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2021 Minerals Yearbook

TITANIUM [ADVANCE RELEASE]

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Titanium

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In 2021, one company produced titanium mineral concentrates from surface mining operations near Offerman, GA, and Starke, FL, and a second company processed existing sand and gravel tailings in California and South Carolina. The United States was an estimated 90% net import reliant (as a percentage of apparent consumption) with regard to titanium mineral concentrates and greater than 95% net import reliant (as a percentage of apparent consumption) with regard to titanium sponge (Gambogi, 2024a, b). 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 descending order of value, South Africa and Australia (table 11). U.S. consumption of titanium used in steel and other alloys was essentially unchanged from that in 2020 (table 7). Based on gross weight, world production of ilmenite and rutile titanium mineral concentrates in 2021 was 13.4 million metric tons (Mt) and 651,000 metric tons (t), respectively. World production of titanium slag was about 1.5 Mt (tables 1, 14).

Titanium is the ninth most abundant element in the earth's crust and can be found in nearly all rocks and sediments. It has a strong affinity for oxygen and is not found as a pure metal in nature. Titanium was isolated first 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 ($TiCl_4$) 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 2021, the USGS annual survey canvassed titanium mineral and pigment producers. Both producers of mineral concentrates responded to the annual surveys, whereas two of the four pigment producers responded.

Mineral Concentrates.—Titanium minerals of economic importance included ilmenite, rutile, and an alteration product of ilmenite and other minerals. Dredging and dry surface mining techniques were usually used for the recovery of heavy minerals, including titanium minerals. Spiral separation by gravity was used to isolate the heavy-mineral suite, and magnetic and high-tension separation circuits were used to separate the heavy-mineral constituents. Ilmenite is the most abundant titanium mineral with a TiO_2 content ranging from 35% to 65%. Rutile, which is naturally occurring TiO_2, has the greatest TiO_2 content, but is less abundant than ilmenite. Ilmenite often is processed to produce a synthetic rutile or titanium slag. Although numerous technologies were used to produce synthetic rutile, nearly all were based on either selective leaching or thermal reduction of iron and other impurities in ilmenite.

In 2021, the The Chemours Co. (Wilmington, DE) produced concentrates of heavy minerals including ilmenite, rutile, zircon, and other accessory minerals at mining operations in Georgia and Florida. Chemours' titanium-mineral feedstocks were used to supply its TiO_2 pigment plants. Twin Pines Minerals LLC's (Birmingham, AL) mobile operations processed existing mine tailings in West Columbia, SC, and Ione, CA, to produce mixed titanium and zircon concentrates.

TiO_2 Pigment.—TiO_2 pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the chloride process, ilmenite, rutile, or titanium slag is converted to $TiCl_4$ by chlorination in the presence of petroleum coke. $TiCl_4$ is oxidized with air or oxygen at about 1,000 degrees Celsius (°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 is added to the $TiCl_4$ to ensure 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 then is 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, freight costs, 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 how 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 TiO_2 pigment was 1.15 Mt in 2021, 14% more than that in 2020 (tables 1, 5). U.S. producers of TiO_2 pigment using the chloride process were Chemours, INEOS Pigments USA Inc., Louisiana Pigment Co. L.P. (a joint venture between Kronos Worldwide, Inc. and Venator Materials Plc), and Tronox Holdings Plc (table 4). TOR Minerals International, Inc. produced a buff-color TiO_2 pigment from finely ground synthetic rutile. There were no domestic producers using the sulfate process to produce TiO_2.

Metal.—In commercial production of titanium metal, titanium mineral concentrates are chlorinated to produce $TiCl_4$, which then is reduced with magnesium (the Kroll process) or sodium (the 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 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.

At yearend, domestic sponge and ingot production capacities were estimated to be 500 metric tons per year (t/yr) and 137,000 t/yr, respectively. U.S. producers of titanium sponge in 2021 were Honeywell Electronic Materials Inc. (Salt Lake City, UT) and Titanium Metals Corp. (Timet), a subsidiary of Precision Castparts Corp. (table 2). At the Salt Lake City, UT, plant, Honeywell Electronic Materials used the Hunter process to produce titanium sponge as feed for the company's production of high-purity titanium in Fombell, PA. Timet's Henderson, NV, plant had produced titanium sponge using the Kroll process. Owing to the economic effects of the global coronavirus disease 2019 (COVID-19) pandemic combined with other factors, Timet indefinitely idled its sponge plant at the Henderson operations in 2020 (Bradford, 2020).

The Henderson plant was the last large-scale domestic sponge plant supplying the domestic titanium metal industry. Prior to this closure, Allegheny Technologies Inc. (ATI) idled its sponge facility in 2016. According to ATI, its Rowley, UT, sponge plant was idled so that it could be restarted if supported by market conditions (Allegheny Technologies Inc., 2016). Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data.

Ferrotitanium usually is 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% and 70% titanium, respectively. U.S. producers of ferrotitanium were Howmet Aerospace Inc. (Canton, OH) and AmeriTi Manufacturing Co. (Detroit, MI). Data on production and production capacity of ferrotitanium were not available.

Consumption

Mineral Concentrates.—Based on estimated TiO_2 content of domestic production, imports, and exports, domestic apparent consumption of titanium mineral concentrates was 1.1 Mt in 2021 compared with 0.9 Mt in 2020 (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. Consumption was estimated based on production, imports, and exports of mineral concentrates.

