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TITANIUM [ADVANCE RELEASE]

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Titanium

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In 2022, U.S. production of titanium mineral concentrates increased to 300,000 metric tons (t) from 200,000 t (revised) 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 Ione, CA. The United States was an estimated 81% 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 in 2022 (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, Canada, Australia, Madagascar, Kenya, Mozambique, and Norway (table 11). Reported U.S. consumption of titanium used in steel and other alloys decreased by 5% from that in 2021 (table 7). Based on gross weight, world production of ilmenite and rutile mineral concentrates in 2022 was about 15.8 million metric tons (Mt), primarily in the form of ilmenite concentrate. World production of titanium slag produced from ilmenite and titaniferous magnetite was about 1.7 Mt (table 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 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 ($TiCl_4$) with magnesium to produce titanium metal.

Government Actions and Legislation

In May 2018, the U.S. Department of the Interior, in coordination with other executive branch agencies, published a list of 35 mineral commodities, which were designated as critical minerals. The list, which included titanium, was developed to serve as an initial focus, pursuant to Executive Order 13817, "A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals" (U.S. Department of the Interior, 2018).

In February 2022, an updated U.S. critical minerals list was published in the Federal Register (U.S. Department of the Interior, 2022). The 2022 critical minerals list contained 50 individual mineral commodities instead of 35 minerals and mineral groups. Titanium metal continued to be included in the critical minerals list. The criteria for developing the list were described in a 2020 report detailing three factors to determine the supply risk for nonfuel minerals, which were the likelihood of a foreign supply disruption, the dependency of U.S. manufacturers on foreign supplies, and the ability of U.S. manufacturers to withstand a supply disruption (Nassar and others, 2020; Nassar and Fortier, 2021, p. 16). The list was to be updated every 3 years and revised as necessary consistent with available data.

The Defense Logistics Agency Strategic Materials listed titanium-base alloys for potential disposal from the National Defense Stockpile (NDS) on the Annual Materials Plan (AMP) for fiscal years 2022 (October 1, 2021, through September 30, 2022) and 2023 (October 1, 2022, through September 30, 2023). The AMP ceiling disposal quantity for titanium-base alloys was 272 t (600,000 pounds) for both fiscal years, which represented the maximum quantity of titanium that could be sold from the NDS during those years. The Defense Logistics Agency Strategic Materials also listed titanium for potential acquisition for fiscal years 2022 and 2023, with a ceiling acquisition quantity of 1,500 t for both fiscal years (Defense Logistics Agency Strategic Materials, 2021a, b, 2022a, b).

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 2022, the USGS annual survey canvassed titanium mineral and pigment producers.

Mineral Concentrates.—Titanium minerals of economic importance include ilmenite, rutile, and an alteration product of ilmenite and other minerals called leucoxene. Dredging and dry surface mining techniques usually are used for the recovery of heavy minerals, including titanium minerals. Spiral separation by gravity is used to isolate the heavy-mineral suite, and magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is the most abundant titanium mineral; the TiO_2 content ranges 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 are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite.

In 2022, The Chemours Co. (Wilmington, DE) produced heavy-mineral concentrates including ilmenite, rutile, zircon, and other accessory minerals at mining operations in Florida and Georgia. Chemours titanium mineral feedstocks were used to supply Chemours' TiO_2 pigment plants. Twin Pines Minerals LLC (Birmingham, AL) mobile operations processed existing mine tailings in 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, natural rutile, synthetic rutile, chloride-grade ilmenite, 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 2022, essentially unchanged compared with that in 2021 (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 of Kronos Worldwide, Inc. and Venator Materials Plc), and Tronox Ltd. (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 pigment.

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 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.

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. Honeywell Electronic Materials Inc. (Salt Lake City, UT) was the only producer of titanium sponge in 2022 (table 2). Honeywell Electronic Materials used the Hunter process to produce titanium sponge as feed for the company's production of electronic-grade titanium at its Salt Lake City, UT, plant. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data.

Titanium Metals Corp., a subsidiary of Precision Castparts Corp., indefinitely suspended sponge production at its Henderson, NV, plant in 2020 owing to the economic effects of the global coronavirus disease 2019 (COVID-19) pandemic combined with other factors (Bradford, 2020). The Henderson plant was the last large-scale domestic sponge plant suppling the domestic titanium metal industry. Prior to this closure, Allegheny Technologies Inc. (ATI) idled its sponge facility in 2016 (Allegheny Technologies Inc., 2016).

