity of 30,000 t/yr (Metal-Pages, 2016b).

**Iran.**—In November, construction began on a titanium mining operation and pilot pigment plant near the Kahnoot Mine in the Kerman Province near Bandar Abbas. The Kahnoot deposit



was expected to support a processing operation with a planned capacity of 130,000 t/yr of ilmenite concentrate and 70,000 t/yr of titanium slag. The capacity of the pilot pigment plant and timeline for construction were not specified. In 2016, Iran imported about 47,000 t of TiO<sub>2</sub> pigment (Metal-Pages, 2016a; Global Trade Information Services Inc., 2017).

**Japan.**—In 2016, Japan produced 19,986 t of titanium ingots and 54,600 t of titanium sponge, a decrease of 15% and an increase of 30%, respectively, from those of 2015. Shipments of mill products rose by 6% in 2016 to 16,700 t, owing partially to increased consumption by the Shuaiba Port desalination plant in Saudi Arabia (Roskill's Letter from Japan, 2017a, p. 1; 2017b, p. 3).

Production of TiO<sub>2</sub> pigment totaled 179,000 t in 2016, an increase of 3% from that of 2015. Ishihara Sangyo Kaisha, Ltd., the leading Japanese producer, accounted for one-half of the total production, and the leading end use was paint pigments at more than 60% (Roskill's Letter from Japan, 2017a, p. 8).

**Kenya.**—Base Resources Ltd. produced 469,000 t of ilmenite and 88,300 t of rutile from its Kwale operation in 2016, increases of 5% and 12%, respectively, from those of 2015 (Base Resources Ltd., 2016, p. 1; 2017, p. 1).

**Mozambique.**—Kenmare Resources plc produced 903,000 t of ilmenite and 7,800 t of rutile at its Moma Mine in 2016, increases of 18% and 30%, respectively, from production in 2015 (Kenmare Resources plc, 2017, p. 1, 2).

**Norway.**—TiZir Ltd. produced 103,600 t of titanium slag at its Tyssedal facility, a decrease of 3% from that of the previous year. In August, a fire at the plant resulted in damage that required the furnace to be relined. Repairs were completed, and operations were restarted on January 7, 2017 (Global Slag, 2017; TiZir Ltd., 2016, p. 2; TiZir Ltd., 2017, p. 1).

**Russia.**—Production of titanium sponge and ingots in 2016 totaled 40,000 t and 62,300 t, respectively. In 2016, the top three end-use sectors in Russia's titanium market were aircraft, engine, and shipbuilding at 30%, 25%, and 20%, respectively (Metz, 2017, p. 2–4).

IRC Ltd. suspended operations at its Kuranakh Mine in March owing to poor profitability. The Kuranakh Mine was a titanomagnetite operation, which produced ilmenite and iron ore concentrate. After placing the mine on care-and-maintenance status, the company sold an additional 60,000 t of ilmenite (IRC Ltd., 2017, p. 29).

**Saudi Arabia.**—The National Industrialization Co. and Toho Titanium Co., Ltd. (Japan) announced the formation of a joint venture called the Advanced Metal Industries Cluster Co., which included a new titanium sponge facility under construction in Yanbu. The new facility would have an initial capacity of 15,600 t/yr of titanium sponge and was expected to begin production in the second half of 2017 (Toho Titanium Co., Ltd., 2016).

**Sierra Leone.**—Sierra Rutile Ltd. produced 148,451 t of rutile in 2016, an increase of 18% from that of 2015. The acquisition of Sierra Rutile by Iluka Resources was completed in December. Iluka was evaluating the expansion of the Lanti dry mining operations and further expansion of Gangama. These two expansions were expected to match

the capacity of the mineral separation plant and increase Iluka's annual production to between 160,000 and 175,000 t (Sierra Rutile Ltd., 2017, p. 5, 8).

**South Africa.**—In April, Tronox opened its Fairbreeze Mine, the mining portion of its KZN Sands operations near Empangeni. Production from Fairbreeze replaced that of Tronox's Hillendale Mine, which closed in 2014. During a 12-year mine life, the Fairbreeze Mine was expected to produce an average of 220,000 t/yr of titanium slag and 25,000 t/yr of rutile (Tronox Ltd., 2017, p. 35).

