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TITANIUM [ADVANCE RELEASE]

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Titanium

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In 2020, 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 South Carolina. The United States was 89% net import reliant (as a percentage of apparent consumption) for titanium mineral concentrates and greater than 50% net import reliant (as a percentage of apparent consumption) for titanium sponge (Gambogi, 2023a, 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, Madagascar, Australia, and Norway (table 11). U.S. consumption of titanium used in steel and other alloys decreased by 21% from that in 2019 (table 7). Based on gross weight, world production of titanium mineral concentrates in 2020 was about 13.2 million metric tons (Mt), primarily in the form of ilmenite concentrates (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 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.

Production

Titanium industry data for this chapter were collected by the U.S. Geological Survey (USGS) from annual and quarterly surveys of domestic titanium operations. In 2020, the USGS annual survey canvassed titanium mineral and pigment producers.

Mineral Concentrates.—Titanium minerals of economic importance include ilmenite, leucoxene (an alteration product of ilmenite and other minerals), and rutile. 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, 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 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 2020, The Chemours Co. (Wilmington, DE) produced concentrates of heavy minerals including ilmenite, rutile, staurolite, and zircon at mining operations in Florida and Georgia. Chemours' titanium-mineral feedstocks were used to supply Chemours' TiO_2 pigment plants. Twin Pines Minerals LLC's (Birmingham, AL) mobile operations processed existing mine tailings in West Columbia, SC, to produce mixed titanium and zircon concentrates. In 2019, the West Columbia mobile operations were located in Florida.

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 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 choice 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 about 1.0 Mt in 2020, unchanged compared with that in 2019 (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.

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 included 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 132,000 t/yr, respectively (table 2). U.S. producers of titanium sponge in 2020 were Honeywell Electronic Materials Inc. (Salt Lake City, UT) and Titanium Metals Corp. (Timet), a subsidiary of Precision Castparts Corp. 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, operation. Timet's Henderson, NV, plant 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 announced that it was indefinitely idling its sponge plant at the Henderson operations by yearend (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 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 normally are produced contain 40% and 70% titanium, respectively. U.S. producers of ferrotitanium were Howmet Aerospace (formerly Arconic, Inc.) (Canton, OH) with an estimated capacity of 7,250 t/yr and AmeriTi Manufacturing Co. (formerly Global Titanium Inc.) (Detroit, MI) with a capacity of more than 10,000 t/yr. Data on production 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 900,000 metric tons (t) 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.

TiO2 Pigment.—Domestic production of TiO_2 pigment was unchanged, and apparent domestic consumption (not accounting for changes in inventory) increased by 7% from that in 2019 (tables 1, 5). On a gross weight basis, 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 66% 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 are 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 preceded 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 included interstitial, free, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 8,700 t, a 21% decrease from that in 2019 (table 7).

Stocks

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

Prices

Yearend titanium mineral concentrate prices are listed in table 9. In 2020, the yearend prices increased for ilmenite and rutile compared with those in 2019. Based on U.S. Census Bureau trade data, the unit value of slag imports from slag-producing countries in December 2019 was $805 to $955 per metric ton and ended 2020 with a broader range of $540 to $1,010 per metric ton. 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 173 in January (June 1982=100), ranged between 169 and 174 during the year, and ended at 171 in December. Although not formally discontinued, the monthly PPI for TiO_2 pigment (June 1982=100) was 208 in February 2019, which was the last month for which it was reported. Based on U.S. Census Bureau data, the average yearend value of TiO_2 pigment was $2,650 per metric ton, a decrease from $2,740 per metric ton compared with that in 2019.

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 2020, the TiO_2 content of imports was estimated to be 810,000 t, primarily in the form of titanium slag (46%), ilmenite (36%), and natural rutile (19%). South Africa, Canada, Madagascar, Australia, and Norway were, in descending order of value, the leading import sources, accounting for 90% of the mineral concentrate import value. The combined value for all forms of titanium mineral concentrate imports in 2020 was $578 million. Imports of titaniferous iron ore, containing less than 35% TiO_2, from Canada (classified as ilmenite by the U.S. Census Bureau) totaled 35,500 t in gross weight and were

valued at $6.8 million. Exports of titanium mineral concentrates were minor relative to imports (tables 10, 11).