TiO_2 Pigment.—Domestic production of TiO_2 pigment was estimated to have increased by 14%, and domestic apparent consumption (not accounting for changes in inventory) increased by 3% from that in 2020 (tables 1, 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 (which accounted for 65% of shipments) followed by plastics and rubber (26%). Other uses included catalysts, ceramics, coated fabrics and textiles, floor coverings, paper, printing ink, and roofing granules (table 8).

Metal.—Titanium metal alloys were used for their high strength-to-weight ratio and corrosion resistance. The aerospace industry was the leading end use for mill products. In general, production of titanium mill products precedes aircraft deliveries by about 12 months. Other uses included consumer goods and the marine, medical, oil and gas, pulp and paper, and specialty chemical industries. A significant quantity of titanium in the form of ferrotitanium, scrap, and sponge 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 8,830 t, essentially unchanged compared with the revised amount in 2020 (table 7).

Stocks

Available data were insufficient to determine yearend consumer inventories of mineral concentrates and pigment. Titanium metal industry stocks were withheld to avoid disclosing company proprietary data.

Prices

Average annual titanium mineral concentrate prices are listed in table 9. In 2021, the average annual prices increased for ilmenite and rutile compared with those in 2020. Based on U.S. Census Bureau data, the average values of slag imports from slag-producing countries decreased in 2021 compared with those in 2020 to $981 per metric ton for Canada, $772 per metric ton for Norway, and $596 per metric ton for South Africa. Published prices for titanium slag were not available.

The U.S. Department of Labor, Bureau of Labor Statistics Producer Price Index (PPI) for titanium mill products was 168 from January through August (June 1982 = 100), 169 from September through November, and 171 in December. Based on U.S. Census Bureau data, the average import value of TiO_2 pigment was $2,920 per metric ton, an 8% increase from $2,710 per metric ton in 2020.

Foreign Trade

Mineral Concentrates.—U.S. imports of titanium mineral concentrates included ilmenite, rutile, synthetic rutile, and titanium slag. The United States was heavily reliant on imports of titanium mineral concentrates because domestic consumption of titanium minerals greatly exceeded domestic production capacity. In 2021, the estimated TiO_2 content of imports was 970,000 t, primarily in the form of ilmenite (39%), natural rutile (31%), and titanium slag (30%). The combined value for all forms of titanium mineral concentrate imports in 2021 was $682 million. South Africa, Canada, Australia, Madagascar, Mozambique, and Norway were, in descending order by import value, the leading import sources, accounting for more than 90% of the mineral concentrate import value. Imports of titaniferous iron ore, containing less than 35% TiO_2, from Canada (classified as ilmenite by the U.S. Census Bureau), were 13,500 t in gross weight and were valued at $2.18 million.

Exports of titanium mineral concentrates were minor relative to imports (tables 10, 11).

TiO_2 Pigment.—In 2021, the United States continued to be a net exporter of TiO_2 pigment, with exports exceeding imports by a ratio of almost 2 to 1. Exports of TiO_2 pigment were 494,000 t valued at $1.51 billion, a 28% increase in quantity compared with those in 2020. About 94% of TiO_2 pigment exports were in the form of finished pigment containing 80% or more TiO_2 content. During 2021, 251,000 t of TiO_2 pigment valued at $718 million was imported, a decrease of 4% in quantity from that in 2020. The leading import sources of TiO_2 pigment were Canada, accounting for 47% of total imports, followed by China and Germany with 10% each. About 84% of pigment imports was in the form of finished pigment containing more than 80% TiO_2 (tables 10, 13).

Metal.—Total imports of titanium metal, excluding ferrotitanium, were 36,900 t and were primarily in the form of sponge (43%) and waste and scrap (29%) (table 12). Japan supplied 87% of imported titanium sponge; Russia (70%) and Kazakhstan (30%) supplied nearly all of the imported titanium ingot; and Germany (21%), Canada (14%), the United Kingdom (14%), and France (11%) were the leading sources of imported scrap. Russia (53%) and China (15%) were the leading sources of wrought products and castings. Exports of titanium metal were 24,300 t, excluding ferrotitanium and ferrosilicon titanium, and were primarily in the form of waste and scrap (43%), wrought products and castings (38%), and ingot (11%) (table 10).

Imports of ferrotitanium and ferrosilicon titanium were 4,150 t, a 46% increase from those in 2020 (table 12). Exports of ferrotitanium and ferrosilicon titanium were 1,280 t, a 32% decrease compared with those in 2020 (table 10).

World Review

In 2021, global production (gross weight) of ilmenite and leucoxene, rutile, and titanium slag was 13.4 Mt, 651,000 t, and 1.50 Mt, respectively. Ilmenite produced in Canada and South Africa is excluded from titanium slag production to avoid duplicative reporting. The leading producers of titanium in mineral concentrates were, in descending order of TiO_2 content, China, Mozambique, South Africa, and Australia (table 14).

