



2009 Minerals Yearbook

TITANIUM

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World production of titanium dioxide (TiO₂) contained in titanium mineral concentrates decreased by 10% compared with that of 2008. The United States continued to be heavily reliant on imports of titanium mineral concentrates from Australia, Canada, and South Africa.

Global TiO₂ pigment production capacity was estimated to be 5.6 million metric tons per year (Mt/yr). According to U.S. Geological Survey (USGS) survey data, domestic production of TiO₂ pigment decreased by 9% compared with that of 2008.

Consumption of titanium used in steel and other alloys decreased by 22% from that in 2008 because of the global economic recession that began in 2008. In 2009, the recession and delays in aircraft programs resulted in decreased domestic production of titanium ingot and mill products.

Legislation and Government Programs

The Defense Advanced Research Projects Agency (DARPA) continued to fund work on low-cost extraction of titanium metal from oxide ores. DARPA efforts were aimed at producing high-quality titanium at a cost of less than \$8.81 per kilogram. In fiscal year (FY) 2009, DARPA hoped to produce up to 1.1 metric tons per day and verify that the cost of production was less than the target cost. In FY 2010, DARPA planned to demonstrate consolidation of titanium powder without using conventional melting techniques (Defense Advanced Research Projects Agency, 2009, p. 183).

In 2009, the U.S. Department of Defense (DOD) initiated two programs to improve the supply of titanium metal. International Titanium Powder (ITP) (a subsidiary of Cristal Global) entered into a Title III agreement with DOD to increase domestic capacity to produce low-cost metallic titanium powder. Title III of the Defense Production Act (50 U.S.C. App. 2061 et seq.) is a program specifically designed to establish, expand, maintain, or modernize industrial capabilities required for national defense. Instead of sponge produced by magnesium reduction via the Kroll process, the plant was designed to produce titanium metal powder by sodium reduction via the Armstrong process. At yearend, ITP neared completion of new titanium production capacity in Ottawa, IL, and was expected to begin production in 2010. Production capacity was expected to be 2,000 metric tons per year (t/yr) by yearend 2011 (International Titanium Powder, 2009). A second Title III effort was aimed at reducing cost and shortening delivery lead times for structural titanium and titanium armor. The initial goal of the second program was to direct roll titanium in widths and thicknesses that can be used for armor tiles on military ground vehicles (U.S. Department of Defense, 2009, p. 89–90).

In response to Congressional requests, a DOD-led Strategic and Critical Materials Working Group was formed to review the present state of the National Defense Stockpile. In April, a

report was sent to Congress recommending the transformation of the National Defense Stockpile into a Strategic Materials Security Program (SMSP). Within the report, several initiatives were recommended for consideration. On an ongoing basis, the SMSP would conduct risk assessments, compare demand to supply by analyzing supply sources and risks of supply chain interruption, and identify mitigation strategies. The proposed SMSP would leverage the buying power of Government by aggregating materials requirements and negotiating long-term strategic sourcing arrangements. The working group also developed a plan for a comprehensive Strategic Materials Security Management System (SMSMS) that would identify, on an ongoing basis, those strategic and critical materials required for national security. The SMSMS would be a joint effort by the Office of the Secretary of Defense, the military services, the Defense Contract Management Agency, and the Defense Logistics Agency, with representation and analysis provided by other Government agencies such as the U.S. Department of Commerce and the USGS (Defense Logistics Agency, 2009, p. 1–3).

Production

Titanium industry data for this report are collected by the USGS from annual and quarterly surveys of domestic titanium operations. In 2009, the USGS annual survey canvassed titanium mineral and pigment production operations. The two producers of titanium mineral concentrates responded, but data were withheld to avoid disclosing company proprietary information. Of the seven domestic TiO₂ pigment operations, five responded, representing 85% of TiO₂ pigment production. Two TiO₂ pigment operations were estimated on the basis of prior-year production levels. Production of titanium ingot and mill products was aggregated from a quarterly survey of producers.

Mineral Concentrates.—Titanium mineral concentrates of economic importance include ilmenite, leucoxene, rutile, synthetic rutile, and titaniferous slag. Mining of titanium minerals is usually performed using surface methods. Dredging and dry mining techniques are used for the recovery of heavy minerals. Gravity spirals are used to separate the heavy-mineral suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often processed to produce a synthetic rutile or titaniferous slag. Although numerous technologies are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite. Titaniferous slag with a TiO₂ content of 75% to 95% is produced commercially using pyrometallurgical processes.

U.S. mineral concentrate producers were DuPont Titanium Technologies [a subsidiary of E.I. du Pont de Nemours and

Co. (DuPont)] and Iluka Resources, Inc. (a subsidiary of Iluka Resources Ltd.). DuPont's mining operations near Starke, FL, produced a mixed product containing ilmenite, leucosene, and rutile that was used as a feedstock in DuPont's TiO₂ pigment plants. In 2009, Iluka produced titanium mineral concentrates from its heavy-mineral operations at Stony Creek, VA.

Iluka began mining at its Brink deposit in Virginia to extend the life of its Virginia mining operations to 2015. The Brink deposit is about 48 kilometers south of the Stony Creek, VA, mineral separation plant. At Green Cove Springs, FL, Iluka ceased reprocessing of stockpiled tailings (Iluka Resources Ltd., 2010, p. 2, 44).

Metal.—Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride (TiCl₄), which is reduced with magnesium (Kroll process) or sodium (Hunter process) to form a commercially pure form of titanium metal. As the metal is formed, it has a porous appearance and is referred to as sponge. Titanium ingot and slab are produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements such as aluminum and vanadium. Electron beam (EB), plasma arc melt (PAM), scull, and vacuum-arc remelting (VAR) are the commercial methods used to produce ingot and slab. Titanium mill products are produced from the 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. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel, but may be produced through the aluminothermic reduction of ilmenite. The two standard grades of ferrotitanium that are normally produced contain 40% and 70% titanium. Domestic ferrotitanium capacity was estimated to be 17,300 t/yr.