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 normally are produced contain 40% and 70% titanium. U.S. producers of ferrotitanium were Howmet Aerospace Inc. (Canton, OH) and AmeriTi Manufacturing LLC (Detroit, MI), a subsidiary of Kymera International (Raleigh, NC). Data on production and production capacity of ferrotitanium were not available.

Consumption

Mineral Concentrates.—Based on an estimate of the TiO_2 content of domestic production, imports, and exports, domestic apparent consumption of titanium mineral concentrates was 1.0 Mt in 2022 compared with an estimated 1.1 Mt in 2021 (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 was estimated to have been essentially unchanged, and apparent domestic consumption (not accounting for changes in inventory) increased by 13% from that in 2021 (tables 1, 5). 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 63% 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 8,460 t, 5% less than the revised amount in 2021 (table 7).

Stocks

Insufficient data were available to determine yearend consumer inventories of mineral concentrates and pigment. Titanium metal industry stock data were withheld to avoid disclosing company proprietary data.

Prices

Average annual titanium mineral concentrate prices are listed in table 9. In 2022, the average annual prices increased for ilmenite and rutile compared with those in 2021. Based on U.S. Census Bureau data, the average unit values of titanium slag imports from slag-producing countries increased in 2022 compared with those in 2021 to $1,040 per metric ton for Canada, $981 per metric ton for Norway, and $751 per metric ton for South Africa. The average unit value of titanium slag imports from Ukraine was $2,030 per metric ton in 2022.

The U.S. Department of Labor, Bureau of Labor Statistics Producer Price Index (PPI) (June 1982 = 100) for titanium mill products increased during 2022 from 177 in January to 202 in December (U.S. Bureau of Labor Statistics, 2023).

Based on U.S. Census Bureau data, the average import unit value of TiO_2 pigment was $3,450 per metric ton, an 18% increase from $2,920 per metric ton in 2021.

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 2022, the estimated TiO_2 content of imports was 960,000 t, primarily in the form of natural rutile (37%), ilmenite (33%), and titanium slag (30%). The combined value for all forms of titanium mineral concentrate imports in 2022 increased to $800 million from $682 million in 2021. South Africa, Canada, Australia, Madagascar, Kenya, Mozambique, and Norway were, in descending order by import value, the leading import sources, accounting for almost 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 46 t in gross weight and were valued at $20,000. Exports of titanium mineral concentrates increased in 2022 to 262,000 t from 54,100 t in 2021 (tables 10, 11).

TiO_2 Pigment.—In 2022, the United States continued to be a net exporter of TiO_2 pigment; exports exceeded imports by a ratio of about 1.4 to 1. Exports of TiO_2 pigment were 378,000 t valued at $1.35 billion, a 23% decrease in quantity from that in 2021. About 94% of TiO_2 pigment exports was in the form of finished pigment containing 80% or more TiO_2 content. During 2022, 265,000 t of TiO_2 pigment valued at $884 million was imported, an increase of 5% in quantity compared with imports in 2021. The leading import sources of TiO_2 pigment were Canada, accounting for 43% of total imports, followed by China (10%) and Germany (7%). 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 59,800 t and were primarily in the form of sponge (52%) and waste and scrap (32%) (table 12). Japan supplied 82% of imported titanium sponge; Russia and Kazakhstan supplied most of the imported titanium ingot; and the United Kingdom (15%), Germany (13%), Japan (12%), and France (11%) were the leading sources of imported scrap. Russia (51%) and China (16%) were the leading sources of wrought products and castings. Exports of titanium metal were 30,700 t, excluding ferrotitanium and ferrosilicon titanium, and were primarily in the form of wrought products and castings (55%), waste and scrap (28%), and unwrought products (17%) (table 10).

Imports of ferrotitanium and ferrosilicon titanium were 3,630 t, 12% less than those in 2021 (table 12). Exports of ferrotitanium and ferrosilicon titanium were 1,670 t, a 31% increase from those in 2021 (table 10).

World Review

Based on gross weight, world production of ilmenite and leucoxene and rutile mineral concentrates in 2022 was 15.1 Mt and 651,000 t, respectively. World production of titanium slag produced from ilmenite and titaniferous magnetite was 1.7 Mt. The leading producers of ilmenite and leucoxene mineral concentrates were China, Mozambique, and South Africa. Australia and Sierra Leone were the leading producers of rutile mineral concentrates. About 1.7 Mt of titanium slag was produced in Canada and South Africa. Production of titanium slag in China, India, Kazakhstan, Norway, Russia, and Vietnam were not quantified owing to insufficient data and (or) to avoid duplicative reporting (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 2022, Iluka Resources' Australian operations produced 556,000 t of ilmenite and 55,100 t of natural rutile, compared with 512,000 t of ilmenite and 67,300 t of natural rutile produced in 2021. Using a portion of its own ilmenite as feedstock, the company produced 238,000 t of synthetic rutile compared with 199,000 t in 2021. At yearend, ore reserves for Iluka Resources' Australian operations were reported to contain 162 Mt of ore containing 9.0 Mt of heavy minerals grading 53% ilmenite and 3% rutile (Iluka Resources Ltd., 2023, p. 31–32, 168).