Huntsman Corp. announced plans to close a sulfate-process TiO<sub>2</sub> pigment plant in Umbogintwini, its smallest and oldest pigment plant in operation with a capacity of 25,000 t/yr, by the end of 2016. The closure was expected to shift production to larger, more efficient operations (Huntsman International LLC, 2016).

Mineral Commodities Ltd. produced 35,813 t of zircon-rutile concentrate at the Tormin Mine in 2016, a decrease of 20% from that of 2015. Production of ilmenite was 211,704 t in 2016, almost double the production of the previous year, owing to the reprocessing of more than 32,000 t of stockpiled ilmenite concentrate (Mineral Commodities Ltd., 2017, p. 15, 16).

**Ukraine.**—The Zaporozhye Titanium & Magnesium Combine Ltd. (ZTMC) passed an audit by Baoji Titanium Industry Co., Ltd. (China), which confirmed that titanium sponge produced at ZTMC met Baoji's standards for aerospace manufacturing (Zaporozhye Titanium & Magnesium Combine Ltd., 2016).

Government-owned United Mining and Chemical Company (UMCC) was incorporated into a joint stock company in preparation for being privatized in 2017. During the first 9 months of 2016, UMCC produced 220,000 t of ilmenite and about 40,000 t of rutile (Metal-Pages, 2016d). UMCC reported a 26% increase in sales of ilmenite in 2016. UMCC operated two mines at Volnogorsk and Irshansk and shipped 532,335 t of ilmenite, an increase of 26% from shipments in 2015. By yearend, UMCC had sold excess inventory (Metal-Pages, 2017).

## Outlook

Global demand for TiO<sub>2</sub> pigment is forecast to increase by 4.1% annually until 2025, to 8.82 Mt/yr. Global production capacity of TiO<sub>2</sub> pigment is expected to increase to meet increased demand. The distribution of chloride-process versus sulfate-process TiO<sub>2</sub> pigment capacity was expected to reach parity by 2021, from 3.3 Mt/yr and 4.0 Mt/yr, respectively, in 2016. The shift in production capacity is expected to be driven mainly by the expansion of sulfate-process capacity in China (Adams, 2017, p. 19, 21).

With continued growth in titanium metal use for aerospace applications and the increasing proportions of titanium for next-generation aircraft, consumption of titanium mill products is expected to increase by 4.9% annually until 2019 (Roegner, 2016, p. 9). The leading end-use sectors for industrial titanium, outside of China and Russia, are expected to be chemical processing, oil and gas industry, and power generation, with consumption increasing slightly from 25,000 t in 2016 to about 27,000 t in 2020 (Cain, 2016, p. 28).

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

		2012	2013	2014	2015	2016
<b>United States:</b>						
<b>Mineral concentrates:</b>						
Production <sup>2</sup>	metric tons	300,000	300,000	200,000	300,000	100,000
Imports for consumption	do.	1,380,000	1,480,000	1,380,000	1,440,000	1,340,000
Consumption <sup>3</sup>	do.	1,940,000	1,820,000	1,790,000	1,720,000	1,740,000
<b>Sponge metal:</b>						
Imports for consumption	do.	33,600	19,900	17,700	20,700	16,200
Consumption	do.	35,100	26,500	26,400	31,200	34,100
Price, yearend <sup>4</sup>	dollars per pound	3.53–6.95	3.20–6.23	4.07–5.96	3.32–5.36	4.37–5.04
<b>Titanium dioxide pigment:</b>						
Production	metric tons	1,140,000	1,280,000	1,260,000	1,220,000	1,240,000
Imports for consumption	do.	203,000	213,000	224,000	221,000 <sup>r</sup>	247,000
Consumption, apparent <sup>5</sup>	do.	722,000	826,000	802,000	788,000 <sup>r</sup>	834,000
Producer price index, yearend <sup>6</sup>	(June 1982=100)	268	236	224	176	175
<b>World, production:</b>						
Ilmenite concentrate <sup>7</sup>	metric tons	7,250,000 <sup>r</sup>	8,270,000 <sup>r</sup>	7,640,000 <sup>r</sup>	6,980,000 <sup>r</sup>	7,000,000
Rutile concentrate, natural <sup>8</sup>	do.	811,000 <sup>r</sup>	640,000 <sup>r</sup>	660,000 <sup>r</sup>	760,000 <sup>r</sup>	889,000
Titanium slag <sup>9</sup>	do.	2,200,000	2,070,000 <sup>r</sup>	1,930,000 <sup>r</sup>	1,650,000 <sup>r</sup>	1,730,000

<sup>9</sup>Estimated. <sup>r</sup>Revised. do. Ditto.