In 2009, U.S. producers of titanium sponge were Allegheny Technologies Inc. (ATI), Honeywell Electronic Materials Inc., and Titanium Metals Corp. (Timet). ATI's Albany, OR, plant and Timet's Henderson, NV, plant produced titanium sponge using the Kroll process. Honeywell Electronic Materials' plant in Salt Lake City, UT, produced titanium sponge using the Hunter process and supported the company's production of electronic-grade titanium. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data (table 2).

In July, owing to poor market conditions and in anticipation of new production capacity, ATI temporarily idled its 9,980-t/yr sponge plant in Albany, OR (Allegheny Technologies Inc., 2009, p. 44). In December, ATI commissioned a new 10,900-t/yr sponge facility in Rowley, UT (Allegheny Technologies Inc., 2010, p. 24).

At yearend, RTI International Metals, Inc. neared completion of production capacity expansions at its Canton (ferrotitanium and specialty alloys) and Niles (titanium ingot), OH, operations. No details were available in regard to the size of the expansions. RTI ceased construction of a 9,070-t/yr sponge plant near Hamilton, MS, in favor of long-term titanium sponge supply agreements with foreign suppliers (RTI International Metals, Inc., 2010, p. 3).

Timet completed an 8,500-t/yr expansion of EB ingot production capacity in Morgantown, PA. The new capacity increased the company's ingot production capacity at Morgantown to 40,700 t/yr (Titanium Metals Corp., 2010).

In 2009, U.S. production of titanium ingot was 35,600 metric tons (t), a 39% decrease compared with the near-record production in 2008. Production of mill products decreased by 20% compared with that of 2008 (table 3). U.S. producers of ferrotitanium were RTI (Canton, OH) and Global Titanium Inc. (Detroit, MI). Data on production of ferrotitanium were not available.

TiO₂ Pigment.—TiO₂ pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the chloride process, rutile is converted to TiCl₄ by chlorination in the presence of petroleum coke. TiCl₄ is oxidized with air or oxygen at about 1,000° C, and the resulting TiO₂ is calcined to remove residual chlorine and any hydrochloric acid that may have formed in the reaction. Aluminum chloride is added to the TiCl₄ to assure that virtually all the titanium is oxidized into the rutile crystal structure. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. Although 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, and waste disposal costs. In finishing operations, the crude form of the pigment is milled to produce a controlled distribution of particle size and surface treated or coated to improve its functional behavior in different media. Some typical surface treatments include alumina, organic compounds, and silica.

TiO₂ pigment produced by either process is categorized by crystal form as either anatase or rutile. Rutile pigment is less reactive with the binders in paint when exposed to sunlight than is the anatase pigment and is preferred for use in outdoor paints. Anatase pigment has a bluer tone than rutile, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which it is produced and subsequently finished, TiO₂ pigment can exhibit a wide range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO₂ pigment was 1.23 million metric tons (Mt) in 2009, a 9% decrease compared with that in 2008 (table 5). U.S. producers of TiO₂ pigment by the chloride process were Cristal Global, DuPont, Louisiana Pigment Co. L.P. (a joint venture of NL Industries, Inc. and Huntsman Corp.), and Tronox Inc. (table 4). TOR Minerals International, Inc. produced a buff TiO₂ pigment from finely ground synthetic rutile.

In January, Tronox filed for reorganization under chapter 11 of the U.S. Bankruptcy Code. At yearend, Tronox announced that it negotiated a framework for a reorganization plan with a new debt facility, new equity financing, the establishment of environmental remediation trusts, and a litigation trust under a comprehensive settlement of legacy environmental liabilities with the U.S. Government. In 2009, Tronox was among the world's leading producers of TiO₂ pigment (PRNewswire-FirstCall, 2009).

Consumption

Mineral Concentrates.—On a gross weight basis, 95% of the domestic consumption of titanium mineral concentrates was used to produce TiO₂ pigment. The remaining 5% was used to produce miscellaneous other products, including fluxes, metal, and welding rod coatings. Based on TiO₂ content, domestic consumption of titanium mineral concentrates was 1.36 Mt, a 5% decrease compared with that of 2008 (table 6). Consumption data for titanium concentrates were estimated by the USGS owing to insufficient response by industry to the voluntary survey for consumption data.

Metal.—Titanium metal alloys are used for their high strength-to-weight ratio and corrosion resistance. Because of delays in aircraft programs and uncertain market conditions, consumption of titanium ingot decreased 37% compared with that of 2008 (table 3).

Domestic shipments of titanium metal mill products decreased by 21%. The aerospace industry (79%) was the leading end use for mill products. Other uses included those in the consumer goods, 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 is consumed in the steel and nonferrous alloy industries. In the steel industry, titanium is used for deoxidation, grain-size control, and controlling and stabilizing 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 9,290 t, a 22% decrease compared with that of 2008 (table 7).

TiO₂ Pigment.—Led by a decrease in the demand for coatings and plastics used in construction and automobiles, domestic consumption of TiO₂ pigment decreased by 5% compared with that of 2008 (table 5). The leading uses of TiO₂ pigment, based on TiO₂ pigment shipments in the United States, were paint and coatings (58.6%), plastics and rubber (25.5%), and paper (9.4%). Other uses (6.5%) included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules (table 8).

Stocks

Insufficient data were available to determine yearend consumer inventories of titanium mineral concentrates and TiO₂ pigment producer stocks. Industry reports indicated that in 2009 the global decrease in the production of mineral concentrates and TiO₂ pigment resulted in a reduction in stocks.

Owing to long-term supply agreements, domestic stocks of sponge increased by 8% compared with those in 2008. Domestic stocks of ingot decreased by 25% because producers reduced production in anticipation of decreased consumption (table 3).