Australia.—Iluka Resources Ltd. was Australia's leading producer of titanium mineral concentrates with active operations in the States of South Australia and Western Australia. In 2021, Iluka's Australian operations produced 512,000 t of ilmenite and 67,300 t of natural rutile, compared with 410,000 t of ilmenite and 52,400 t of natural rutile produced in 2020. Using a portion of its own ilmenite as feedstock, the company produced 199,000 t of synthetic rutile compared with 227,000 t in 2020. At yearend, ore reserves for Iluka's Australian operations were reported to contain 182 Mt of ore containing 10.6 Mt of heavy minerals grading 55% ilmenite and 3% rutile (Iluka Resources Ltd., 2022, p. 26–27, 151).

Development of the Thunderbird heavy-mineral-sands project in Western Australia continued during the year. In March, YGH Australia Investment, a subsidiary of Tangshan Yanshan Iron & Steel Co., Ltd. (China), acquired 50% interest in the Thunderbird project from Sheffield Resources Ltd. with Sheffield Resources retaining the remaining 50% interest. At yearend, Thunderbird reserves were 748 Mt containing 11.2% heavy minerals including ilmenite (27.8%) and leucoxene (4.8%) (Sheffield Resources Ltd., 2022, p. 9, 31–32).

Strandline Resources Ltd. began construction on the Coburn mineral sands project in Western Australia with production scheduled to begin in 2022. Coburn was expected to produce 110,000 t/yr of ilmenite and 24,000 t/yr of rutile during an initial 22.5-year mine life. Strandline expected 80% of its production would be supplied to customers in Europe and North America with the remainder destined for Asia (Strandline Resources Ltd., 2020; 2022, p. 3–4).

Canada.—In Quebec, Rio Tinto Fer et Titane Inc. (RTFT), a subsidiary of Rio Tinto plc (United Kingdom), produced titanium slag at its Sorel-Tracy operations. RTFT supplemented mineral concentrates from its Lac Tio mining operations in Quebec Province with concentrates from its operations in Madagascar. In 2021, combined titanium slag production from Rio Tinto's operations in Canada and South Africa decreased by 9% from that in 2020 to 1.0 Mt, partly owing to unplanned maintenance and equipment issues at RTFT. Titanium slag production capacity at the Sorel-Tracy operations was reported to be 1.3 million metric tons per year (Mt/yr) (Rio Tinto plc, 2022, p. 64, 403).

China.—China was the leading producer and consumer of titanium mineral concentrates, producing an estimated 6.1 Mt of ilmenite in 2021 (table 14). Imports of titanium mineral concentrates under the Harmonized System (HS) code 261400 were 3.8 Mt in 2021, a 26% increase from those in 2020. The leading sources, in descending order of quantity, were Mozambique, 39%; Vietnam, 11%; Kenya, 8%; Norway, 7%; and Australia, 7%. Exports of titanium mineral concentrates (HS code 261400) were 34,700 t in 2021, a 34% increase from 2020 (Zen Innovations AG, 2024).

China's TiO_2 pigment production in 2021 was 3.79 Mt, with about 90% of the production from operations using the sulfate process. Imports of titanium-based pigments (HS codes 282300, 320611, and 320619) were 219,000 t in 2021, 12% more than those in 2020. Exports of titanium-based pigments (HS codes 282300, 320611, and 320619) totaled 1.4 Mt in 2021, an increase of 7% from exports in 2020 (Henan Jinhe Industry Co., Ltd., 2022; Zen Innovations AG, 2024).

China also was the leading producer and consumer of titanium metal. In 2021, production capacity of titanium sponge was 181,000 t/yr, an increase from 177,000 t/yr in 2020. Production from nine major producers in China was reported to be 140,000 t, a 14% increase compared with that in 2020. Imports of titanium metal and articles thereof (HS code 8108) were 23,800 t, and exports were 22,900 t (Argus Metals International, 2022; Zen Innovations AG, 2024).

LB Group Co., Ltd. (formerly Lomon Billions Group Co. Ltd.) was China's leading TiO_2 pigment producer with 1.01 Mt/yr of TiO_2 pigment production capacity. LB Group produced 902,200 t of TiO_2 pigment in 2021, a 10% increase compared with that in 2020. About 72% of its TiO_2 output was produced using the sulfate process. The company also produced 14,800 t of titanium sponge, 63% more than that in 2020. LB Group was working to significantly increase its TiO_2 pigment and titanium sponge production (LB Group Co., Ltd., 2022, p. 29, 39–40, 171).

Finland.—During 2021, Venator Materials Plc (United Kingdom) was in the process of closing its TiO_2 pigment operation at Pori. In 2017, a fire significantly damaged the plant that had a design capacity of 130,000 t/yr (Venator Materials Plc, 2022, p. 46).

Japan.—Titanium sponge producers in Japan included Toho Titanium Co., Ltd. (25,000 t/yr) and OSAKA Titanium technologies Co., Ltd. (40,000 t/yr). Exports of titanium metal under HS code 8108 increased by 20% to 42,200 t from 35,100 t in 2020. The leading categories of exports were unwrought (72%), other articles of titanium (18%), and waste and scrap (10%) (JX Nippon Mining & Metals Corp., 2021, p. 26; OSAKA Titanium technologies Co., Ltd., 2022; Zen Innovations AG, 2024).