<sup>1</sup>Table includes data available through August 16, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Rounded to one significant digit to avoid disclosing company proprietary data.

<sup>3</sup>Does not include consumption used to produce synthetic rutile.

<sup>4</sup>Landed duty-paid unit based on U.S. imports for consumption.

<sup>5</sup>Production plus imports minus exports. Does not include stock changes.

<sup>6</sup>Source: U.S. Department of Labor, Bureau of Labor Statistics.

<sup>7</sup>Includes U.S. production of ilmenite and rutile rounded to one significant digit to avoid disclosing company proprietary data.

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

TABLE 2  
ESTIMATED U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2016<sup>1, 2</sup>

(Metric tons per year)

Company	Plant location	Yearend capacity	
		Sponge	Ingot <sup>3</sup>
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
Arconic Inc.	Niles, OH	--	13,600
Do.	Whitehall, MI	--	3,200
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

Do. Ditto. -- Zero.

<sup>1</sup>Table includes data available through August 16, 2018. 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-arc, and vacuum-arc remelting capacity.



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

(Metric tons)

Component	2015	2016
<b>Production:</b>		
Ingot	61,800	66,200
Mill products	38,100	38,200
<b>Exports:</b>		
Waste and scrap	7,000 <sup>r</sup>	9,890
Sponge	1,700 <sup>r</sup>	724
Other unwrought	1,740 <sup>r</sup>	1,730
Wrought products and castings	19,500 <sup>r</sup>	19,500
Total	30,000 <sup>r</sup>	31,900
<b>Imports:</b>		
Waste and scrap	22,100 <sup>r</sup>	18,500
Sponge	20,700	16,200
Other unwrought	1,490 <sup>r</sup>	1,230
Wrought products and castings	6,260 <sup>r</sup>	7,190
Total	50,500 <sup>r</sup>	43,100
<b>Stocks, industry, yearend:</b>		
Sponge	25,000	25,100
Scrap	20,700	16,500
Ingot	9,610	9,480
<b>Consumption, reported:</b>		
Sponge	31,200	34,100
Scrap	52,200	55,000
Ingot	57,200	56,200
<b>Shipments:</b>		
Ingot	18,700	21,600
<b>Mill products:</b>		
Forging and extrusion billet	24,100	25,200
Other	13,900	12,800
Total	38,000	38,000
Castings	W	W
<b>Receipts, scrap:</b>		
Home	21,000	21,800
Purchased	43,800	41,100
Total	64,700	62,900

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

<sup>1</sup>Table includes data available through August 16, 2018. 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 2016<sup>1,2,3</sup>

(Metric tons per year)

Company	Plant location	Yearend capacity <sup>4</sup>
The Chemours Co.	De Lisle, MS	340,000
Do.	New Johnsonville, TN	400,000
Cristal Global	Ashtabula, OH	245,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	150,000
Tronox Ltd.	Hamilton, MS	225,000
Total		1,360,000

Do. Ditto.

<sup>1</sup>Table includes data available through August 16, 2018. Data are rounded to no more than three significant digits; may not add to total shown.

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

<sup>3</sup>Table does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of about 26,400 metric tons per year of buff TiO<sub>2</sub> pigment that is produced by refining and fine grinding of synthetic rutile.

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

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

		2015		2016	
		Gross weight	TiO <sub>2</sub> content	Gross weight	TiO <sub>2</sub> content
Production <sup>2</sup>	metric tons	1,220,000	1,150,000	1,240,000	1,170,000
Shipments: <sup>3</sup>					
Quantity	do.	1,260,000	1,190,000	1,260,000	1,190,000
Value	thousands	\$2,900,000 <sup>r</sup>	XX	\$2,750,000	XX
Exports	metric tons	652,000 <sup>r</sup>	613,000 <sup>r</sup>	656,000	617,000
Imports for consumption	do.	221,000 <sup>r</sup>	208,000	247,000	232,000
Consumption, apparent <sup>e,4</sup>	do.	788,000 <sup>r</sup>	741,000 <sup>r</sup>	834,000	784,000

<sup>e</sup>Estimated. <sup>r</sup>Revised. do. Ditto. XX Not applicable.