Prices

Titanium mineral concentrate prices are listed in table 9. Although lower during much of the year, yearend prices for bulk ilmenite and rutile concentrates were higher compared with prices in 2008. Published prices for titanium slag were not available. Based on U.S. Customs Service data, the yearend unit

value of slag imports ranged from \$401 to \$439 per metric ton in 2008 compared with \$393 to \$407 per ton in 2008. The unit value of slag hit a low in the first quarter with a range of \$331 to \$411 per ton.

The U.S. Department of Labor, Bureau of Labor Statistics, yearend producer price index (PPI) for TiO₂ pigment decreased by 3% compared with that of 2008. The monthly PPI started the year at a low of 154, hit a peak of 172 in November, and then fell to 164 by yearend (U.S. Department of Labor, Bureau of Labor Statistics, 2010).

Delays in large aircraft programs, an uncertain global economy, and excess inventory caused prices of titanium mill products to fall significantly. The monthly PPI for titanium mill products reached a high of 281 in February and declined to a low of 197 by yearend. Sponge and ingot prices were less affected by reduced demand because of long-term contracts and significant curtailments in production.

Foreign Trade

Mineral Concentrates.—Imports of titanium mineral concentrates include ilmenite, rutile, synthetic rutile, and titaniferous slag. The United States was heavily reliant on imports of titanium mineral concentrates because domestic consumption of titanium minerals greatly exceeded domestic production capacity. In 2009, the TiO₂ content of imports was estimated to be 763,000 t, primarily in the form of titaniferous slag (46%) and natural rutile (28%). South Africa, Australia, and Canada, in descending order of quantity, were the leading import sources. The combined value for all forms of titanium concentrate imports in 2009 was \$330 million (table 11). Because of reduced steel production, imports of titaniferous iron ore from Canada, classified as ilmenite by the U.S. Census Bureau, decreased significantly. Exports of titanium concentrates were minor relative to imports (tables 10, 11).

Metal.—Imports of titanium metal are primarily in the form of unwrought titanium and scrap. Kazakhstan (60%) and Japan (35%) were the leading sources of imported titanium sponge, while France (25%), the United Kingdom (24%), Germany (19%), and Japan (11%) were the leading sources of imported scrap. The leading import sources of titanium ingot were Germany (69%) and Russia (29%). China (71%) was the major source of titanium powder. Imports of powder and other unwrought forms of titanium decreased by 82% and 69%, respectively, compared with those of 2008.

Imports of titanium wrought products and castings were primarily in the form of plate, sheet, strip, and foil (37%); bar, rod, profiles, and wire (25%); and billets (24%). Russia (76%) and China (7%) were the leading sources of wrought products and castings imports. Imports of wrought products and castings decreased from a record high set in 2008.

Owing to decreased consumption of titanium for steel and other alloys, imports of ferrotitanium and ferrosilicon titanium were 2,540 t, a 10% decrease compared with those of 2008. The leading import sources were Canada (32%), the United Kingdom (31%), and Russia (25%). Exports of ferrotitanium and ferrosilicon titanium were 2,020 t, a 25% increase compared with those of 2008.

TiO₂ Pigment.—The United States continued to be a net exporter of TiO₂ pigment. In 2009, exports exceeded imports by a ratio of 3.7 to 1. Exports of TiO₂ pigment were 649,000 t, an 11% decrease compared with those of 2008. About 95% of TiO₂ pigment exports was in the form of finished pigment with 80% or more TiO₂ content.

During 2009, 175,000 t of TiO₂ pigment was imported, a 4% decrease compared with that in 2008. The leading import sources of TiO₂ pigment were Canada (39%) and China (12%). Pigment imports were primarily in the form of pigment with more than 80% TiO₂ (table 13).

World Review

Australia.—Iluka began production of heavy-mineral concentrate at its Jacinth-Ambrosia Mine in the Eucla Basin, South Australia. During its projected mine life of more than 10 years, Jacinth-Ambrosia was expected to produce approximately 1.5 Mt of ilmenite, 350,000 t of rutile, and 2.8 Mt of zircon (Iluka Resources Inc., 2009b).

In Western Australia, Iluka idled its Eneabba Mine because of declining ore grades and the opening of the Jacinth-Ambrosia Mine. In 2009, Iluka was in the process of upgrading the Narngulu mineral separation plant to process heavy-mineral concentrate from the Jacinth-Ambrosia concentration plant (Iluka Resources Inc., 2009a).

The Australian Government approved Astron Ltd.'s environmental plan to develop its Donald heavy-mineral deposit in the Murray Basin, Victoria. Astron planned to produce heavy-mineral concentrate from Donald and then process the concentrate through a mineral sand separation plant in China (Astron Ltd., 2009, p. 6). According to Astron, the deposit contained an indicated and inferred resource of ilmenite (8.5 Mt), leucoxene (5.4 Mt), rutile (1.2 Mt), and zircon (5.2 Mt) (Astron Ltd., undated).

Australian Zircon NL suspended mining activities at its Mindarie operation in South Australia, and the company went into administration to obtain relief from its creditors. During 2009, the company continued a feasibility study of the WIM150 deposit and produced ilmenite, rutile, and zircon from previously mined ore through yearend (Mineral Sands Report, 2009a). Although no data were available for 2009, in 2008, the Mindarie operation produced about 8,600 t of ilmenite and 3,000 t of rutile in 2008 (Geoscience Australia, 2009, p. 48).

In May, Unimin Australia Ltd. acquired Consolidated Rutile Ltd. (CRL) from Iluka (Mineral Sands Report, 2009b). In 2009, the CRL Mine on North Stradbroke Island, Queensland, was reported to contain reserves of 3.2 Mt of heavy minerals (Iluka Resources Ltd., 2010, p. 75).

Canada.—Sustainable Development Technology Canada awarded Titanium Corp.'s "Creating value from waste" project \$4.9 million in funding. The award was expected to promote technologies that recover bitumen and heavy minerals, including ilmenite and rutile, from oil sands tailings. Consortium members of the project included Sojitz Corp., Syncrude Canada Ltd., Titanium Corp., and the Government of Alberta (Titanium Corp., 2009).