During the fourth quarter, Sheffield Resources Ltd. and YGH Australia Investment, a subsidiary of Tangshan Yanshan Iron & Steel Co., Ltd. (China), began construction on the Thunderbird heavy-mineral-sands project in Western Australia. Project construction was reported to be more than 60% complete before yearend, and shipments were expected to begin in 2024. At yearend, Thunderbird reserves were about 750 Mt containing 11% heavy minerals grading 28% ilmenite and 4.9% leucoxene (Sheffield Resources Ltd., 2022; 2023, p. 6, 8).

Strandline Resources Ltd. began commercial production at the Coburn mineral sands project in Western Australia in November. 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. Coburn's production would be supplied to customers in Europe, China, and the United States (Strandline Resources Ltd., 2020, p. 5; 2023, p. 3).

Canada.—In Quebec Province, Rio Tinto Iron and Titanium (RTIT), a subsidiary of Rio Tinto plc, produced titanium slag at its Sorel-Tracy operations. RTIT supplemented its mineral concentrates feed from its Lac Tio mining operations in Quebec with concentrates from its operations in Madagascar. In 2022, combined titanium slag production from Rio Tinto's share of

operations in Canada and South Africa increased by 18% from that in 2021 to 1.2 Mt. Rio Tinto attributed the production increase partly to improved operational performance at RTIT during the year. 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, 2023, p. 43, 331).

China.—China was the leading producer and consumer of titanium mineral concentrates, producing an estimated 6.3 Mt of ilmenite in 2022 (table 14). Under Harmonized System (HS) code 261400, China imported 3.47 Mt of titanium mineral concentrates in 2022, a 9% decrease from those in 2021. The leading sources, in descending order of quantity, were Mozambique, 49%; Kenya, 9%; Vietnam, 8%; the United States and Norway, 7% each; and Australia, 5%. Exports of titanium mineral concentrates (HS code 261400) were 22,200 t in 2022, a 36% decrease from 2021, and were mostly sent to India (30%) and Russia (21%) (Zen Innovations AG, 2024).

According to Shanghai Metals Market, China's TiO_2 pigment production in 2022 was 3.81 Mt, slightly more than that in 2021. Imports of titanium-based pigments (HS codes 282300, 320611, and 320619) were 147,000 t in 2022, 33% less than those in 2021. Exports of titanium-based pigments (HS codes 282300, 320611, and 320619) totaled 1.48 Mt in 2022, an increase of 6% from exports in 2021. Leading destinations included India (13%), Brazil (7%), Vietnam (6%), and Indonesia, Russia, and Turkey (5% each) (Shanghai Metals Market, 2023; Zen Innovations AG, 2024).

China also was the leading producer and consumer of titanium metal. In 2022, production capacity of titanium sponge was 210,000 t/yr, an increase from 181,000 t/yr in 2021. Imports of titanium metal and articles thereof (HS 8108) were 20,700 t, and exports were 30,100 t (Argus Media group, Argus Non-Ferrous Markets, 2023; Zen Innovations AG, 2024).

LB Group Co., Ltd. was China's leading TiO_2 pigment producer with 1.22 Mt/yr of TiO_2 pigment production capacity. LB Group increased its TiO_2 pigment production capacity by 200,000 t/yr in 2022 by commissioning two 100,000-t/yr production lines (chloride process)—one at its plant in Chuxiong, Yunnan Province, and the other at its plant in Jiaozuo, Henan Province. The company's TiO_2 pigment production was 990,000 t in 2022, a 10% increase from that in 2021. About 69% of its TiO_2 pigment output was produced using the sulfate process. The company also produced 38,100 t of titanium sponge, more than double that in 2021. Sponge production capacity was 50,000 t/yr, with 35,000 t/yr at Chuxiong and 15,000 t/yr at its plant in Jinchang, Gansu Province. LB Group planned to further increase its TiO_2 pigment and sponge production capacities by 300,000 t/yr and 15,000 t/yr, respectively (Reid, 2022; LB Group Co., Ltd., 2023, p. 33–34).