<sup>1</sup>Table includes data available through August 16, 2018. Data are rounded to no more than three significant digits.

<sup>2</sup>Does not include production of buff pigment.

<sup>3</sup>Production 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 MINERAL CONCENTRATES<sup>1,2</sup>

(Metric tons)

	2015		2016	
	Gross weight	TiO <sub>2</sub> content	Gross weight	TiO <sub>2</sub> content
Pigment	1,600,000	NA	1,640,000	NA
Miscellaneous <sup>3</sup>	120,000	NA	99,100	NA
Total	1,720,000	1,390,000 <sup>r</sup>	1,740,000	1,390,000

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

<sup>1</sup>Table includes data available through August 16, 2018. 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)

	2015	2016
Steel:		
Carbon steel	5,380	5,510
Stainless and heat-resisting steel	3,590	3,440
Other alloy steel <sup>3</sup>	793	593
Total steel	9,770	9,550
Cast irons	8	9
Superalloys	528	246
Alloys, other than above	1,180	1,140
Miscellaneous and unspecified	87	98
Grand total	11,600	11,000

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

<sup>2</sup>Table includes data available through August 16, 2018. 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  
ESTIMATED U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS, TITANIUM DIOXIDE CONTENT, BY INDUSTRY<sup>1</sup>

(Percent)

Industry	2015	2016
Paint, varnish, and lacquer	60.3	67.5
Paper	4.5	3.0
Plastics and rubber	28.7	25.0
Other <sup>2</sup>	6.5	4.5
Total	100.0	100.0

<sup>1</sup>Table includes data available through August 16, 2018. Does not include exports.

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

TABLE 9  
YEAREND PRICES OF TITANIUM PRODUCTS

		2015	2016
<b>Concentrate:</b>			
Ilmenite, free on board (f.o.b.) Australian ports <sup>1</sup>	dollars per metric ton	100–120	100–110
Rutile, bagged, f.o.b. Australian ports <sup>1</sup>	do.	800–840	770–850
Rutile, bulk, f.o.b. Australian ports <sup>1</sup>	do.	790–890	710–770
Titanium slag, import, 80% to 95% TiO <sub>2</sub> <sup>2</sup>	do.	630–751	674–676
<b>Metal:</b>			
Sponge import <sup>2</sup>	dollars per pound	3.32–5.36	5.03–5.42
Scrap, turnings, unprocessed <sup>3</sup>	do.	0.75–0.80	0.40–0.50
Ferrotitanium, 70% Ti <sup>3</sup>	do.	1.90–2.10	1.70–1.80
Mill products <sup>4</sup>	producer price index	171	163
Titanium dioxide pigment <sup>4</sup>	do.	176	175

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>June 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> code	2015		2016	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
<b>Metal:</b>					
Scrap	8108.30.0000	6,860	\$25,900	9,720	\$25,600
<b>Unwrought:</b>					
Sponge	8108.20.0010	1,650 <sup>†</sup>	17,300	697	5,400
Ingot	8108.20.0030	5,610	86,900	7,720	118,000
<b>Wrought:</b>					
Bloom, sheet bar, slab	8108.90.6020	2,590	84,900 <sup>†</sup>	3,090	96,100
Bar, rod, profile, wire	8108.90.6031	6,190 <sup>†</sup>	283,000 <sup>†</sup>	5,730	261,000
Other	8108.90.8000	10,400	963,000	10,100	1,020,000
Total		19,200 <sup>†</sup>	1,330,000	18,900	1,370,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,140	9,070	2,020	6,130
Ores and concentrates	2614.00.0000	2,040	3,490 <sup>†</sup>	7,330	9,830
<b>Pigment:</b>					
80% or more titanium dioxide pigment	3206.11.0000	625,000	1,340,000	633,000	1,330,000
Other titanium dioxide pigment	3206.19.0000	20,100	109,000 <sup>†</sup>	14,400	90,700
Unfinished titanium dioxide <sup>3</sup>	2823.00.0000	3,680	7,980	3,050	9,310
Total		649,000 <sup>†</sup>	1,460,000	651,000	1,430,000

<sup>†</sup>Revised.