Citing the slump in construction activity and weakness in the automotive sector, Rio Tinto Fer et Titane shut down its

titaniferous magnetite mine near Lac Allard, Quebec, and its smelting operations in Sorel, Quebec, for 8 weeks in the summer (Rio Tinto plc, 2009, p. 1).

Chile.—White Mountain Titanium Corp. (WMT) was proceeding with the exploration and development of its Cerro Blanco rutile deposit. In December, WMT completed a pilot-plant test to produce a natural rutile concentrate meeting the specifications of titanium pigment and sponge metal producers. WMT planned to complete a study for commercial feasibility by the first quarter 2011 (White Mountain Titanium Corp., 2010, p. 16).

China.—Despite a drop in domestic consumption, China's titanium metal and pigment production capacity continued to rise. The top five sponge producers increased capacity to 63,000 t/yr in 2009 from 44,000 t/yr in 2008. However, owing to market conditions, several less-efficient sponge plants were idled in 2009. Total sponge production capacity was estimated to be more than 80,000 t/yr (Dewhurst, 2010, p. 15–17). TiO₂ production was reported to have reached a record 1.04 Mt, a 259,000-t increase from that in 2008. Owing to rising domestic consumption, TiO₂ production was expected to increase to 1.2 Mt in 2010 and may reach 1.9 Mt by 2015 (Titanium Dioxide Report, 2010). Although the development of domestic mine production was ongoing, increased consumption of titanium concentrates was met through increased imports of titanium mineral concentrates. In 2009, Chinese imports of titanium mineral concentrates increased to 1.48 Mt from 1.07 Mt in 2008 (United Nations Statistics Division, undated).

Hainan Taixin Minerals Co. Ltd. acquired mining rights to a heavy-mineral deposit near Wanning City, Hainan Province. The deposit was reported to have a proven reserve of ilmenite (2.24 Mt) and zircon (0.5 Mt). While granting the mining rights, the Provincial government stipulated that the company would be required to produce value-added products beyond ilmenite and zircon concentrates (Mineral Sands Report, 2009c).

Germany.—Huntsman Corp. closed its 40,000-t/yr TiO₂ pigment plant at Grimsby. According to the company, the Grimsby plant was its oldest and least-efficient manufacturing facility. Huntsman produced TiO₂ pigment in seven countries with a combined production capacity of approximately 560,000 t/yr (Huntsman Corp., 2009).

India.—Trimex Group was preparing to begin production of up to 200,000 t/yr of ilmenite and 6,000 t/yr of rutile in the Srikurmam district, Andhra Pradesh. Proven reserves reportedly were estimated to be 5.5 Mt of ilmenite (Industrial Minerals, 2008).

Kerala Minerals & Metals Ltd. (KMML) continued construction on a 500-t/yr titanium sponge plant. TiCl₄ was to be supplied to the plant from KMML's Chavara TiO₂ pigment plant. The plant was scheduled to be in production by June 2010 (Kerala Minerals & Metals Ltd., undated).

Japan.—Although curtailing production in 2009, Toho Titanium Co., Ltd. was proceeding with plans to increase its total sponge production capacity to 28,000 t/yr through the addition of a new 12,000-t/yr plant at Wakamatsu, Fukuoka Prefecture (Metal-Pages, 2009a).

In the Hyogo Prefecture, Osaka Titanium technologies Co., Ltd. delayed plans to increase capacity at its Amagasaki sponge

plant to 41,000 t/yr. In 2008, the production capacity was raised by 33% to 32,000 t/yr (Bloomberg.com, 2009).

Kazakhstan.—Ust-Kamenogorsk Titanium-Magnesium Complex, the sole producer of titanium sponge in Kazakhstan, neared completion of new ingot production capacity. A 16,000-t/yr ingot plant was expected to be commissioned in 2010 and reach full production capacity in 2011 (Metal-Pages Ltd., 2010).

Kenya.—In August, Jinchuan Group Ltd. entered into an understanding with Tiomin Resources Inc. wherein Jinchuan would acquire 70% of Tiomin Kenya Ltd.'s (TKL) Kwale mineral sands project; however, in October, Jinchuan terminated the agreement. At yearend, Tiomin abandoned plans to develop the deposit and wrote off all the costs associated with the Kwale project. In early 2010, Tiomin changed its name to Vaaldiam Mining Inc. (Vaaldiam Mining Inc., 2010, p. 12).

Madagascar.—QIT Madagascar Minerals SA (QMM) was ramping up production at its 700,000-t/yr mineral sands project near Mutamba. QMM was a joint venture between Rio Tinto plc and the Government of Madagascar. Rio Tinto began exporting 60% grade ilmenite to its slag operation at Sorel, Quebec (Rio Tinto plc, 2010, p. 2).

Mozambique.—BHP Billiton Ltd. completed a prefeasibility study of the Corridor Sands heavy-minerals project and concluded that further development of the project was not warranted (BHP Billiton Ltd., 2009, p. 33). The Corridor Sands project was based on 10 deposits near Chibuto in southern Mozambique. Previously, total resources of ore were estimated to be 14 billion metric tons, with the largest deposit containing about 300 Mt of ilmenite.

Kenmare Resources plc was addressing startup problems that prevented the Moma operation from achieving its design capacity of 800,000 t/yr of ilmenite, 14,000 t/yr of rutile, and 50,000 t/yr of zircon. In 2009, the Moma operation produced about 474,000 t of ilmenite concentrate. The company also made plans to increase its design capacity by about 50% by 2012 (Kenmare Resources plc, 2010, p. 6).