TiO_2 Pigment.—In 2020, the United States continued to be a net exporter of TiO_2 pigment, with exports exceeding imports by a ratio of about 3 to 2. Exports of TiO_2 pigment were 386,000 t valued at $1.09 billion, a 4% decrease in quantity compared with those in 2019 (table 10). About 95% of TiO_2 pigment exports was in the form of finished pigment containing 80% or more TiO_2 content. During 2020, 262,000 t of TiO_2 pigment valued at $681 million was imported, a decrease of 16% in quantity from that in 2019. The leading import sources of TiO_2 pigment were Canada and China. About 85% of pigment imports was in the form of finished pigment containing more than 80% TiO_2 (table 13).

Metal.—Total imports of titanium metal, excluding ferrotitanium and ferrosilicon titanium, were 43,800 t and were primarily in the form of waste and scrap (36%) and sponge (44%) (table 12). Japan supplied 88% of imported titanium sponge; Russia and Kazakhstan supplied nearly all of the imported titanium ingot; and Germany (19%), Japan (18%), the United Kingdom (13%), and France (11%) were the leading sources of imported scrap. Russia (51%) and China (17%) were the leading sources of wrought products and castings. Exports of titanium metal were 34,800 t, excluding ferrotitanium and ferrosilicon titanium, and were primarily in the form of wrought products and castings (42%), waste and scrap (40%), and ingot (11%) (table 10).

Imports of ferrotitanium and ferrosilicon titanium were 2,850 t, a decrease from those in 2019 (table 12). Exports of ferrotitanium and ferrosilicon titanium were 1,890 t, an increase compared with those in 2019 (table 10).

World Review

In 2020, global production of ilmenite and leucoxene, titanium slag, and rutile was 11.1 Mt, 1.52 Mt, and 632,000 t, 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, and South Africa (table 14).

Australia.—Iluka Resources Ltd. was Australia's leading producer of titanium mineral concentrates with operations in the Eucla Basin, the Murray Basin (idle in 2020), and the State of Western Australia. In 2020, Iluka's Australian operations produced 410,000 t of ilmenite and 52,400 t of natural rutile, compared with 259,300 t of ilmenite and 46,800 t of natural rutile produced in 2019. Using a portion of its own ilmenite as feedstock, the company produced a record-high 227,000 t of synthetic rutile compared with 196,000 t in 2019 (Iluka Resources Ltd., 2021, p. 28, 29, 156).

Sheffield Resources Ltd. continued work on the development of its Thunderbird heavy-mineral-sands project in the State of Western Australia. In 2020, Sheffield was conducting trial mining and pursued a joint venture with YGH Australia Investment (Yansteel) to develop the project. In December, the company reported that it had received approval from Australia's Foreign Investment Review Board for a 50% investment by Yansteel whose parent company was based in Hong Kong. Ore reserves were 750Mt grading 3.1% ilmenite as of December 31, 2020 (Sheffield Resources Ltd., 2020; 2021, p. 3, 7).

In mid-2019, an updated definitive feasibility study was completed for Strandline Resources Ltd.'s Coburn Project in the State of Western Australia. Coburn would produce an average of 110,000 t/yr of ilmenite and 24,000 t/yr of rutile over an initial 22.5-year mine life, based on current reserves. The company indicated a potential extension of mine life through the conversion of adjacent resources. At midyear 2020, offtake agreements covered 66% of Coburn's production for the first 5 to 7 years (Strandline Resources Ltd., 2020).

Canada.—In Quebec, Rio Tinto Fer et Titane Inc. (RTFT), a subsidiary of Rio Tinto plc, produced titanium slag at its Lac Tio mining operations and Sorel-Tracy titanium slag operations. The RTFT Sorel-Tracy operation supplemented Lac Tio mineral concentrates with feedstock from its QIT Madagascar Minerals operations. In 2020, combined titanium slag production from Rio Tinto's operations in Canada and South Africa decreased by 7% to 1.12 Mt from 1.21 Mt in 2019. 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, 2021, p. 3, 367).