<sup>1</sup>Table includes data available through August 16, 2018. 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 MINERAL CONCENTRATES, BY COUNTRY OR LOCALITY<sup>1</sup>

Concentrate and country or locality	HTS <sup>2</sup> code	2015		2016	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
<b>Ilmenite:</b>	2614.00.6020				
Australia		327,000	\$54,300	207,000	\$23,800
Mozambique		217,000	41,200	186,000	29,100
Other		105,000	43,900 <sup>r</sup>	200,000	31,300
<b>Total</b>		<b>649,000</b>	<b>139,000<sup>r</sup></b>	<b>592,000</b>	<b>84,200</b>
<b>Titanium slag:</b>	2620.99.5000				
Australia		56,400	7,280	--	--
Canada		102,000	75,600	122,000	82,900
Norway		--	--	11,000	6,390
South Africa		241,000	166,000	269,000	165,000
<b>Total</b>		<b>399,000</b>	<b>248,000</b>	<b>402,000</b>	<b>254,000</b>
<b>Rutile, natural:</b>	2614.00.6040				
Australia		68,000	47,600	62,700	40,000
Sierra Leone		35,200	27,600	27,700	19,600
South Africa		167,000	113,000	135,000	82,000
Other		21,700	18,600	41,700	30,200
<b>Total</b>		<b>292,000</b>	<b>207,000</b>	<b>267,000</b>	<b>172,000</b>
<b>Rutile, synthetic:</b>	2614.00.3000				
Australia		98,800	71,500	68,900	46,400
Other		2,850	3,480	13,700	12,100
<b>Total</b>		<b>102,000</b>	<b>75,000</b>	<b>82,700</b>	<b>58,500</b>
Titaniferous iron ore, Canada <sup>3</sup>	2614.00.6020	64,700	32,400	15,200	1,430

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

<sup>1</sup>Table includes data available through August 16, 2018. 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 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 OR LOCALITY<sup>1</sup>

Class and country or locality	HTS <sup>2</sup> code	2015		2016	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		1,160	\$4,390 <sup>r</sup>	1,260	\$4,520
China		635	5,120	300	2,550
France		2,550 <sup>r</sup>	15,800 <sup>r</sup>	2,250	14,700
Germany		3,400	23,400	2,690	13,900
Israel		597 <sup>r</sup>	3,130	352	1,850
Italy		1,130	5,360	1,110	3,370
Japan		3,310 <sup>r</sup>	18,300 <sup>r</sup>	2,430	10,300
Korea, Republic of		1,870	11,000	1,290	5,440
Mexico		773	2,920	634	2,320
Taiwan		554	3,030	132	567
United Kingdom		4,170 <sup>r</sup>	20,600	4,480	27,900
Other		1,920 <sup>r</sup>	11,500 <sup>r</sup>	1,560	6,240
Total		22,100 <sup>r</sup>	124,000 <sup>r</sup>	18,500	93,600
Unwrought:					
Sponge:	8108.20.0010				
China		890	6,690	49	415
Japan		15,500	161,000	15,800	145,000
Kazakhstan <sup>c</sup>		2,600	21,400	45	374
Ukraine		1,310	10,300	44	323
Other		413	3,960 <sup>r</sup>	206	2,060
Total		20,700	203,000	16,200	148,000
Ingot:	8108.20.0030				
Japan		39	3,580	41	3,500
Russia		325 <sup>r</sup>	6,460 <sup>r</sup>	620	11,500
Other		40 <sup>r</sup>	698 <sup>r</sup>	28	151
Total		404 <sup>r</sup>	10,700 <sup>r</sup>	689	15,100
Powder:	8108.20.0015				
Canada		14	3,410 <sup>r</sup>	27	5,720
China		100	1,750	115	2,000
Germany		7	1,840	11	3,060
Other		8 <sup>r</sup>	1,260	8	1,180
Total		129 <sup>r</sup>	8,260 <sup>r</sup>	161	12,000
Other:	8108.20.0095				
France		7 <sup>r</sup>	464 <sup>r</sup>	54	2,120
Germany		298 <sup>r</sup>	6,620 <sup>r</sup>	15	173
Russia		1,110 <sup>r</sup>	23,200 <sup>r</sup>	1,010	22,700
United Kingdom		27 <sup>r</sup>	2,350 <sup>r</sup>	140	6,280
Other		46 <sup>r</sup>	772 <sup>r</sup>	14	647
Total		1,490 <sup>r</sup>	33,400 <sup>r</sup>	1,230	31,900
Wrought products and castings: <sup>3</sup>	8108.90.3030, 8108.90.3060, 8108.90.6020, 8108.90.6031, 8108.90.6045, 8108.90.6060, 8108.90.6075				
Canada		140	9,190 <sup>r</sup>	147	8,980
China		957 <sup>r</sup>	35,700 <sup>r</sup>	924	40,500
Japan		484	15,500	704	17,800
Russia		2,550 <sup>r</sup>	101,000 <sup>r</sup>	3,210	124,000
United Kingdom		290 <sup>r</sup>	37,800 <sup>r</sup>	504	52,200
Other		1,830 <sup>r</sup>	118,000 <sup>r</sup>	1,710	108,000
Total		6,260 <sup>r</sup>	317,000 <sup>r</sup>	7,190	351,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	1,730	6,260	3,140	7,840