Norway.—Nordic Mining ASA was developing an eclogite deposit at Engebøfjellet in Sogn and Fjordane County. In 2009, Nordic Mining's work was related to mineral resource prospecting and developing methods for ore dressing and beneficiation for the production of rutile and garnet. Nordic Mining also submitted a proposal with an environmental impact statement for the development of the deposit to the Naustdal and Askvoll municipalities. In 2010, the company planned to focus on optimizing rutile recovery and prepare for pilot-plant production (Nordic Mining ASA, 2010).

Russia.—ARZM Uranium Holding Co. was developing the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. ARZM planned to commission a mine and processing plant with the capacity to process up to 1.5 Mt/yr of heavy-mineral concentrates by 2014. According to the Russian classification system, ore reserves in categories "C1" and "C2" were estimated to be 30 Mt containing about 1 Mt of titanium and more than 350,000 t of zirconium oxide (ARZM Uranium Holding Co., 2009).

VSMPO-AVISMA Corp. decided to postpone an expansion of its titanium sponge production capacity to 42,000 t/yr until

2015. VSMPO was proceeding with plans to increase its capacity to produce downstream products such as sheet and forgings (Metal-Pages, 2009b).

Senegal.—A feasibility study of Mineral Deposits Ltd.'s Grande Cote deposit was underway in 2009. The study was expected to be completed in 2010 and was to include updated capital costs, circuit model test work, financial modeling, geological block modeling, hydrological modeling, and mine path design (Mineral Deposits Ltd., 2010b). The company planned to produce up to 75,000 t/yr of zircon and 600 t/yr of ilmenite for a mine life of more than 25 years (Mineral Deposits Ltd., 2010a).

Sierra Leone.—Construction of Titanium Resources Group Ltd.'s (TRG) third mining dredge was underway, and the dredge was expected to be commissioned in 2011. At yearend, repairs to TRG's second dredge that capsized in July 2008 were pending the resolution of its insurance claim. In 2010, TRG expected its rutile production to increase by 30% from 63,900 t produced in 2009 (Titanium Resources Group Ltd., 2010, p. 1, 13).

South Africa.—In December, Rio Tinto Iron & Titanium concluded a Broad Based Black Economic Empowerment transaction at Richards Bay Minerals (RBM) in South Africa. Under the transaction, 24% of the equity of RBM was sold to a consortium of historically disadvantaged groups, with an additional 2% transferred to a trust for the benefit of RBM employees. The remaining 74% was split equally between BHP Billiton and Rio Tinto (Rio Tinto plc, 2010, p. 22).

Exxaro Resources Ltd. decided not to proceed with the development of the Fairbreeze mineral sands mine in KwaZulu-Natal. Subsequently, Exxaro planned to close the KZN Sands operations during the next 5 years unless new feedstock alternatives were located. Exxaro postponed restarting a slag furnace at its Namakwa Sands operation, which was shut down to be relined in March 2009. In addition, production at the mine and separation plants was temporarily halted in August to adjust for market conditions (Exxaro Resources Ltd., 2010, p. 48–49).

Ukraine.—Rutile-Ilmenite Co. (RICO) was preparing to mine and process heavy-mineral sands at its deposit in Tarasovka. In 2011, RICO planned to produce 51,000 t of heavy-mineral concentrates including ilmenite (6,000 t), leucoxene (20,000 t), rutile (15,000 t), and zircon (10,000 t). In 2012, production was expected to reach its maximum capacity of 196,000 t/yr (Industrial Minerals, 2009).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam temporarily lifted a ban on exports of heavy-mineral concentrates. Producers were permitted to export from mid-2009 through the end of 2010. The ban had been imposed to encourage the production of value-added products. In 2008, the export tariff for zircon ore was raised to 20% from 15% (Mineral Sands Report, 2009d).

Outlook

For the foreseeable future, the market for titanium minerals was expected to be driven by the production of TiO₂ pigment. Unless new mines are developed, the U.S. reliance on imports of titanium mineral concentrates is likely to increase as existing mines are depleted within the next 10 years.

During the next decade, global demand growth for TiO₂ was expected to track with the total global gross domestic product and the production of paint, paper, and plastics. Higher-than-average growth was expected in Asia. China, in particular, was expected to lead world growth in production and consumption. TiO₂ production capacity in China was scheduled to double by the end of the decade. During the next several years, prices for TiO₂ pigment were expected to rise because of increasing costs for caustic soda, chlorine, coke, and energy.

Aerospace, defense, and industrial uses were expected to strongly influence consumption of titanium metal for the foreseeable future. Commercial aircraft will remain a major consumer of titanium metal. The growth of the global airplane fleet was projected to average 3.3% per year from 2009 to 2029 (Boeing Co., The, 2010, p. 4). Within the next 3 years, global titanium metal production was expected to increase in line with the construction of new aircraft and increased industrial output. Government and private industry programs were working to commercialize lower cost methods of producing titanium metal.

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TABLE 1
SALIENT TITANIUM STATISTICS¹

		2005	2006	2007	2008	2009
United States:						
Mineral concentrate:						
Imports for consumption	metric tons	1,190,000	1,230,000	1,460,000	1,380,000 ^r	943,000
Consumption ^{e, 2}	do.	1,720,000	1,870,000	1,950,000	1,780,000 ^r	1,700,000
Sponge metal:						
Imports for consumption	do.	15,800	24,400	25,900	23,900	16,600
Consumption	do.	26,100	28,400	33,700	W	W
Price, yearend ³	dollars per pound	3.46–12.22	5.87–12.84	6.33–7.06	6.16–8.02	4.50–7.07
Titanium dioxide pigment:						
Production	metric tons	1,310,000	1,370,000	1,440,000	1,350,000	1,230,000
Imports for consumption	do.	341,000	288,000	221,000	183,000	175,000
Consumption, apparent	do.	1,130,000 ⁴	1,080,000 ⁵	979,000 ⁵	800,000 ⁵	757,000 ⁵
Producer price index, yearend ⁶	(1982=100)	172	165	162	170	164
World, production:						
Ilmenite concentrate ⁷	metric tons	6,050,000	6,850,000 ^r	7,120,000 ^r	6,870,000 ^r	6,180,000
Rutile concentrate, natural ⁸	do.	377,000 ^r	515,000 ^r	604,000 ^r	628,000 ^r	577,000
Titaniferous slag ^e	do.	1,880,000	2,160,000	2,230,000 ^r	2,230,000	2,000,000

^eEstimated. ^rRevised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

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

²Excludes consumption used to produce synthetic rutile.