China.—China was a leading producer and the leading consumer of titanium mineral concentrates, producing an estimated 5.1 Mt of ilmenite in 2020 (table 14). Imports of titanium mineral concentrates under the Harmonized System (HS) code 261400 were 3.0 Mt in 2020, a 15% increase from those in 2019. The leading sources, in descending order of quantity, were Mozambique, 35%; Vietnam, 14%; Australia, 13%; Kenya, 9%; Norway, 7%; and the Republic of Korea, 5%. Exports of titanium mineral concentrates (HS code 261400) were 25,800 t in 2020, a slight increase from those in 2019 (Zen Innovations AG, 2023).

China's TiO_2 pigment production in 2020 was 3.51 Mt, an increase from 3.18 Mt in 2019. Imports of titanium-based pigments (HS codes 282300, 320611, and 320619) were 196,000 t in 2020, essentially unchanged from those in 2019. Exports of titanium-based pigments (HS codes 282300, 320611, and 320619) totaled 1.31 Mt in 2020, an increase of 21% from exports in 2019 (Artikol, 2021; Zen Innovations AG, 2023).

China also was the leading producer and consumer of titanium metal. In 2020, production capacity of titanium sponge was 177,000 t/yr, an increase from 147,500 t/yr in 2019. Production from the 12 major producers was 123,000 t, a 45% increase compared with that in 2019. Imports of titanium metal and articles thereof (HS code 8108) were 12,000 t, and exports were 16,200 t (Argus Media group—Argus Metals International, 2021; Zen Innovations AG, 2023).

Lomon Billions Group Co., Ltd. was China's leading TiO_2 pigment producer, with 1.01 Mt/yr of TiO_2 pigment production capacity. Lomon Billions produced 817,000 t of TiO_2 pigment in 2020, a 30% increase compared with that in 2019. About 74% of production was made using the sulfate process. The company also produced 9,100 t of titanium sponge. In 2020, the company was adding to its existing 15,000 t/yr of titanium sponge capacity. New sponge capacity was being installed and commissioned at its Yunnan Province and Gansu Province operations (Lomon Billions Group Co., Ltd., 2021, p. 20, 25).

Finland.—In 2018, Venator Materials Plc (United Kingdom) maintained plans to close its TiO_2 pigment operation at Pori. In 2017, a fire significantly damaged the plant that was reported to have a design capacity of 130,000 t/yr (Venator Materials Plc, 2021, p. 31).

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). Titanium exports of titanium metal under HS code 8108 decreased by 34% to 35,100 t from 53,500 t in 2019. Exports were divided among unwrought (57%), waste and scrap (17%), powders (1%), and other articles of titanium (25%) (JX Nippon Mining & Metals Corp., 2021, p. 26; Osaka Titanium Technologies Co., Ltd., 2022; Zen Innovations AG, 2023).

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 156,000 t in 2020, an 18% decrease compared with that in 2019. About 83% of production was rutile pigment and the remainder was anatase pigment. Japan's TiO_2 pigment production capacity was about 310,000 t/yr (Roskill's Letter from Japan, 2021).

Norway.—In June, Norway's Directorate of Mining granted Nordic Mining ASA an operating license for its Engebø rutile-garnet project in southwestern Norway. A definitive feasibility study (DFS) published in January expected the project to operate for 42 years, processing an average of 1.5 Mt/yr of ore. Proven and probable ore reserves were estimated to be 63.1 Mt containing 3.34% TiO_2. In October, the company made plans with Hatch and Axe Valley Mining to update the DFS (Nordic Mining ASA, 2020, p. 7–8; 2021, p. 6–9).

Russia.—Russia's sponge and ingot production capacities were about 46,500 t/yr and 81,000 t/yr, respectively. PJSC VSMPO-AVISMA Corp. was the leading producer of both sponge and ingot. In 2020, Russia exported 18,700 t of titanium metal under HS code 8108, compared with 28,600 t in 2019. Germany, the United States, the Netherlands, and Estonia, in descending order of quantity, were the leading destinations. About 31% of Russia's titanium metal exports were in the form of unwrought products (Tirus International SA, 2020; Zen Innovations AG, 2023).

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 2020, exports of titanium metal under HS code 8108 were 4,120 t, compared with 5 t in 2019 (Argus Media group—Argus Metals International, 2019; Zen Innovations AG, 2023).