Finland.—During 2022, Venator Materials Plc (United Kingdom) closed 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, 2023, p. 39, 129).

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 19% to 50,300 t from 42,200 t in 2021. The leading categories of metal exports were unwrought (69%), other articles of titanium (19%), and waste and scrap (12%). Exports of titanium powder increased to 97 t from 53 t in 2021 (JX Nippon Mining & Metals Corporation, 2021, p. 26; Osaka Titanium Technologies Co., Ltd., 2022; Zen Innovations AG, 2024).

Leading producers of TiO_2 pigment in Japan were Ishihara Sangyo Kaisha, Ltd., Sakai Chemical Industry Co., Ltd., and Tayca Corp. According to the Ministry of Economy, Trade and Industry, Japan's production of TiO_2 pigment totaled 177,000 t in 2022, a 5% decrease from production in 2021 (Ministry of Economy, Trade and Industry, 2023).

Norway.—Nordic Mining ASA began construction on the 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. Production was projected to begin in the second half of 2024 (Hatch Ltd., 2021, p. 5–6, 19; Nordic Mining ASA, 2023, p. 7).

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 2022, Russia exported 14,700 t of titanium metal under HS code 8108, essentially unchanged compared with 14,600 t in 2021. Germany, the United States, France, the United Kingdom, and China, in descending order of quantity, were the leading destinations and accounted for 70% of exports. About 18% 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 35% interest in the project. In 2022, exports of titanium metal under HS code 8108 were 9,670 t, 70% more than 5,680 t in 2021 (Argus Media group—Argus Metals International, 2019; Zen Innovations AG, 2024).

Sierra Leone.—Sierra Rutile Holdings Ltd. produced 59,000 t of ilmenite and 136,000 t of rutile in 2022 and, at yearend, ore reserves in the active mining area were 41 Mt containing 550,000 t of rutile and 300,000 t of ilmenite. During the year, the company began a definitive feasibility study of the nearby Sembehun deposit, which contained 2.5 Mt of rutile and 1.6 Mt of ilmenite in reserves. Sierra Rutile expected the study to be complete by the end of 2023, followed by a final investment decision. Iluka Resources demerged from Sierra Rutile in August (Sierra Rutile Holdings Ltd., 2023a, p. 6, 14, 16, 31; 2023b).

South Africa.—In 2022, South Africa was a leading global producer and exporter of titanium mineral concentrates. The leading producers, in descending order of production capacity, included Rio Tinto and Tronox. Exports of titanium concentrates under HS code 2614 were 707,000 t, 5% more than those in 2021 (Zen Innovations AG, 2024). Although a leading producer of titanium slag from ilmenite mineral concentrate, 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 2022, 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 2021, Rio Tinto suspended operations at RBM and declared force majeure on customer contracts after a security incident at the mine. Operations restarted in August 2021, and the force majeure was lifted in March 2022. Construction at the Zulti South project at RBM remained suspended (Rio Tinto plc, 2023, p. 32, 136, 331).

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 and Namakwa Sands was 55,000 t/yr of rutile and 410,000 t/yr of slag. Ilmenite capacity used to produce titanium slag was not available. Tronox reported that its South Africa operations produced 47,600 t of rutile and 857,000 t of ilmenite in 2022 (Tronox Holdings plc, 2021, p. 33; 2024, p. 31).

Tanzania.—Strandline continued to advance its Fungoni and Tajiri mineral sands projects under a joint venture company, Nyati Mineral Sands Ltd., of which Strandline held 84% interest and the Government of Tanzania held 16% interest. During 2022, Strandline worked towards obtaining Government approvals and completing project analyses in preparation for an investment decision (Strandline Resources Ltd., 2023, p. 4–5).

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 2022, Ukraine was estimated to have produced 410,000 t of ilmenite and 100,000 t of rutile (table 14). Reported exports of titanium mineral concentrates were 322,000 t in 2022, 42% less than exports in 2021, owing to the ongoing military conflict with Russia. Ukraine's sole producer of titanium sponge was the Zaporozhye Titanium and Magnesium Combine Ltd. with a capacity of 12,000 t/yr. Exports of titanium metal under HS code 8108 decreased by 81% to 1,130 t in 2022 from 6,100 t in 2021 (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 global economic trends. According to the International Monetary Fund, global economic annual growth is expected to increase steadily between 2023 and 2025 at a rate of 3.2%, which is less than the average increase of 3.8% between 2000 and 2019. According to the leading producer of TiO_2 pigment in China, global consumption of TiO_2 pigment is expected to increase at a compound annual growth rate of 3.5% between 2021 and 2026 (International Monetary Fund, 2024, p. 9; LB Group Co., Ltd., 2023, p. 14).