The leading producers of TiO_2 pigment in Japan, in descending order of capacity, were Ishihara Sangyo Kaisha, Ltd., Tayca Corp., and Sakai Chemical Industry Co., Ltd. According to the Ministry of Economy, Trade and Industry, Japan's production of TiO_2 pigments totaled 187,000 in 2021, a 20% decrease compared with that in 2020 (Roskill's Letter from Japan, 2021; Ministry of Economy, Trade and Industry, 2024).

Norway.—In May, Nordic Mining ASA released an updated definitive feasibility study for its Engebø rutile-garnet project in southwestern Norway. Once commissioned, Nordic planned to operate the mine for 39 years and produce an average of 35,000 t/yr of rutile during the first 10 years of operation. Proven and probable ore reserves were 57 Mt containing 3.57% TiO_2 (Hatch Ltd., 2021, p. 5–6, 19).

Russia.—Russia's sponge and ingot production capacities were 46,500 t/yr and 81,000 t/yr, respectively. PJSC VSMPO-AVISMA Corp. was the leading producer of both sponge and ingot. In 2021, Russia exported 14,600 t of titanium metal under HS code 8108, 22% less than 18,700 t in 2020. The United States, Germany, China, and the Netherlands, in descending order of quantity, were the leading destinations and accounted for 76% of exports. About 37% of Russia's titanium metal exports were in the form of unwrought titanium (Tirus International SA, 2020; Zen Innovations AG, 2024).

Saudi Arabia.—Advanced Metal Industries Co. continued to operate its 15,600-t/yr sponge operation at Yanbu that was commissioned in 2019. Toho Titanium Co., Ltd. (Japan) owned a 35% interest in the project. In 2021, exports of titanium metal under HS code 8108 were 5,680 t, 38% more compared with that in 2020 (Argus Metals International, 2019; Zen Innovations AG, 2024).

Sierra Leone.—Sierra Rutile Ltd., a subsidiary of Iluka, produced 52,100 t of ilmenite and 129,000 t of rutile in 2021 compared with 45,800 t of ilmenite and 120,000 t of rutile in 2020. At yearend, Sierra Rutile ore reserves were 212 Mt containing 1.5% (3.1 Mt) of rutile (Iluka Resources Ltd., 2022, p. 28, 152).

South Africa.—In 2021, South Africa was a leading global producer and exporter of titanium mineral concentrates. Leading producers, in descending order of production capacity, included Rio Tinto and Tronox. Exports of titanium concentrates under HS code 2614 were 672,000 t, 7% less than those in 2020 (Zen Innovations AG, 2024). Although a leading producer of titanium slag from ilmenite mineral concentrates, South Africa did not have a specific export trade code for titanium slag (table 14).

Rio Tinto held a 74% interest in the Richards Bay Minerals (RBM) mining and slag operations. In 2021, titanium slag production capacity at RBM was reported to be 1.05 Mt/yr, and slagging operations were supported by mining at the Zulti North deposit. In June, Rio Tinto suspended operations at RBM and declared force majeure on customer contracts after a security incident at the mine. Operations restarted in August, but the force majeure remained in place. Construction at the Zulti South project remained suspended pending ilmenite concentrate requirements from its slag operations (Rio Tinto plc, 2022, p. 34, 199, 403).

Tronox operations included the KwaZulu-Natal (KZN) Sands mining and titanium slag operations on the east coast and Namakwa Sands mining and titanium slag operations on the west coast. The combined production capacity of KZN Sands and Namakwa Sands included 55,000 t/yr of rutile and 410,000 t/yr of slag. Ilmenite capacity used to produce titanium slag was not available (Tronox Holdings plc, 2021, p. 33).

Tanzania.—Strandline Resources continued to advance its Fungoni and Tajiri mineral sands projects. In December, Strandline announced that its Tanzanian deposits would be developed under a joint venture with the Government of Tanzania. Under an agreement with the Government, a joint venture called Nyati Mineral Sands Ltd. was to be created with Strandline holding 84% interest in the new company (Strandline Resources Ltd., 2021a, p. 6; 2021b).

Ukraine.—Ukraine was a significant producer of titanium mineral concentrates and titanium sponge. Titanium mineral concentrates were produced by private companies and one state-owned company, United Mining and Chemical Company JSC. In 2021, Ukraine produced 703,000 t of ilmenite and an estimated 100,000 t of rutile (table 14). Reported exports of titanium minerals concentrates were 553,000 t in 2021. Ukraine's sole producer of titanium sponge was the Zaporozhye Titanium and Magnesium Combine Ltd. with a capacity of about 12,000 t/yr. Exports of titanium metal under HS code 8108 increased slightly to 6,100 t, of which 91% was in the form of unwrought titanium and powder (Tirus International SA, 2020; Zen Innovations AG, 2024).

Outlook

Because titanium pigments are consumed in paints and coatings, plastics, and paper, consumption is linked to economic growth. According to the International Monetary Fund, global economic annual growth was expected to slow to 2.9% by 2024, a decrease compared with an historical average of 3.8% from 2000–2019. However, according to the leading producer of TiO_2 in China, global consumption of TiO_2 is expected to increase at a compound annual growth rate of about 5% between 2020 and 2025 (LB Group Co., Ltd., 2022, p. 15; International Monetary Fund, 2023).