Sierra Leone.—Sierra Rutile Ltd., a subsidiary of Iluka, produced 45,800 t of ilmenite and 120,000 t of rutile in 2020 compared with 59,200 t of ilmenite and 137,200 t of rutile in 2019. At yearend, Sierra Rutile ore reserves were reported to be 268 Mt containing 1.4% (3.6 Mt) of rutile (Iluka Resources Ltd., 2021, p. 156, 158).

South Africa.—In 2020, South Africa was a leading global producer and exporter of titanium mineral concentrates. Exports of titanium concentrates under HS code 2614 were 724,000 t (Zen Innovations AG, 2023). The leading producers, in descending order, included Rio Tinto and Tronox. Although a leading producer of titanium slag from ilmenite mineral concentrates, South Africa did not have a titanium-specific export trade code (table 14).

Rio Tinto held a 74% interest in the Richards Bay Minerals (RBM) mining and slag operations. In 2020, 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 2020, construction at the Zulti South project was suspended pending feedstock requirements from its slag operations (Rio Tinto plc, 2021, p. 3, 363, 367).

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 was reported to include rutile (55,000 t/yr), and slag (410,000 t/yr). Ilmenite capacity used to produce titanium slag was not reported (Tronox Holdings plc, 2021, p. 33).

Tanzania.—Strandline Resources continued to advance its Fungoni and Tajiri mineral sands projects. Measured and indicated resources for the Fungoni deposit were 21.7 Mt containing about 600,000 t of heavy minerals. In October, a scoping study for the Tajiri project projected a 24.3-year mine life, producing 150,000 t/yr of ilmenite and 16,000 t/yr of rutile-leucoxene contained in mixed heavy-mineral concentrates (Strandline Resources Ltd., 2021, p. 6).

Ukraine.—Ukraine was the leading source of titanium mineral concentrates in the Commonwealth of Independent States and a significant producer of titanium sponge. Titanium mineral concentrates were produced by private companies and one state-owned company, United Mining and Chemical Company JSC. In 2020, Ukraine produced about 773,000 t of ilmenite and 100,000 t of rutile (table 14) and exported 539,000 t of titanium minerals concentrates in 2020. 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 were 5,960 t. About 80% of Ukraine's titanium metal exports were in the form of unwrought products (Tirus International SA, 2020; Zen Innovations AG, 2023).

Outlook

Despite market disruptions caused by the COVID-19 pandemic, increased production from China resulted in increased global production of titanium mineral concentrates in 2020 compared with that in 2019. Although numerous mineral sands projects are in various stages of development, most project timelines have been extended owing to market uncertainties from COVID-19 pandemic-related shutdowns.

Global production capacity of TiO_2 pigments is expected to increase to meet increased demand. The distribution of chloride-process versus sulfate-process TiO_2 pigment capacity is expected to reach parity and is expected to be driven mainly by the expansion of chloride-process capacity in China (Adams, 2018a, p. 27; 2018b, p. 25, 26). According to the largest producer of TiO_2 in China, global consumption of TiO_2 is expected to

increase at an annual growth rate of about 5% between 2020 and 2025 (Lomon Billions Group Co., Ltd., 2022, p. 15).

Future demand for titanium metal is primarily dependent 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 increase 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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TABLE 1
SALIENT TITANIUM STATISTICS[1]

		2016	2017	2018	2019	2020
United States:						
Mineral concentrate:						
Production[2]	metric tons	100,000	100,000	100,000	100,000	100,000
Imports for consumption[3]	do.	1,330,000	1,560,000	1,470,000	1,540,000	1,070,000
Consumption[e, 4]	do.	1,740,000	1,760,000	1,610,000	1,630,000	1,150,000
Sponge metal:						
Imports for consumption	do.	16,200	23,300	23,700	30,000	19,200
Consumption	do.	34,100	37,400	35,200	W	W
Price, yearend[5]	dollars per pound	11.10 [r]	10.70 [r]	10.80 [r]	10.60 [r]	11.50
Titanium dioxide pigment:						
Production	metric tons	1,240,000	1,260,000	1,150,000	1,000,000 [r]	1,000,000
Imports for consumption	do.	247,000	240,000	268,000	226,000	262,000
Consumption, apparent[6]	do.	840,000	870,000	893,000	825,000 [r]	880,000
Producer price index, yearend[7]	(June 1982=100)	175	205	205	NA	NA
World, production:[8]						
Ilmenite concentrate[9]	metric tons	9,800,000	10,100,000 [r]	10,300,000 [r]	10,600,000 [r]	11,100,000
Rutile concentrate, natural[10]	do.	799,000 [r]	818,000 [r]	679,000 [r]	667,000 [r]	632,000
Titanium slag	do.	1,500,000 [r]	1,800,000	1,650,000 [r]	1,700,000	1,520,000