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 domestic sponge capacity in 2020 is expected to increase reliance on imports and stimulate recycling efforts. 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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TABLE 1
SALIENT TITANIUM STATISTICS[1]

		2018	2019	2020	2021	2022
United States:						
Mineral concentrates:						
Production	metric tons	100,000	100,000	100,000	200,000	300,000
Exports	do.	51,400	12,200	28,800	54,100	262,000
Imports for consumption[2]	do.	1,470,000	1,540,000	1,070,000	1,290,000	1,240,000
Consumption[e]	do.	1,600,000	1,600,000	1,200,000	1,400,000	1,300,000
Sponge metal:						
Exports	do.	533	869	711	117	105
Imports for consumption	do.	23,700	30,000	19,200	16,000	30,900
Consumption	do.	35,200	W	W	W	W
Price, annual average[3]	dollars per pound	10.70 [r]	10.70 [r]	10.60 [r]	11.10 [r]	11.10
Titanium dioxide pigment:						
Production	metric tons	1,150,000	1,000,000	1,000,000	1,150,000	1,150,000
Exports	do.	528,000	401,000	386,000	494,000	378,000
Imports for consumption	do.	268,000	226,000	262,000	251,000	265,000
Consumption, apparent[4]	do.	893,000	825,000	880,000	912,000 [r]	1,030,000
Producer price index, yearend[5]	(June 1982=100)	205	NA	NA	NA	NA
World, production:[6]						
Ilmenite concentrate[7]	metric tons	12,400,000 [r]	12,500,000 [r]	13,900,000 [r]	14,200,000 [r]	15,100,000
Rutile concentrate, natural[8]	do.	680,000	668,000	633,000 [r]	625,000 [r]	651,000
Titanium slag	do.	1,650,000	1,700,000	1,520,000	1,420,000 [r]	1,700,000

[e]Estimated. [r]Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through January 9, 2024. Data are rounded to no more than three significant digits, except for U.S. production, which is rounded to one significant digit to avoid disclosing company proprietary data.
[2]Excludes titaniferous iron ore imported from Canada that is classified as ilmenite under the Harmonized Tariff Schedule of the United States.
[3]Landed duty-paid unit based on U.S. imports for consumption.
[4]Production plus imports minus exports. Does not include stock changes.
[5]Source: U.S. Department of Labor, Bureau of Labor Statistics.
[6]May include estimated data.
[7]Includes U.S. production of ilmenite and rutile rounded to one significant digit to avoid disclosing company proprietary data.
[8]U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2
ESTIMATED U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2022[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 Janaury 9, 2024. 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	2021	2022
Production:		
Ingot	W	W
Mill products	W	W
Exports:		
Waste and scrap	10,400	8,610
Sponge	117	105
Ingot	2,590 r	3,630
Other unwrought	2,030	1,490
Wrought products and castings	12,100 r	16,800
Total	27,200 r	30,700
Imports:		
Waste and scrap	10,600	19,300
Sponge	16,000	30,900
Ingot	875	733
Powder	214	194
Other unwrought	1,270	847
Wrought products and castings	7,930	7,910
Total	36,900	59,800
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

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available January 9, 2024. 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 2022[1, 2]

(Metric tons per year)

Company	Plant location	Yearend capacity[3]
The Chemours Co.	De Lisle, MS	340,000
Do.	New Johnsonville, TN	350,000
INEOS Pigments USA Inc.	Ashtabula, OH	245,000
Louisiana Pigment Co. L.P.[4]	Lake Charles, LA	168,000
Tronox Ltd.	Hamilton, MS	225,000
Total		1,330,000

Do. Ditto.
[1]Table includes data available through January 9, 2024. 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 about 26,400 metric tons per year of buff pigment that is produced by fine grinding of synthetic rutile.
[3]All plants used the chloride process to manufacture TiO_2 pigment.
[4]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]

		2021		2022	
Component		Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
Production[2]	metric tons	1,150,000	1,080,000	1,150,000	1,080,000
Shipments:[e]					
Quantity	do.	1,150,000	1,080,000	1,150,000	1,080,000
Value	thousands	$3,440,000 [r]	XX	$3,980,000	XX
Exports	metric tons	494,000	464,000 [r]	378,000	355,000
Imports for consumption	do.	251,000	236,000	265,000	249,000
Consumption, apparent[3]	do.	912,000 [r]	857,000 [r]	1,030,000	971,000