Future demand for titanium metal is dependent primarily on demand for aircraft and engines supplemented by other uses such as chemical processing, desalination, power generation, and specialty steels. The closure of sponge production capacity

in Henderson, NV, is expected to result in increased U.S. imports of titanium sponge and scrap. Production of titanium ingot and mill products is expected to be dependent on increased air travel and the associated demand from the aerospace industry.

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Titanium Newsletter. International Titanium Association, quarterly.

TABLE 1
SALIENT TITANIUM STATISTICS[1]

		2017	2018	2019	2020	2021
United States:						
Mineral concentrates:						
Production[2]	metric tons	100,000	100,000	100,000	100,000	200,000
Imports for consumption[3]	do.	1,560,000	1,470,000	1,540,000	1,070,000	1,290,000
Consumption[e]	do.	1,800,000 [r]	1,600,000 [r]	1,600,000 [r]	1,200,000 [r]	1,400,000
Sponge metal:						
Imports for consumption	do.	23,300	23,700	30,000	19,200	16,000
Consumption	do.	37,400	35,200	W	W	W
Price, annual average[4]	dollars per kilogram	10.70	10.80	10.60	11.50	11.60
Titanium dioxide pigment:						
Production	metric tons	1,260,000	1,150,000	1,000,000	1,000,000	1,150,000
Imports for consumption	do.	240,000	268,000	226,000	262,000	251,000
Consumption, apparent[5]	do.	870,000	893,000	825,000	880,000	906,000
Producer price index, yearend[6]	(June 1982=100)	205	205	NA	NA	NA
World, production:[7]						
Ilmenite and leucoxene[8]	metric tons	10,000,000 [r]	10,500,000 [r]	10,700,000 [r]	13,000,000 [r]	13,400,000
Rutile, natural[9]	do.	817,000 [r]	680,000 [r]	668,000 [r]	632,000	651,000
Titanium slag	do.	1,800,000	1,650,000	1,700,000	1,520,000	1,500,000

[e]Estimated. [r]Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through June 1, 2023. Data are rounded to no more than three significant digits.
[2]U.S. production rounded to one significant digit to avoid disclosing company proprietary data.
[3]Excludes titaniferous iron ore imported from Canada that is classified as ilmenite under the Harmonized Tariff Schedule of the United States.
[4]Landed duty-paid unit based on U.S. imports for consumption.
[5]Production plus imports minus exports. Does not include stock changes.
[6]Source: U.S. Department of Labor, Bureau of Labor Statistics.
[7]May include estimated data.
[8]Includes U.S. production of ilmenite and rutile rounded to one significant digit to avoid disclosing company proprietary data.
[9]U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2
ESTIMATED U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2021[1, 2]

(Metric tons per year)

		Yearend capacity	
Company	Plant location	Sponge	Ingot[3]
Allegheny Technologies Inc.	Albany, OR	--	10,900
Do.	Monroe, NC	--	23,200
Do.	Richland, WA	--	10,000
Honeywell Electronic Materials Inc.	Salt Lake City, UT	500	--
Howmet Aerospace Inc.	Canton, OH	--	9,600
Do.	Niles, OH	--	13,600
Do.	Whitehall, MI	--	3,200
Perryman Co.	Houston, PA	--	11,800
Titanium Metals Corp.[4]	Salisbury, NC	--	1,800
Do.	Henderson, NV	-- [5]	12,300
Do.	Morgantown, PA	--	40,700
Total		500	137,000

Do. Ditto. -- Zero.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Estimated operating capacity based on 7-day-per-week full production.
[3]Includes electron-beam, plasma-arc and vacuum-arc-remelting capacity.
[4]A subsidiary of Precision Castparts Corp. (Berkshire Hathaway Inc.).
[5]A 12,600-metric-ton-per-year sponge plant was idled in 2020.

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

(Metric tons)

Component	2020	2021
Production:		
Ingot	W	W
Mill products	W	W
Exports:		
Waste and scrap	14,100	10,400
Sponge	711	117
Ingot	3,700	2,580
Other unwrought	1,570	2,030
Wrought products and castings	14,800	9,170
Total	34,800	24,300
Imports:		
Waste and scrap	15,800	10,600
Sponge	19,200	16,000
Ingot	1,210	875
Powder	195	214
Other unwrought	642	1,270
Wrought products and castings	6,670	7,930
Total	43,700 r	36,900
Stocks, industry, yearend:		
Sponge	W	W
Scrap	W	W
Ingot	W	W
Consumption, reported:		
Sponge	W	W
Scrap	W	W
Ingot	W	W
Shipments:		
Ingot	W	W
Mill products (net shipments):		
Forging and extrusion billet	W	W
Other	W	W
Total	W	W
Castings (shipments)	W	W
Receipts, scrap:		
Home	W	W
Purchased	W	W
Total	W	W

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
U.S. PRODUCERS OF TITANIUM DIOXIDE (TiO_2) PIGMENT IN 2021[1, 2]

(Metric tons per year)

Company	Plant location	Yearend capacity
The Chemours Co.	DeLisle, MS	340,000
Do.	New Johnsonville, TN	350,000
INEOS Pigments USA Inc.	Ashtabula, OH	245,000
Louisiana Pigment Co. L.P.[3]	Lake Charles, LA	168,000
Tronox Holdings plc	Hamilton, MS	225,000
Total		1,330,000

Do. Ditto.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to total shown.
[2]Estimated operating capacity based on 7-day-per-week full production. Table does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of 26,400 metric tons per year of buff pigment that is produced by fine grinding of synthetic rutile. All plants used the chloride process to manufacture TiO_2 pigment.
[3]A joint venture of Kronos Worldwide, Inc. and Venator Materials PLC.