[e]Estimated. [r]Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through July 29, 2022. 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]Does not include consumption used to produce synthetic rutile.
[5]Landed duty-paid unit based on U.S. imports for consumption.
[6]Production plus imports minus exports. Does not include stock changes.
[7]Source: U.S. Department of Labor, Bureau of Labor Statistics.
[8]May include estimated data.
[9]Includes U.S. production of ilmenite and rutile rounded to one significant digit to avoid disclosing company proprietary data.
[10]U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2
ESTIMATED U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2020[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	Canton, OH	--	9,600
Do.	Niles, OH	--	13,600
Do.	Whitehall, MI	--	3,200
Perryman Co.[4]	Houston, PA	--	5,900
Titanium Metals Corp.[4]	Salisbury, NC	--	1,800
Do.	Henderson, NV	-- [5]	12,300
Do.	Morgantown, PA	--	40,700
Do.	Vallejo, CA	--	800
Total		500	132,000

Do. Ditto. -- Zero.
[1]Table includes data available through July 29, 2022. 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, 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 prior to yearend.

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

(Metric tons)

Component	2019	2020
Production:		
Ingot	W	W
Mill products	W	W
Exports:		
Waste and scrap	15,000	14,100
Sponge	869	711
Ingot	7,260	3,700
Other unwrought	2,350	1,570
Wrought products and castings	20,800 r	14,800
Total	46,300 r	34,800
Imports:		
Waste and scrap	30,100	15,800
Sponge	30,000	19,200
Ingot	2,100	1,210
Powder	189	195
Other unwrought	1,070	642
Wrought products and castings	9,930 r	6,670
Total	73,400	43,800
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 through July 29, 2022. 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 2020[1, 2, 3]

(Metric tons per year)

Company	Plant location	Yearend capacity[4]
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.	Lake Charles, LA	168,000
Tronox Ltd.	Hamilton, MS	225,000
Total		1,330,000

Do. Ditto.
[1]Table includes data available through July 29, 2022. 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.
[3]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.
[4]All plants used the chloride process to manufacture TiO_2 pigment.

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

		2019		2020	
		Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
Production[2]	metric tons	1,000,000 [r]	940,000 [r]	1,000,000	943,000
Shipments:					
Quantity	do.	1,000,000 [r, e]	940,000 [r]	1,000,000 [e]	943,000
Value	thousands	$2,950,000 [r, e]	XX	$2,840,000 [e]	XX
Exports	metric tons	401,000	377,000	386,000	363,000
Imports for consumption	do.	226,000	213,000	262,000	247,000
Consumption, apparent[3]	do.	825,000 [r]	776,000 [r]	880,000	827,000

[e]Estimated. [r]Revised. do. Ditto. XX Not applicable.
[1]Table includes data available through July 29, 2022. 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, 3]

(Metric tons)

	2019		2020	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Pigment	1,550,000	NA	1,090,000	NA
Miscellaneous[4]	81,500	NA	57,500	NA
Total	1,630,000	1,300,000 [r]	1,150,000	900,000

[r]Revised. NA Not available.
[1]Table includes data available through July 29, 2022. 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.
[3]Excludes inventory changes.
[4]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)

	2019	2020
Steel:		
Carbon steel	5,340	4,170
Stainless and heat-resisting steel	3,310	2,010
Other alloy steel[3]	413	590
Total steel	9,070	6,770
Cast irons	3	2
Superalloys	565	547
Alloys, other than above	1,410	1,360
Miscellaneous and unspecified	14	13
Grand total	11,100	8,700