³Landed duty-paid unit based on U.S. imports for consumption.

⁴Production plus imports minus exports plus stock decrease or minus stock increase.

⁵Production plus imports minus exports. Excludes stock changes.

⁶Source: U.S. Department of Labor, Bureau of Labor Statistics.

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

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

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2009^{1,2}

(Metric tons per year)

Company	Plant location	Yearend capacity ^c	
		Sponge	Ingot ³
Alcoa Howmet	Whitehall, MI	--	3,200
Allegheny Technologies Inc.	Albany, OR	(4)	10,900
Do.	Monroe, NC	--	23,200
Do.	Richland, WA	--	10,000
Do.	Rowley, UT	10,900	--
Alloy Works LLC	Greensboro, NC	--	1,800
Honeywell Electronic Materials Inc.	Salt Lake City, UT	500	--
Perryman Co.	Houston, PA	--	1,800
RTI International Metals, Inc.	Niles, OH	--	13,600
Titanium Metals Corp.	Henderson, NV	12,600	12,300
Do.	Morgantown, PA	--	40,700
Do.	Vallejo, CA	--	800
Total		24,000	118,000

^cEstimated. Do. Ditto. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Estimated operating capacity based on 7-day-per-week full production.

³Includes electron-beam, plasma, and vacuum-arc-remelting capacity.

⁴In July 2009, sponge capacity of 9,980 metric tons per year was temporarily idled.

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

(Metric tons)

Component	2008	2009
Production:		
Ingot	58,600	35,600
Mill products	39,700	31,900
Exports:		
Waste and scrap	8,180	4,200
Sponge	2,370	820
Other unwrought	3,440	3,790
Wrought products and castings	19,000	12,500
Total	33,000	21,300
Imports:		
Waste and scrap	10,400	4,770
Sponge	23,900	16,600
Other unwrought	1,540	573
Wrought products and castings	8,350	6,930
Total	44,200	28,900
Stocks, industry, yearend:		
Sponge	14,200	15,300
Scrap	W	9,880
Ingot	3,590	2,680
Consumption, reported:		
Sponge	W	W
Scrap	23,200	25,700
Ingot	47,700	30,100
Shipments:		
Ingot	17,200	10,600
Mill products (net shipments):		
Forging and extrusion billet	12,300	9,520
Plate, sheet, strip	15,600	11,400
Rod, bar, fastener stock, wire	(2)	(2)
Other ³	6,940	6,700
Total	34,800	27,700
Castings (shipments)	W	W
Receipts, scrap:		
Home	(4)	10,600
Purchased	(4)	17,700
Total	31,900	28,300

W Withheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Included with "Other."

³Data for pipe, tube, and other have been combined to avoid disclosing company proprietary data.

⁴Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4
U.S. PRODUCERS OF TITANIUM DIOXIDE PIGMENT IN 2009^{1, 2, 3}

(Metric tons per year)

Company	Plant location	Yearend capacity ⁴
Cristal Global	Ashtabula, OH	220,000
Du Pont Titanium Technologies	De Lisle, MS	340,000
Do.	Edgemoor, DE	154,000
Do.	New Johnsonville, TN	380,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	146,000
Tronox Inc.	Hamilton, MS	225,000
Do.	Savannah, GA	(⁵)
Total		1,470,000

Do. Ditto.

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

²Table does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of about 26,400 metric tons per year (t/yr) of buff TiO₂ pigment that is produced by refining and fine grinding of synthetic rutile.

³Data are rounded to no more than three significant digits; may not add to total shown.

⁴All plants use the chloride process to manufacture TiO₂ pigment.

⁵Tronox Inc. idled its 110,000-t/yr plant in the fourth quarter of 2009.

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

		2008		2009	
		Gross weight	TiO ₂ content	Gross weight	TiO ₂ content
Production ²	metric tons	1,350,000	1,270,000 ^{r, e}	1,230,000	1,150,000 ^e
Shipments: ³					
Quantity	do.	1,390,000	1,300,000 ^e	1,280,000	1,200,000 ^e
Value	thousands	\$3,070,000	XX	\$2,830,000	XX
Exports	metric tons	733,000	688,000 ^e	649,000	609,000 ^e
Imports for consumption	do.	183,000	172,000 ^e	175,000	165,000 ^e
Consumption, apparent ^{e, 4}	do.	800,000	751,000	757,000	711,000

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

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

²Excludes production of buff pigment.

³Includes interplant transfers.

⁴Production plus imports minus exports. Excludes stock changes.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6
ESTIMATED U.S. CONSUMPTION OF TITANIUM CONCENTRATE^{1,2}

(Metric tons)

	2008		2009	
	Gross weight	TiO ₂ content	Gross weight	TiO ₂ content
Pigment	1,670,000	NA	1,620,000	NA
Miscellaneous ³	115,000 ^r	NA	78,400	NA
Total	1,780,000 ^r	1,440,000 ^r	1,700,000	1,360,000

^rRevised. NA Not available.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes a mixed product containing altered ilmenite, leucoxene, and rutile.

³Includes alloys, carbide, ceramics, chemicals, glass fibers, titanium metal, and welding-rod coatings and fluxes.

TABLE 7
U.S. CONSUMPTION OF TITANIUM IN STEEL AND OTHER ALLOYS^{1,2}

(Metric tons)

	2008	2009
Steel:		
Carbon steel	5,930	4,660
Stainless and heat-resisting steel	3,270	2,600
Other alloy steel ³	636	517
Total steel	9,840	7,780
Cast irons	16	12
Superalloys	1,060	462
Alloys, other than above	1,030	965
Miscellaneous and unspecified	40	72
Grand total	12,000	9,290

¹Includes ferrotitanium, scrap, sponge, and other titanium additives.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Includes high-strength low-alloy and tool steel.