TABLE 5
COMPONENTS OF U.S. TITANIUM DIOXIDE (TiO_2) PIGMENT SUPPLY AND DEMAND[1]

		2020		2021	
		Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
Production[2]	metric tons	1,000,000	943,000	1,150,000 [e]	1,080,000
Shipments:					
Quantity	do.	1,000,000 [e]	943,000	1,150,000 [e]	1,080,000
Value	thousands	$2,840,000 [e]	XX	$3,500,000 [e]	XX
Exports	metric tons	386,000	363,000	494,000	465,000
Imports for consumption	do.	262,000	247,000	251,000	236,000
Consumption, apparent[3]	do.	880,000	827,000	906,000	851,000

[e]Estimated. do. Ditto. XX Not applicable.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits.
[2]Does not include production of buff pigment.
[3]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. APPARENT CONSUMPTION OF TITANIUM CONCENTRATE[1, 2]

(Metric tons)

	2020		2021	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Pigment	1,200,000 [r]	NA	1,400,000	NA
Miscellaneous[3]	48,000 [r]	NA	56,000	NA
Total	1,200,000 [r]	900,000	1,400,000	1,100,000

[r]Revised. NA Not available.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than two significant digits; may not add to totals shown.
[2]Includes a mixed product containing altered ilmenite, leucoxene, and rutile. Excludes inventory changes.
[3]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[1, 2]

(Metric tons)

	2020	2021
Steel:		
Carbon steel	4,170	4,770
Stainless and heat-resisting steel	2,020 r	1,580
Other alloy steel[3]	590	553
Total steel	6,780 r	6,910
Cast irons	2	2
Superalloys	547	554
Alloys, other than above	1,370 r	1,360
Miscellaneous and unspecified	13	13
Grand total	8,710 r	8,830

rRevised.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes ferrotitanium, scrap, sponge, and other titanium additives.
[3]Includes high-strength low-alloy and tool steel.

TABLE 8
ESTIMATED U.S. DISTRIBUTION OF TITANIUM DIOXIDE PIGMENT SHIPMENTS, TITANIUM CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2020	2021
Paint, varnish, and lacquer	66	65
Plastics and rubber	26	26
Other[2]	8	9
Total	100	100

[1]Table includes data available through May 18, 2023. Does not include exports.
[2]Includes agricultural, building materials, ceramics, coated fabrics and textiles, cosmetics, food, paper, and printing ink. Also includes shipments to distributors.

TABLE 9
AVERAGE PRICES OF TITANIUM PRODUCTS

		2020	2021
Concentrates:			
Ilmenite, cost including freight, China[1]	dollars per metric ton	225	289
Rutile, bagged, f.o.b.[2] Australian ports[1]	do.	1,320	1,420
Rutile, bulk, f.o.b. Australian ports[1]	do.	1,170	1,300
Titanium slag, import:[3]			
Canada	do.	1,010	981
Norway	do.	797	772
South Africa	do.	670	596
Metal:			
Sponge import[3]	dollars per kilogram	11.50	11.60
Scrap, turnings, unprocessed[4]	dollars per pound	0.89	1.69
Ferrotitanium, 70% titanium[4]	do.	2.45	4.12
Mill products[5]	producer price index	172	169
Titanium dioxide pigment, import[6]	dollars per metric ton	2,710	2,920

do. Ditto.
[1]Source: Fastmarkets IM.
[2]Free on board.
[3]Landed duty-paid unit value based on U.S. imports for consumption from producing countries.
[4]Source: S&P Global Platts Metals Week.
[5]June 1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.
[6]Unit value based on landed-duty-paid U.S. imports for consumption.

TABLE 10
U.S. EXPORTS OF TITANIUM BY CLASS[1]

Class	Schedule B number	2020 Quantity (metric tons)	2020 Value (thousands)	2021 Quantity (metric tons)	2021 Value (thousands)
Metal:					
Scrap	8108.30.0000	14,100	$34,100	10,400	$42,700
Unwrought:					
Sponge	8108.20.0010	711	4,330	117	1,810
Ingot	8108.20.0030	3,700	59,400	2,580	37,100
Other unwrought	8108.20.0090	1,570	47,300	2,030	23,900
Total		5,980	111,000	4,730	62,800
Wrought:					
Bloom, sheet bar, slab	8108.90.6020	1,540	42,900	1,700	47,400
Bar, rod, profile, wire	8108.90.6031	5,180	261,000	6,190	663,000
Other	8108.90.8000	8,040	853,000	1,280	7,120
Total		14,800	1,160,000	9,170	717,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	1,890	6,160	1,280	7,120
Ores and concentrates	2614.00.0000	28,800	36,600	54,100	21,400
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	368,000	1,000,000	466,000	1,380,000
Other titanium dioxide pigment	3206.19.0000	13,400	82,100	13,000	87,300
Unfinished titanium dioxide[2]	2823.00.0000	4,820	11,600	15,600	42,800
Total		386,000	1,090,000	494,000	1,510,000