[1]Table includes data available through July 29, 2022. 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 PIGMENT SHIPMENTS, TITANIUM DIOXIDE CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2019	2020
Paint, varnish, and lacquer	64 [r]	66
Plastics and rubber	25 [r]	26
Other[2]	11 [r]	8
Total	100	100

[r]Revised.
[1]Table includes data available through July 29, 2022. 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
YEAREND PRICES OF TITANIUM PRODUCTS

		2019	2020
Concentrate:			
Ilmenite, cost including freight, China[1]	dollars per metric ton	190–210	230–250
Rutile, bagged, free on board (f.o.b.) Australian ports[1]	do.	1,250–1,300	1,300–1,350
Rutile, bulk, f.o.b. Australian ports[1]	do.	1,100–1,200	1,150–1,200
Titanium slag, import, 80% to 95% titanium dioxide[2]	do.	805–955	540–1,010
Metal:			
Sponge import[2]	dollars per kilogram	10.60 [r]	11.50
Scrap, turnings, unprocessed[3]	dollars per pound	0.85–0.90	1.00–1.10
Ferrotitanium, 70% titanium[3]	do.	2.90–3.10	3.00–3.30
Mill products[4]	producer price index	172	171
Titanium dioxide pigment, import[4]	do.	2,740	2,650

[r]Revised. do. Ditto.
[1]Source: Industrial Minerals.
[2]Landed duty-paid unit value based on U.S. imports for consumption from producing countries.
[3]Source: S&P Global Platts Metals Week.
[4]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	2019 Quantity (metric tons)	2019 Value (thousands)	2020 Quantity (metric tons)	2020 Value (thousands)
Metal:					
Scrap	8108.30.0000	15,000	$40,200	14,100	$34,100
Unwrought:					
Sponge	8108.20.0010	869	5,660	711	4,330
Ingot	8108.20.0030	7,260	109,000	3,700	59,400
Other unwrought	8108.20.0090	2,350	72,900	1,570	47,300
Total		10,500	188,000	5,980	111,000
Wrought:					
Bloom, sheet bar, slab	8108.90.6020	1,330	32,900	1,540	42,900
Bar, rod, profile, wire	8108.90.6031	7,370 r	343,000 r	5,180	261,000
Other	8108.90.8000	12,100	1,280,000	8,040	853,000
Total		20,800 r	1,650,000	14,800	1,160,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	1,520	6,310	1,890	6,160
Ores and concentrates	2614.00.0000	12,200	20,300	28,800	36,600
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	382,000	1,080,000	368,000	1,000,000
Other titanium dioxide pigment	3206.19.0000	13,000	86,200	13,400	82,100
Unfinished titanium dioxide[2]	2823.00.0000	5,670	10,600	4,820	11,600
Total		401,000	1,180,000	386,000	1,090,000

rRevised.
[1]Table includes data available July 29, 2022. 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	2019 Quantity (metric tons)	2019 Value (thousands)	2020 Quantity (metric tons)	2020 Value (thousands)
Ilmenite:	2614.00.6020				
Australia		113,000	$18,200	112,000	$17,500
Madagascar		250,000	52,500	218,000	52,500
Mozambique		172,000	32,400	69,200	15,000
Norway		--	--	190	133
Senegal		131,000	23,300	42,200	10,600
Ukraine		60,300	8,590	40,000	8,580
Total		726,000	135,000	481,000	104,000
Titanium slag:	2620.99.5000				
Canada		74,000	66,400	83,700	83,700
Kenya		--	--	5,000	5,950
Norway		30,100	23,000	45,000	35,800
South Africa		369,000	274,000	301,000	193,000
Total		473,000	363,000	435,000	318,000
Rutile, natural:	2614.00.6040				
Australia		78,400	71,600	21,600	23,600
Kenya		37,600	37,900	13,200	15,600
Norway		10,000	7,660	--	--
South Africa		188,000	147,000	120,000	112,000
Ukraine		6,150	5,840	881	1,240
Other		4,080 r	4,230 r	2,380	3,540
Total		324,000	274,000	158,000	156,000
Rutile, synthetic:	2614.00.3000				
Australia		12,000	8,180	41	36
Kenya		1,200	14,100	--	--
South Africa		5,000	2,190	--	--
Other		140	209	87	120
Total		18,300	24,700	128	156
Titaniferous iron ore, Canada[3]	2614.00.6020	41	29	35,500	6,800