[e]Estimated. [r]Revised. do. Ditto. XX Not applicable.
[1]Table includes data available through January 9, 2024. 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 MINERAL CONCENTRATES[1, 2]

(Metric tons)

	2021		2022	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Pigment	1,400,000	NA	1,300,000	NA
Miscellaneous[3]	<100,000	NA	<100,000	NA
Total	1,400,000	1,100,000	1,300,000	1,000,000

NA Not available.
[1]Table includes data available through January 9, 2024. Data are rounded to no more than three 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)

	2021	2022
Steel:		
Carbon steel	4,820 r	W
Stainless and heat-resisting steel	1,580	1,380
Other alloy steel[3]	550 r	W
Total steel	6,950 r	7,030
Cast irons	2	2
Superalloys	554	578
Alloys, other than above	1,350 r	832
Miscellaneous and unspecified	13	13
Grand total	8,870 r	8,460

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total steel."
[1]Table includes data available through January 9, 2024. 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 DIOXIDE CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2021	2022
Paint, varnish, and lacquer	64 r	63
Plastics and rubber	25 r	26
Other[2]	11 r	11
Total	100	100

rRevised.
[1]Table includes data available through January 9, 2024. 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

		2021	2022
Concentrate:			
Ilmenite, cost including freight, China[1]	dollars per metric ton	289	409
Rutile, bagged, free on board (f.o.b.) Australian ports[1]	do.	1,420	2,080
Rutile, bulk, f.o.b. Australian ports[1]	do.	1,300	1,470
Titanium slag, import:[2]			
Canada	do.	981	1,040
Norway	do.	772	981
South Africa	do.	596	751
Ukraine	do.	NA	2,030
Metal:			
Sponge, import[2]	dollars per kilogram	11.10 r	11.10
Scrap, turnings, unprocessed[3]	dollars per pound	1.69	2.92
Ferrotitanium, 70% titanium[3]	do.	4.11 r	5.39
Mill products	producer price index[4]	169	189
Titanium dioxide pigment, import[5]	dollars per metric ton	2,920	3,450

rRevised. do. Ditto. NA Not available.
[1]Source: Fastmarkets IM.
[2]Landed duty-paid unit value based on monthly U.S. imports for consumption from producing countries.
[3]Source: S&P Global Platts Metals Week.
[4]June 1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.
[5]Unit value based on landed-duty-paid U.S. imports for consumption.

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

		2021		2022	
Class	Schedule B number	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:					
Scrap	8108.30.0000	10,400	$42,500 r	8,610	$47,200
Unwrought:					
Sponge	8108.20.0010	117	1,810	105	1,270
Ingot	8108.20.0030	2,590 r	37,500 r	3,630	55,700
Other unwrought	8108.20.0090	2,030	23,900	1,490	30,700
Total		4,740 r	63,200 r	5,230	87,600
Wrought:					
Bloom, sheet bar, slab	8108.90.6020	1,700	47,400	1,790	49,700
Bar, rod, profile, wire	8108.90.6031	4,210 r	216,000 r	6,510	331,000
Other	8108.90.8000	6,190 r	663,000 r	8,520	864,000
Total		12,100 r	926,000 r	16,800	1,240,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	1,280	7,120	1,670	8,990
Ores and concentrates	2614.00.0000	54,100	21,400	262,000	74,700
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	465,000 r	1,370,000 r	354,000	1,210,000
Other titanium dioxide pigment	3206.19.0000	13,000	87,300	12,500	102,000
Unfinished titanium dioxide[2]	2823.00.0000	15,600	42,700 r	11,400	36,700
Total		494,000	1,500,000 r	378,000	1,350,000

rRevised.
[1]Table includes data available January 9, 2024. 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 MINERAL CONCENTRATES, BY COUNTRY OR LOCALITY[1]

Concentrate and country or locality	HTS[2] code	2021 Quantity (metric tons)	2021 Value (thousands)	2022 Quantity (metric tons)	2022 Value (thousands)
Ilmenite:	2614.00.6020				
Madagascar		291,000	$65,900	277,000	$68,200
Mozambique		232,000	57,700	143,000	47,100
Senegal		88,800	23,500	91,100	29,000
Ukraine		20,300 r	5,710	17,900	6,380
Other		41 r	37 r	80	45
Total		632,000	153,000	529,000	151,000
Rutile, natural:	2614.00.6040				
Australia		127,000	101,000	109,000	91,100
Canada		48,900	51,500	17,400	31,200
Kenya		20,200	23,000	28,700	60,500
South Africa		123,000	92,700	168,000	134,000
Ukraine		1,660	2,590	34,000	30,500
Other		213	491	14,300	15,300
Total		320,000	272,000	371,000	363,000
Rutile, synthetic:	2614.00.3000				
Australia		100	185	305	971
Germany		--	--	11	23
Netherlands		307	668	6	20
Sierra Leone		260	403	85	131
South Africa		95	181	--	--
Ukraine		227	473	--	--
Total		990	1,910	408	1,140
Titaniferous iron ore, Canada[3]	2614.00.6020	13,500	2,180	46	20
Titanium slag:	2620.99.5000				
Canada		131,000	126,000	85,100	86,600
Norway		57,500	44,400	47,500	46,400
South Africa		151,000	85,300	188,000	138,000
Other		--	--	15,200	13,600
Total		339,000	256,000	336,000	285,000