[1]Table includes data available May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATES, BY COUNTRY OR LOCALITY[1]

Concentrate and country or locality	HTS[2] code	2020 Quantity (metric tons)	2020 Value (thousands)	2021 Quantity (metric tons)	2021 Value (thousands)
Ilmenite:	2614.00.6020				
Australia		112,000	$17,500	40	$18
Madagascar		218,000	52,500	291,000	65,900
Mozambique		69,200	15,000	232,000	57,700
Senegal		42,200	10,600	88,800	23,500
Ukraine		40,000	8,580	20,200	5,710
Other		190	133	1	19
Total		481,000	104,000	632,000	153,000
Rutile, natural:	2614.00.6040				
Australia		21,600	23,600	127,000	101,000
Canada		2,340	3,480	48,900	51,500
Kenya		13,200	15,600	20,200	23,000
South Africa		120,000	112,000	123,000	92,700
Ukraine		881	1,240	1,660	2,590
Other		40 r	61 r	213	491
Total		158,000	156,000	320,000	272,000
Rutile, synthetic:	2614.00.3000				
Australia		41	36	100	185
China		7	14	--	--
Netherlands		--	--	307	668
Sierra Leone		80	106	260	403
South Africa		--	--	95	181
Ukraine		--	--	227	473
Total		128	156	990	1,910
Titanium slag:	2620.99.5000				
Canada		83,700	83,700	131,000	126,000
Kenya		5,000	5,950	--	--
Norway		45,000	35,800	57,500	44,400
South Africa		301,000	193,000	151,000	85,300
Total		435,000	318,000	339,000	256,000
Titaniferous iron ore, Canada[3]	2614.00.6020	35,500	6,800	13,500	2,180

rRevised. -- Zero.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States.
[3]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[1]

Class and country or locality	HTS[2] code	2020 Quantity (metric tons)	2020 Value (thousands)	2021 Quantity (metric tons)	2021 Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		1,140	$2,290	1,460	$5,710
China		524	6,050	47	669
France		1,680	6,900	1,160	5,430
Germany		3,030	17,500	2,210	13,200
Italy		781	3,050	449	1,750
Japan		2,900	11,800	857	3,990
Korea, Republic of		698	3,380	755	2,830
Mexico		799	1,890	766	2,200
Singapore		361	956	238	381
Spain		303	1,290	226	1,080
United Kingdom		2,130	9,200	1,500	6,760
Other		1,450 r	7,070 r	971	5,140
Total		15,800	71,300	10,600	49,200
Unwrought:					
Sponge:	8108.20.0010				
China		1	36 r	14	91
Japan		16,900	152,000	13,900	130,000
Kazakhstan		1,870 r, e	17,300	1,770 e	15,400
Russia		53	477	94	763
Saudi Arabia		--	--	18	167
Ukraine		268	2,470	--	--
Other		61	511	156	1,380
Total		19,200	173,000	16,000	148,000
Ingot:	8108.20.0030				
Kazakhstan		238	4,330	260	4,510
Russia		970	15,400	614	6,230
Other		6	101	1	18
Total		1,210	19,900	875	10,800
Powder:	8108.20.0015				
Canada		75	10,400	100	15,900
China		99	1,670	82	1,420
Germany		16	4,630	16	3,750
Japan		3	543	9	1,410
Other		3	358	7	1,030
Total		195	17,600	214	23,500
Other:	8108.20.0095				
Germany		28	236	6	120
Japan		28	2,190	51	3,980
Russia		559	12,700	1,180	14,700
United Kingdom		11	1,590	10	1,270
Other		16	1,480	19	2,470
Total		642	18,200	1,270	22,600
Wrought products and castings:[3]	8108.90.3030, 8108.90.3060, 8108.90.6020, 8108.90.6031, 8108.90.6045, 8108.90.6060, 8108.90.6075				
Canada		218	21,700	192	15,800
China		1,110	55,200	1,210	43,700
France		268	31,900	339	19,300
Japan		309	12,000	274	9,170
Korea, Republic of		561	10,300	438	7,730
Russia		3,390	127,000	4,200	108,000
Ukraine		60	1,770	560	4,790
United Kingdom		181	24,900	107	16,500
Other		574	73,400	604	60,400
Total		6,670	358,000	7,930	286,000

See footnotes at end of table.

TABLE 12—Continued
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY OR LOCALITY[1]

Class and country or locality	HTS[2] code	2020 Quantity (metric tons)	2020 Value (thousands)	2021 Quantity (metric tons)	2021 Value (thousands)
Ferrotitanium and ferrosilicon titanium:	7202.91.0000				
Canada		754	2,200	753	4,370
Russia		893	2,750	1,510	7,190
Ukraine		324	861	323	1,170
United Kingdom		665	2,200	1,390	6,650
Other		218 r	531 r	176	722
Total		2,850	8,540	4,150	20,100

[e]Estimated. [r]Revised.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States.
[3]Includes bar, billet, bloom, castings, foil, pipe, plate, profile, rod, sheet, sheet bar, slab, strip, tube, wire, and other.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM DIOXIDE PIGMENT, BY COUNTRY OR LOCALITY[1]