rRevised. -- Zero.
[1]Table includes data available through July 29, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States (HTS).
[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	2019 Quantity (metric tons)	2019 Value (thousands)	2020 Quantity (metric tons)	2020 Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		1,750	$3,800	1,140	$2,290
China		383	3,240	524	6,050
France		3,640	15,200	1,680	6,900
Germany		5,120	29,200	3,030	17,500
Italy		2,210	8,170	781	3,050
Japan		4,810	21,500	2,900	11,800
Korea, Republic of		1,230	6,520	698	3,380
Mexico		1,650	5,260	799	1,890
Singapore		715	2,270	361	956
United Kingdom		5,800	25,900	2,130	9,200
Other		2,800 r	12,200 r	1,750	8,360
Total		30,100	133,000	15,800	71,300
Unwrought:					
Sponge:	8108.20.0010				
China		3	134	1	35
Japan		26,600	240,000	16,900	152,000
Kazakhstan		2,930 e	26,500	1,930 e	17,300
Russia		73	605	53	477
Ukraine		297	2,820	268	2,470
Other		155 r	1,300 r	61	511
Total		30,000	271,000	19,200	173,000
Ingot:	8108.20.0030				
Kazakhstan		391	6,890	238	4,330
Russia		1,530	23,800	970	15,400
Other		180	4,300	6	101
Total		2,100	35,000	1,210	19,900
Powder:	8108.20.0015				
Canada		70	11,900	75	10,400
China		99	1,520	99	1,670
Germany		14	4,870	16	4,630
Japan		4	863	3	543
Other		3 r	721 r	3	358
Total		189	19,900	195	17,600
Other:	8108.20.0095				
Germany		25	273	28	236
Japan		22	1,680	28	2,190
Russia		943	20,900	559	12,700
United Kingdom		42	2,780	11	1,590
Other		36 r	2,510 r	16	1,480
Total		1,070	28,100	642	18,200
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		336	27,700	218	21,700
China		1,210	63,800 r	1,110	55,200
France		729	45,900	268	31,900
Japan		408	13,100	309	12,000
Korea, Republic of		434	8,230	561	10,300
Russia		4,260	177,000	3,390	127,000
Ukraine		1,390	17,800	60	1,770
United Kingdom		243	26,500	181	24,900
Other		913 r	86,600 r	574	73,400
Total		9,930 r	466,000	6,670	358,000

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	2019 Quantity (metric tons)	2019 Value (thousands)	2020 Quantity (metric tons)	2020 Value (thousands)
Ferrotitanium and ferrosilicon titanium:	7202.91.0000				
Canada		1,210	$3,770	754	$2,200
Poland		487	1,590	19	64
Russia		193	576	893	2,750
Ukraine		247	736	324	861
United Kingdom		1,050	4,000	665	2,200
Other		205	600	199	467
Total		3,390	11,300	2,850	8,540

[e]Estimated. [r]Revised.
[1]Table includes data available through July 29, 2022. 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 PIGMENT, BY COUNTRY OR LOCALITY[1]

Country or locality	HTS[2] code	2019 Quantity (metric tons)	2019 Value (thousands)	2020 Quantity (metric tons)	2020 Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Australia		7,490 [r]	$16,000	11,700	$28,400
Belgium		13,700	35,800	12,000	31,500
Canada		81,600	199,000	89,100	229,000
China		13,300	29,500	27,800	49,800
Czechia		5,550	14,600	5,980	15,700
Germany		17,400	49,500	20,200	59,300
Japan		5,320	26,500	4,100	18,300
Mexico		4,100	8,890	11,900	28,000
Norway		4,170	9,920	6,210	15,300
Spain		12,600	33,800	14,300	37,600
Other		19,200	51,100	19,100	47,300
Total		184,000	475,000	222,000	560,000
Other titanium dioxide pigment:	3206.19.0000				
Canada		11,600	30,700	13,300	34,700
China		1,200 [r]	4,370 [r]	1,420	5,290
Germany		370 [r]	4,450 [r]	465	3,740
Italy		476	1,810	677	2,460
Mexico		325	1,880	613	3,780
Other		1,300 [r]	12,000 [r]	1,180	9,310
Total		15,300	55,200 [r]	17,700	59,300
Unfinished titanium dioxide:[3]	2823.00.0000				
Canada		5,620	19,000	2,470	7,380
China		9,240 [r]	20,600	8,850	17,400
Czechia		1,100	2,880	579	1,680
France		2,020 [r]	5,900 [r]	2,830	7,820
Germany		3,300	14,900	2,100	9,450
India		2,280	5,500	1,820	4,370
Korea, Republic of		1,240	3,000	2,050	5,120
Other		1,680 [r]	9,680 [r]	1,770	9,130
Total		26,500	81,500	22,500	62,300
Grand total		226,000	612,000	262,000	681,000