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

<sup>1</sup>Table includes data available through August 16, 2018. 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 billet, pipe and tube, plate, rod and bar, sheet, strip, and wire.

Source: U.S. Census Bureau.

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

Country or locality	HTS <sup>2</sup> code	2015		2016	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Australia		7,520	\$17,500	1,180	\$2,770
Belgium		3,560 <sup>r</sup>	8,170 <sup>r</sup>	5,100	10,400
Brazil		12 <sup>r</sup>	39 <sup>r</sup>	4	10
Canada		60,600	155,000	66,900	147,000
China		35,000 <sup>r</sup>	66,500 <sup>r</sup>	42,700	72,500
Czechia		2,130 <sup>r</sup>	5,240 <sup>r</sup>	1,610	3,680
Finland		6,000	14,900	8,290	18,600
France		2,160 <sup>r</sup>	5,340 <sup>r</sup>	2,620	6,020
Germany		13,000	30,600	15,000	33,900
India		1,070 <sup>r</sup>	1,800 <sup>r</sup>	881	1,420
Italy		1,740 <sup>r</sup>	3,960 <sup>r</sup>	1,780	3,730
Japan		4,720 <sup>r</sup>	21,200 <sup>r</sup>	6,500	23,200
Malaysia		57 <sup>r</sup>	89 <sup>r</sup>	57	97
Mexico		6,420	20,900	14,400	27,900
Netherlands		541 <sup>r</sup>	1,860 <sup>r</sup>	500	1,620
Norway		4,970	10,500	3,390	6,780
Saudi Arabia		1,020	2,070	40	73
Slovenia		535 <sup>r</sup>	1,030 <sup>r</sup>	852	1,530
Spain		8,780	20,100	7,470	14,100
Ukraine		2,900	4,830	3,150	4,870
United Kingdom		472 <sup>r</sup>	1,070 <sup>r</sup>	2,040	4,000
Other		4,550 <sup>r</sup>	8,120 <sup>r</sup>	641	1,170
Total		168,000	401,000 <sup>r</sup>	185,000	385,000
Other titanium dioxide:	3206.19.0000				
Canada		9,530	25,200	9,220	21,700
China		1,130	3,620	1,830	5,420
Colombia		80 <sup>r</sup>	231 <sup>r</sup>	22	59
France		192 <sup>r</sup>	1,010 <sup>r</sup>	181	566
Germany		900	5,390	190	2,550
India		312 <sup>r</sup>	1,710 <sup>r</sup>	318	1,270
Israel		6 <sup>r</sup>	293 <sup>r</sup>	3	344
Italy		937	3,080	460	1,880
Japan		247 <sup>r</sup>	5,100 <sup>r</sup>	280	4,620
Korea, Republic of		36 <sup>r</sup>	522 <sup>r</sup>	21	592
Mexico		92 <sup>r</sup>	445 <sup>r</sup>	58	250
Spain		1 <sup>r</sup>	43 <sup>r</sup>	38	205
United Kingdom		140 <sup>r</sup>	2,970 <sup>r</sup>	88	2,710
Other		151 <sup>r</sup>	1,180 <sup>r</sup>	105	1,260
Total		13,700 <sup>r</sup>	50,800 <sup>r</sup>	12,800	43,500
Unfinished titanium dioxide: <sup>3</sup>	2823.00.0000				
China		16,200 <sup>r</sup>	31,000 <sup>r</sup>	24,400	41,500
Czechia		2,550	5,920	2,870	5,800
Finland		3,000	9,800	2,860	9,040
France		4,710	14,600	6,060	14,300
Germany		3,930	11,000	5,300	15,400
India		1,180 <sup>r</sup>	2,190 <sup>r</sup>	2,090	3,720
Italy		2,640	5,880	2,220	5,910
Japan		945 <sup>r</sup>	4,530 <sup>r</sup>	369	4,090
Korea, Republic of		2,660	4,860	868	2,090
Other		1,590 <sup>r</sup>	4,700 <sup>r</sup>	1,690	4,230
Total		39,400 <sup>r</sup>	94,500 <sup>r</sup>	48,800	106,000
Grand total		221,000 <sup>r</sup>	547,000 <sup>r</sup>	247,000	535,000