TABLE 8
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS,
TITANIUM DIOXIDE CONTENT, BY INDUSTRY¹

(Percent)

Industry	2008	2009
Paint, varnish, lacquer	59.2	58.6
Paper	10.1	9.4
Plastics and rubber	24.5	25.5
Other ²	6.2	6.5
Total	100.0	100.0

¹Excludes exports.

²Includes 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

		2008	2009
Concentrate:			
Ilmenite, free on board (f.o.b.) Australian ports ¹	dollars per metric ton	84–137	60–85
Rutile, bagged, f.o.b. Australian ports ¹	do.	675–725	700–800
Rutile, bulk, f.o.b. Australian ports ¹	do.	500–550	525–540
Titaniferous slag, import, 80% to 95% TiO ₂ ²	do.	393–407	401–439
Metal:			
Sponge import ²	dollars per pound	6.16–8.02	4.50–7.07
Scrap, turnings, unprocessed ³	do.	0.45–0.55	0.90–1.00
Ferrotitanium, 70% Ti ³	do.	2.95–3.05	2.12–2.20
Mill products ⁴	producer price index	233	197
Titanium dioxide pigment ⁴	do.	170	164

do. Ditto.

¹Source: Industrial Minerals.

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

³Source: Platts Metals Week.

⁴1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 10
U.S. EXPORTS OF TITANIUM BY CLASS¹

Class	HTS ²	2008		2009	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:					
Scrap	8108.30.0000	8,180	\$52,000	4,200	\$14,000
Unwrought:					
Sponge	8108.20.0010	2,370	41,100	820	8,560
Ingot	8108.20.0030	725	19,500	776	19,800
Other	8108.20.0090	2,710	51,300	3,020	41,300
Wrought:					
Billet	8108.90.6010	3,200	135,000	2,010	75,200
Bloom, sheet bar, slab	8108.90.6020	1,980	60,900	913	26,900
Bar, rod, profile, wire	8108.90.6031	3,300	210,000	2,300	130,000
Other	8108.90.8000	10,500	714,000	7,240	476,000
Total		33,000	1,280,000	21,300	792,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	1,620	9,090	2,020	7,360
Ores and concentrates	2614.00.0000	14,900	8,590	14,800	8,230
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	668,000	1,310,000	617,000	1,230,000
Other titanium dioxide pigment	3206.19.0000	60,200	152,000	28,000	67,000
Unfinished titanium dioxide ³	2823.00.0000	5,040	10,400	3,500	7,720
Total		733,000	1,470,000	649,000	1,310,000

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States.

³Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATE, BY COUNTRY¹

Concentrate and country	HTS ²	2008		2009	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:	2614.00.6020				
Australia		218,000	\$23,200	105,000	\$10,200
Mozambique		98,600	8,050	120,000	8,840
South Africa		87,500	33,700	--	--
Other		29,000	3,690	25,000	2,770
Total		433,000	68,600	250,000	21,800
Titaniferous slag:	2620.99.5000				
Canada		106,000	45,700	109,000	44,600
South Africa		355,000	141,000	305,000	123,000
Other ³		--	--	91	32
Total		461,000	187,000	414,000	168,000
Rutile, natural:	2614.00.6040				
Australia		136,000	77,200	122,000	70,700
Canada		39,700	17,300	--	--
South Africa		176,000	84,800	75,700	37,100
Other ³		12,900	7,840	26,100	15,000
Total		365,000	187,000	224,000	123,000
Rutile, synthetic:	2614.00.3000				
Australia		111,000	40,300	48,000	14,000
Malaysia		3,090 ^r	2,080 ^r	4,790	2,920
Other ³		7,650 ^r	3,000 ^r	2,810	848
Total		122,000	45,400	55,600	17,700
Titaniferous iron ore, Canada ⁴	2614.00.6020	140,000	44,600	10,000	532

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States.

³All or part of these data have been referred to the U.S. Census Bureau for verification.

⁴Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux. Titaniferous iron ore from Canada is classified as ilmenite under the HTS.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY¹

Class and country	HTS ²	2008		2009	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		728	\$2,950	341	\$563
China		199	1,550	--	--
France		1,560	14,000	1,220	5,500
Germany		1,310	10,500	903	3,940
Israel		363	2,020	6	6
Japan		1,960	12,600	505	1,700
Korea, Republic of		252	1,850	100	683
Mexico		233	711	90	136
Russia		158	2,030	--	--
Taiwan		441	2,450	133	516
United Kingdom		2,660	14,200	1,140	3,190
Other		581 ^r	4,010 ^r	335	1,400
Total		10,400	68,900	4,770	17,600
Unwrought:					
Sponge:	8108.20.0010				
China		1,510	18,500	81	1,130
Japan		7,860	121,000	5,870	81,600
Kazakhstan ^e		12,000	110,000	9,930	88,800
Ukraine		1,540	18,300	--	--
Other		966	10,000	725	6,470
Total		23,900	278,000	16,600	178,000
Ingot:	8108.20.0030				
Germany		771	25,200	364	10,300
Russia		466	9,370	155	2,830
Other		107	2,220	12	223
Total		1,340	36,800	531	13,300
Powder:	8108.20.0015				
Canada		17	1,200	1	427
China		94	2,420	17	385
Japan		17	3,520	4	1,070
Other		6 ^r	576 ^r	2	509
Total		134	7,710	24	2,390
Other:	8108.20.0091				
Canada		9	969	1	275
China		17	187	(4)	6
Germany		7	61	10	202
Netherlands		19	156	2	14
United Kingdom		6	55	4	572
Other		2 ^r	138	1	151
Total		59	1,570	18	1,220

See footnotes at end of table.