rRevised. -- Zero.
[1]Table includes data available through January 9, 2024. 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	2021 Quantity (metric tons)	2021 Value (thousands)	2022 Quantity (metric tons)	2022 Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		1,460	$5,710	1,810	$9,870
China		47	669	731	9,790
France		1,160	5,430	2,040	16,200
Germany		2,210	13,200	2,450	23,900
Italy		449	1,750	1,350	8,420
Japan		857	3,990	2,340	19,700
Korea, Republic of		755	2,830	1,170	9,740
Mexico		766	2,200	1,650	6,630
Poland		153	781	585	5,220
Singapore		238	381	519	3,130
United Kingdom		1,500	6,760	2,840	21,400
Other		1,040 r	5,430 r	1,770	14,500
Total		10,600	49,200	19,300	148,000
Unwrought:					
Sponge:	8108.20.0010				
China		14	91	6	77
Japan		13,900	130,000	25,200	223,000
Kazakhstan		1,770 e	15,400	3,120 e	27,700
Russia		94	763	104	968
Saudi Arabia		18	167	2,300	19,900
Ukraine		--	--	9	78
Other		156	1,380	106	1,110
Total		16,000	148,000	30,900	273,000
Ingot:	8108.20.0030				
Kazakhstan		260	4,510	281	6,260
Russia		614	6,230	423	3,860
Other		1	18	29	504
Total		875	10,800	733	10,600
Powder:	8108.20.0015				
Canada		101 r	16,100 r	85	14,400
China		82	1,420	68	1,810
Germany		15 r	3,470 r	23	5,320
Japan		9	1,410	16	2,400
Other		7	1,030	3	280
Total		214	23,500	194	24,300
Other:	8108.20.0095				
Canada		13	1,930	14	2,200
Japan		51	3,980	63	4,950
Russia		1,180	14,700	740	7,520
United Kingdom		10	1,270	9	878
Other		13 r	667 r	21	583
Total		1,270	22,600	847	16,100
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		192	15,800	221	19,300
China		1,210	43,700	1,250	44,700
France		339	19,300	360	25,600
Japan		274	9,130 r	501	19,600
Korea, Republic of		438	7,730	519	10,500
Mexico		137	14,700	178	18,900
Russia		4,200	108,000	4,050	63,800
Ukraine		560	4,790	21	762
United Kingdom		107	16,400 r	191	27,300
Other		466 r	45,500 r	617	59,800
Total		7,930	285,000 r	7,910	290,000

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	2021 Quantity (metric tons)	2021 Value (thousands)	2022 Quantity (metric tons)	2022 Value (thousands)
Ferrotitanium and ferrosilicon titanium:	7202.91.0000				
Canada		753	$4,370	1,180	$6,220
Estonia		73	335	453	2,840
Russia		1,470 r	7,010 r	282	1,350
Ukraine		323	1,170	114	443
United Kingdom		1,390	6,650	1,480	8,450
Other		100 r	382 r	118	449
Total		4,110 r	19,900 r	3,630	19,800

eEstimated. rRevised.
[1]Table includes data available through January 9, 2024. 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.

Source: U.S. Census Bureau.