<sup>r</sup>Revised.

<sup>1</sup>Table includes data available through August 16, 2018. 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 OR LOCALITY<sup>1</sup>

(Metric tons, gross weight)

Country or locality	2012	2013	2014	2015	2016
<b>Ilmenite and leucoxene:<sup>2,3</sup></b>					
Australia	1,570,000 <sup>r</sup>	1,560,000 <sup>r</sup>	1,250,000 <sup>r</sup>	1,160,000 <sup>r</sup>	1,300,000
Brazil <sup>4</sup>	115,000 <sup>r</sup>	130,000 <sup>r</sup>	135,000 <sup>r</sup>	133,000 <sup>r</sup>	130,000
China	1,330,000 <sup>r,e</sup>	1,700,000 <sup>r,e</sup>	1,860,000 <sup>r,e</sup>	1,780,000 <sup>r,e</sup>	1,400,000
Egypt	--	20,000	--	--	--
India	340,000 <sup>e</sup>	436,000 <sup>e</sup>	320,000 <sup>e</sup>	300,000 <sup>e</sup>	300,000
Indonesia	103,000 <sup>r</sup>	26,600 <sup>r</sup>	1,490 <sup>r</sup>	23,000	20,000
Kazakhstan	25,000 <sup>e</sup>	10,000 <sup>r,e</sup>	10,000 <sup>r,e</sup>	8,000 <sup>r,e</sup>	10,000
Kenya	--	5,540 <sup>r</sup>	368,000 <sup>r</sup>	445,000 <sup>r</sup>	469,000
Madagascar	621,000 <sup>r</sup>	530,000 <sup>r</sup>	334,000 <sup>r</sup>	240,000 <sup>r,e</sup>	240,000
Malaysia	22,300 <sup>r</sup>	16,000 <sup>r</sup>	8,160 <sup>r</sup>	5,810 <sup>r</sup>	30,400
Mozambique	574,000 <sup>r</sup>	780,000 <sup>r,e</sup>	927,000 <sup>r</sup>	829,000 <sup>r</sup>	1,340,000
Norway	831,000	826,000	864,000	430,000 <sup>r</sup>	439,000
Russia	125,000 <sup>r</sup>	150,000 <sup>r</sup>	178,000 <sup>r</sup>	193,000 <sup>r</sup>	--
Senegal	--	--	101,000 <sup>r</sup>	428,000 <sup>r</sup>	416,000
Sierra Leone	22,600 <sup>r</sup>	32,300 <sup>r</sup>	35,800 <sup>r</sup>	37,600 <sup>r</sup>	26,000
Sri Lanka	40,100 <sup>r</sup>	44,100 <sup>r</sup>	33,000 <sup>r</sup>	39,400 <sup>r</sup>	32,700
Ukraine	247,000 <sup>r</sup>	670,000 <sup>e</sup>	450,000 <sup>r,e</sup>	350,000 <sup>r,e</sup>	350,000
United States <sup>4,5</sup>	300,000 <sup>e</sup>	300,000 <sup>e</sup>	200,000 <sup>e</sup>	300,000 <sup>e</sup>	100,000
Vietnam <sup>6</sup>	978,000 <sup>r</sup>	1,030,000 <sup>r</sup>	558,000 <sup>r</sup>	282,000 <sup>r</sup>	400,000
<b>Total<sup>7</sup></b>	<b>7,250,000<sup>r</sup></b>	<b>8,270,000<sup>r</sup></b>	<b>7,640,000<sup>r</sup></b>	<b>6,980,000<sup>r</sup></b>	<b>7,000,000</b>
<b>Rutile:<sup>3</sup></b>					
Australia	439,000 <sup>r</sup>	232,000	212,000	320,000 <sup>r</sup>	400,000
Brazil <sup>4</sup>	2,090 <sup>r</sup>	2,250 <sup>r</sup>	2,040 <sup>r</sup>	2,220 <sup>r</sup>	2,000
India	24,000 <sup>e</sup>	26,000 <sup>e</sup>	19,100 <sup>e</sup>	20,000 <sup>e</sup>	20,000