TABLE 12—Continued
 U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY¹

Class and country	HTS ²	2008		2009	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Wrought products and castings: ³	8108.90.3030, 8108.90.3060, 8108.90.6010, 8108.90.6020, 8108.90.6031, 8108.90.6045, 8108.90.6060, 8108.90.6075				
China		1,070	\$45,700	470	\$18,700
Germany		356	21,900	121	8,370
Japan		325	19,300	229	16,500
Russia		5,590	178,000	5,260	171,000
United Kingdom		377	32,200	309	32,800
Other		625	51,000	536	44,500
Total		8,350	349,000	6,930	292,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,830	14,900	2,540	6,750

⁴Estimated. ¹Revised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States.

³Includes bar, billet, bloom, castings, foil, pipe, plate, profile, rod, sheet, sheet bar, slab, strip, tube, wire, and other.

Source: U.S. Census Bureau.

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

Country	HTS ²	2008		2009	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Belgium		2,820	\$5,120	3,120	\$6,100
Canada		74,300	150,000	59,600	130,000
China		6,590	12,800	9,910	15,600
Finland		9,260	20,000	8,290	19,100
France		1,820	3,360	3,150	5,980
Germany		4,730	11,100	6,970	14,900
Italy		6,210	10,800	4,870	9,120
Japan		2,940	11,500	3,300	12,800
Netherlands		3,200	5,950	3,620	6,880
South Africa		--	--	10,300	21,300
Spain		5,070	8,840	1,580	3,100
Ukraine		4,450	7,620	6,150	9,560
Other		13,800 ^r	23,700 ^r	9,380	16,500
Total		135,000	271,000	130,000	271,000
Other titanium dioxide:	3206.19.0000				
Canada		5,930	20,300	8,160	20,700
China		1,070	4,510	766	2,880
Germany		615	2,430	2,500	7,800
Japan		719	6,460	509	5,450
Korea, Republic of		630	1,000	307	588
Other		1,590 ^r	8,400 ^r	712	6,430
Total		10,500	43,100	13,000	43,900
Unfinished titanium dioxide: ³	2823.00.0000				
China		9,620	17,800	9,880	14,200
Czech Republic		2,290	4,240	1,920	3,480
Finland		1,790	4,410	1,800	4,450
France		2,800	10,500	4,350	14,500
Germany		4,510	10,400	3,570	7,750
Japan		5,710	15,600	5,240	16,900
Korea, Republic of		2,880	4,770	2,980	3,890
United Kingdom		5,290	6,680	670	1,140
Other		2,210 ^r	4,740 ^r	1,510	3,800
Total		37,100	79,300	31,900	70,100
Grand total		183,000	393,000	175,000	385,000

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States.

³Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 14
TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY^{1,2}

(Metric tons)

Concentrate type and country	2005	2006	2007	2008	2009
Ilmenite and leucoxene:^{3,4}					
Australia	2,080,000	2,508,000	2,503,000	2,199,000	1,700,000
Brazil ⁵	81,818 ^r	94,909 ^r	100,364 ^r	175,076 ^r	71,122
China ^e	900,000	1,000,000	1,100,000	1,000,000 ^r	900,000
India ^e	686,000	690,000	700,000	610,000 ^r	700,000
Kazakhstan ^e	10,000	25,000	25,000	25,000	25,000
Madagascar	--	--	--	--	78,000 ^c
Malaysia	38,196	45,649	60,250 ^r	36,779 ^r	15,983
Mozambique	--	--	140,515	328,875	471,524
Norway ^e	810,000 ^r	850,000	882,000 ^r	915,000 ^r	671,000
Sierra Leone	--	13,819	15,750	17,528	15,161
Sri Lanka ^e	50,000	50,000	50,000	50,000	50,000
Ukraine	375,000 ^c	470,000	500,000	520,000 ^r	500,000 ^c
United States ^{e,6}	500,000	500,000	400,000	300,000	300,000
Vietnam ^{e,7}	523,000	605,000	643,000 ^r	693,000 ^r	687,000
Total⁸	6,050,000	6,850,000^r	7,120,000^r	6,870,000^r	6,180,000
Rutile:⁴					
Australia	177,000	232,000	312,000	325,000	280,000
Brazil ⁵	2,069 ^r	2,100 ^r	3,000 ^r	2,431 ^r	2,881
India ^e	20,100	21,000	21,000	21,000	21,000
Madagascar	--	--	--	--	2,000 ^c
Mozambique	--	--	8,782	6,552	1,697
Sierra Leone	--	73,802	82,527	78,908	63,864
South Africa ^e	115,000	123,000	114,000	127,000	134,000
Sri Lanka ^e	3,000	3,000	3,000	7,500	12,000
Ukraine ^e	60,000	60,000	60,000	60,000	60,000
United States	(9)	(9)	(9)	(9)	(9)
Total	377,000^r	515,000^r	604,000^r	628,000^r	577,000
Titaniferous slag:^{e,10}					
Canada	860,000	930,000	960,000	1,000,000	765,000
South Africa	1,020,000	1,230,000	1,270,000 ^r	1,230,000	1,230,000
Total	1,880,000	2,160,000	2,230,000^r	2,230,000	2,000,000

^eEstimated. ^rRevised. -- Zero.

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

²Table includes data available through July 14, 2010.

³Ilmenite 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 "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

⁴Small amounts of titanium minerals were reportedly produced in various countries; information, however, is inadequate to make reliable estimates of output levels.

⁵Excludes production of unbeneficiated anatase ore.

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

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

⁸Includes U.S. production, rounded to one significant digit, of ilmenite, leucoxene, and rutile to avoid disclosing company proprietary data.

⁹Included with ilmenite to avoid disclosing company proprietary data.

¹⁰Slag is also produced in Kazakhstan, Norway, and Russia, but this output is not included under "Titaniferous slag" to avoid duplicative reporting.