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

Country or locality	HTS[2] code	2021 Quantity (metric tons)	2021 Value (thousands)	2022 Quantity (metric tons)	2022 Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Australia		12,600	$35,200	14,600	$39,300
Belgium		9,020	23,400	9,880	28,300
Canada		102,000	281,000	98,700	309,000
China		15,400	31,200 r	17,400	44,500
Czechia		5,840	16,100	6,210	22,500
Germany		22,000	65,100	14,400	55,200
Italy		6,790	19,500	5,870	22,400
Mexico		4,220	11,500	13,300	44,400
Spain		8,820	22,900	12,900	42,000
United Kingdom		3,410	9,470	7,400	25,500
Other		20,300 r	61,000 r	21,100	74,200
Total		210,000	576,000	222,000	707,000
Other titanium dioxide pigment:	3206.19.0000				
Canada		13,300	40,100	13,100	47,600
China		1,570	7,010	856	4,020
India		125	694	687	2,140
Italy		1,060	4,530	1,270	5,790
Mexico		527	4,260	907	7,720
Other		1,080 r	10,200 r	1,960	14,400
Total		17,600	66,800	18,800	81,700
Unfinished titanium dioxide:[3]	2823.00.0000				
Canada		4,180	12,400	2,010	7,130
China		7,200	19,900	8,240	25,600
France		2,060	6,420	5,680	20,100
Germany		3,360	13,500	2,960	15,900
India		2,600	7,200 r	2,820	12,000
Korea, Republic of		2,200	6,810	996	4,290
Other		1,800 r	8,880 r	1,590	9,840
Total		23,400 r	75,100 r	24,300	94,900
Grand total		251,000	718,000	265,000	884,000

rRevised.
[1]Table includes data available through January 9, 2024. 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, BY COUNTRY OR LOCALITY[1]

(Metric tons, gross weight)

Concentrate and country or locality	2018	2019	2020	2021	2022
Ilmenite and leucoxene:[2, 3]					
Australia	1,400,000	1,000,000	1,100,000	600,000 r	600,000 e
Brazil[e, 4]	110,000	41,000	56,000	55,000	47,000
China	4,200,000	4,600,000	5,442,000 r, 5	5,714,000 r	6,300,000 e
India[e]	290,000	310,000 r	350,000 r	350,000 r	350,000
Indonesia	2,000 e	4,000 e	3,000 e	90,000 r, e	40,000
Kazakhstan[e]	10,000	15,000	12,000	14,000 r	14,000
Kenya	453,133	341,182	334,241	329,800 r	339,000
Madagascar	381,924	448,185 r	499,768 r	620,000 r, e	530,000 e
Malaysia	14,158	2,334	2,548	4,600 r	24,093
Mozambique	1,283,075	1,442,711	1,608,011	2,071,046 r	2,553,269
Norway[e]	600,000	720,000	820,000	780,000	690,000
Russia	3,000	3,100	3,000	3,000 e	3,000 e
Senegal	506,938	491,602	762,000	740,000 r, e	685,000 e
Sierra Leone	54,500	59,200	45,800	52,100	58,600
South Africa[e]	1,900,000	1,800,000	1,700,000	1,500,000	1,800,000
Sri Lanka	60,847	43,789	18,016	49,068	34,492
Ukraine	745,417	818,543	773,093	702,249 r	410,000 e
United States[6]	100,000	100,000	100,000	200,000	300,000
Vietnam[7]	235,100	216,700	268,800	300,000 r	331,500
Total	12,400,000 r	12,500,000 r	13,900,000 r	14,200,000 r	15,100,000
Rutile:[3, 8]					
Australia	200,000	200,000	200,000	200,000	200,000 e
Brazil[4]	2,000 e	600 e	226	710 e	1,200 e
India[e]	12,000	13,000	13,000 r	13,000	13,000
Kenya	95,715	78,961	76,402	75,800 r	76,500
Malaysia	5,070	5,947	5,136	5,400 r, e	5,000 e
Mozambique	8,830	8,264	5,958	8,915	8,869
Senegal	9,605	10,130	9,100 e	-- r	9,000 e
Sierra Leone	121,500	137,200	120,200	127,100 r	135,800
South Africa	110,000 e	105,000	95,000 e	85,000 r, e	100,000 e
Sri Lanka	2,319	1,959	1,311	1,881	741
Turkey	6,498	6,450	6,795	7,451 r	1,100 e
Ukraine	106,858	100,000 e	100,000	100,000 e	100,000 e
Total	680,000	668,000	633,000 r	625,000 r	651,000
Titanium slag:[9]					
Canada[e, 10]	700,000	800,000	700,000	700,000	800,000
South Africa	950,000 e	903,000	820,000 e	720,000 r, e	900,000 e
Total	1,650,000	1,700,000	1,520,000	1,420,000 r	1,700,000

[e]Estimated. [r]Revised. -- Zero.

[1]Table includes data available through August 30, 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 also is produced in Canada, 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 were reportedly produced in other countries and (or) localities, 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 U.S. production of ilmenite, leucoxene, and rutile, which is rounded to one significant digit to avoid disclosing company proprietary data.

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

[8]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" owing to insufficient data and (or) to avoid duplicative reporting.

[10]Produced from domestic and imported concentrates.