Kenya	--	152	59,300 <sup>r</sup>	78,900 <sup>r</sup>	88,300
Madagascar <sup>e</sup>	12,000	11,000	6,900 <sup>r</sup>	4,800 <sup>r</sup>	4,800
Malaysia	20,000 <sup>r</sup>	5,980 <sup>r</sup>	3,070 <sup>r</sup>	198	200
Mozambique	4,000	4,000 <sup>r</sup>	6,100 <sup>e</sup>	5,980 <sup>r</sup>	7,780
Senegal	--	--	663	5,310 <sup>r</sup>	6,000
Sierra Leone	94,500 <sup>r</sup>	120,000 <sup>r</sup>	114,000 <sup>r</sup>	126,000 <sup>r</sup>	148,000
South Africa <sup>e</sup>	150,000	70,000 <sup>r</sup>	120,000 <sup>r</sup>	100,000 <sup>r</sup>	110,000
Sri Lanka	1,970 <sup>r,e</sup>	1,590 <sup>r,e</sup>	1,750 <sup>r</sup>	1,810 <sup>r</sup>	2,000
Turkey	5,000	5,000	5,000	5,000	5,000
Ukraine	58,000 <sup>e</sup>	162,000 <sup>e</sup>	110,000 <sup>r,e</sup>	90,000 <sup>r,e</sup>	100,000
United States	(8)	(8)	(8)	(8)	(8)
<b>Total</b>	<b>811,000<sup>r</sup></b>	<b>640,000<sup>r</sup></b>	<b>660,000<sup>r</sup></b>	<b>760,000<sup>r</sup></b>	<b>889,000</b>
<b>Titanium slag:<sup>e,9</sup></b>					
Canada	900,000	900,000	900,000 <sup>r</sup>	700,000	900,000
South Africa	1,300,000	1,170,000 <sup>r</sup>	1,030,000 <sup>r</sup>	950,000 <sup>r</sup>	830,000
<b>Total</b>	<b>2,200,000</b>	<b>2,070,000<sup>r</sup></b>	<b>1,930,000<sup>r</sup></b>	<b>1,650,000<sup>r</sup></b>	<b>1,730,000</b>

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

<sup>1</sup>Table includes data available through November 23, 2017. All data are reported unless otherwise noted. Estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Ilmenite is also produced in Canada and South Africa, but this output is not included here because most of it is duplicative of output reported under "Titanium slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

<sup>3</sup>Small amounts of titanium minerals were reportedly produced in various countries and localities, but information was inadequate to make reliable estimates of output levels.

<sup>4</sup>Does not include production of unbeneficiated anatase ore.

<sup>5</sup>Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

<sup>6</sup>Estimate based on import statistics from trading partners (primarily China and Japan).

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

<sup>8</sup>Included with ilmenite and leucoxene to avoid disclosing company proprietary data.

<sup>9</sup>Slag was also produced in China, India, Kazakhstan, Norway, Russia, and Vietnam, but this output was not included under "Titanium slag" to avoid duplicative reporting.