Pigment class and country or locality	HTS[2] code	2020 Quantity (metric tons)	2020 Value (thousands)	2021 Quantity (metric tons)	2021 Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Australia		11,700	$28,400	12,600	$35,200
Belgium		12,000	31,500	9,020	23,400
Canada		89,100	229,000	102,000	281,000
China		27,800	49,800	15,400	31,100
Czechia		5,980	15,700	5,840	16,100
Germany		20,200	59,300	22,000	65,100
Italy		2,940	8,990	6,790	19,500
Mexico		11,900	28,000	4,220	11,500
Norway		6,210	15,300	4,270	10,900
Spain		14,300	37,600	8,820	22,900
Other		20,200 r	56,600 r	19,400	59,400
Total		222,000	560,000	210,000	576,000
Other titanium dioxide pigment:	3206.19.0000				
Canada		13,300	34,700	13,300	40,100
China		1,420	5,290	1,570	7,010
Italy		677	2,460	1,060	4,530
Mexico		613	3,780	527	4,260
Other		1,640 r	13,000 r	1,210	10,900
Total		17,700	59,300	17,600	66,800
Unfinished titanium dioxide:[3]	2823.00.0000				
Canada		2,470	7,380	4,180	12,400
China		8,850	17,400	7,200	19,900
France		2,830	7,820	2,060	6,420
Germany		2,100	9,450	3,360	13,500
India		1,820	4,370	2,600	7,260
Korea, Republic of		2,050	5,120	2,200	6,810
Other		2,350 r	10,800 r	1,880	9,150
Total		22,500	62,300	23,500	75,400
Grand total		262,000	681,000	251,000	718,000

[r]Revised.
[1]Table includes data available through May 18, 2023. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States.
[3]Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 14
TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES AND TITANIUM SLAG, BY COUNTRY OR LOCALITY[1]

(Metric tons, gross weight)

Country or locality	2017	2018	2019	2020	2021
Ilmenite and leucoxene:[2, 3]					
Australia	1,500,000	1,400,000	1,000,000	1,100,000 r	1,000,000 e
Brazil[4]	67,000	110,000	41,000	56,000 r	55,000
China	3,830,000	4,200,000	4,600,000	6,330,000 r, 5	6,100,000 e
India[e]	360,000 r	290,000 r	340,000 r	310,000 r	340,000
Indonesia[e]	20,000	2,000	4,000	3,000 r	110,000
Kazakhstan	9,400	10,000 e	15,000 e	12,000 e	12,000 e
Kenya	470,317	453,133	341,182	334,241	330,000
Madagascar	469,326	381,924	461,800	424,000	600,000 e
Malaysia	6,363	14,158	2,334	2,548	2,500 e
Mozambique	1,197,419	1,283,075	1,442,711	1,608,011	2,000,000 e
Norway[e]	760,000 r	600,000 r	720,000 r	820,000 r	780,000
Russia	2,900	3,000	3,100	3,000 r	3,000 e
Senegal	492,441	506,938	491,602	762,000 r	804,000
Sierra Leone	58,000	54,500	59,200	45,800	52,100
Sri Lanka	51,940	60,847	43,789	18,016	49,068
Ukraine	392,000	745,417	818,543	773,093 r	702,741
United States[4, 6]	100,000	100,000	100,000	100,000	200,000
Vietnam[7]	225,300	235,100	216,700	268,800 r	244,400
Total	10,000,000 r	10,500,000 r	10,700,000 r	13,000,000 r	13,400,000
Rutile:[8]					
Australia	300,000	200,000	200,000	200,000	200,000 e
Brazil[4]	1,000 e	2,000 e	600 e	226	710 e
India[e]	13,000 r	12,000 r	13,000 r	12,000	13,000
Kenya	91,456	95,715	78,961	76,402	75,700
Malaysia	5,266	5,070	5,947	5,136	6,000 e
Mozambique	9,137	8,830	8,264	5,958	8,915
Senegal	9,975	9,605	10,130	9,100 e	9,100 e
Sierra Leone	168,000	121,500	137,200	120,200	129,300
South Africa	110,000 e	110,000 e	105,000	95,000 e	100,000 e
Sri Lanka	2,174	2,319	1,959	1,311	1,881
Turkey	6,706	6,498	6,450	6,795	6,800 e
Ukraine	100,000 e	106,858	100,000 e	100,000 e	100,000 e
Total	817,000 r	680,000 r	668,000 r	632,000	651,000
Titanium slag:[9]					
Canada[e, 10]	800,000	700,000	800,000	700,000	700,000
South Africa	1,000,000 e	950,000 e	903,000	820,000 e	800,000 e
Total	1,800,000	1,650,000	1,700,000	1,520,000	1,500,000

[e]Estimated. [r]Revised.

[1]Table includes data available through June 1, 2023. All data are reported unless otherwise noted; totals may include estimated data. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]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.

[3]Small amounts of titanium minerals reportedly were produced in other countries, but information was inadequate to make reliable estimates of output levels.

[4]Does not include production of unbeneficiated anatase ore.

[5]Source: Panzhihua Vanadium and Titanium Industry Association.

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

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

[8]Excludes U.S. production of rutile which is included with ilmenite and leucoxene.

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

[10]Produced from domestic and imported concentrates.