[r]Revised.
[1]Table includes data available through July 29, 2022. 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)

Country or locality	2016	2017	2018	2019	2020
Ilmenite and leucoxene:[2, 3]					
Australia	1,400,000	1,500,000	1,400,000	1,000,000 r	800,000 e
Brazil[4]	106,400	67,000 e	110,000 e	41,000 e	57,000 e
China	3,800,000	3,830,000	4,200,000	4,600,000 r	5,100,000 e
India[e]	618,000	517,000	172,000 r	291,000 r	290,000
Indonesia[e]	20,000	20,000	2,000	4,000	6,000
Kazakhstan[e]	14,000	9,400	10,000	15,000 r	12,000
Kenya	468,903	470,317	453,133	341,182	334,241
Madagascar	267,962	469,326 r	381,924 r	461,800	424,000
Malaysia	4,316	6,363	14,158	2,334	2,548
Mozambique	1,340,330	1,197,419	1,283,075	1,442,711 r	1,608,011
Norway[e]	590,000	670,000	590,000	640,000 r	740,000
Russia	18,900	2,900 r	3,000 r	3,100 r	40,000 e
Senegal	416,349	492,441	506,938 r	491,602 r	500,000 e
Sierra Leone	50,000	58,000	54,500	59,200	45,800
Sri Lanka	26,159	51,940	60,847	43,789 r	18,016
Ukraine	350,000 e	392,000	745,417	818,543	772,953
United States[4, 5]	100,000	100,000	100,000	100,000	100,000
Vietnam	210,800	225,300	235,100	216,700 r	230,400
Total	9,800,000	10,100,000 r	10,300,000 r	10,600,000 r	11,100,000
Rutile:[6]					
Australia	300,000	300,000	200,000	200,000	200,000 e
Brazil[4]	2,700 e	1,000 e	2,000 e	600 e	226
India[e]	16,200	14,100	11,000 r	12,000	12,000
Kenya	88,288	91,456	95,715	78,961	76,402
Malaysia	3,810	5,266	5,070	5,947	5,136
Mozambique	7,781	9,137	8,830	8,264 r	5,958
Senegal	9,664	9,975	9,605 r	10,130 r	9,100 e
Sierra Leone	143,000	168,000	121,500	137,200	120,200
South Africa	120,000 r	110,000 r, e	110,000 e	105,000 r	95,000 e
Sri Lanka	2,237	2,174	2,319	1,959	1,311
Turkey	5,000 e	6,706	6,498	6,450	6,795
Ukraine	100,000 e	100,000 e	106,858	100,000 e	100,000 e
United States	(7)	(7)	(7)	(7)	(7)
Total	799,000 r	818,000 r	679,000 r	667,000 r	632,000
Titanium slag:[8]					
Canada[e, 9]	700,000	800,000	700,000	800,000	700,000
South Africa	800,000 r, e	1,000,000 e	950,000 r, e	903,000 r	820,000 e
Total	1,500,000 r	1,800,000	1,650,000 r	1,700,000	1,520,000

[e]Estimated. [r]Revised.

[1]Table includes data available through February 16, 2022. 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 were reportedly produced in various 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]Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

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

[7]Included with ilmenite and leucoxene to avoid disclosing company proprietary data.

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

[9]Produced from domestic and imported mineral concentrates.