TITANIUM

By Joseph Gambogi

Titanium occurs primarily in the minerals anatase, brookite, ilmenite, leucoxene, perovskite, rutile, and sphene. Of these minerals, only ilmenite, leucoxene, and rutile have significant economic importance. As a metal, titanium is well known for corrosion resistance and for its high strength-to-weight ratio. However, approximately 95% of titanium is consumed in the form of titanium dioxide (TiO_2), a white pigment in paints, paper, and plastics. Other end uses of titanium include ceramics, chemicals, welding rod coatings, heavy aggregate, and steel furnace flux.

Global consumption of TiO_2 was nearly unchanged in 1996 compared with 1995. U.S. production and apparent consumption of TiO_2 pigment decreased, 2% and 1%, respectively. In contrast to the pigment industry, the titanium metal industry experienced high growth in demand. Demand from commercial aerospace and golf club markets resulted in a near record year for titanium metal production. U.S. production and shipments of ingot increased by 29% and 26%, respectively, compared with those of 1995. *(See table 1.)*

Legislation and Government Programs

The U.S. Government's National Defense Stockpile (NDS) held 33,200 metric tons of titanium sponge at yearend. In accordance with the National Defense Authorization Act for fiscal year 1996, Public Law 104-106, Section 3305, 227 tons (250 short tons) of titanium sponge from the NDS was transferred to the U.S. Army during 1996. The material was designated for use in the weight reduction program of the main battle tank upgrade program.

The U.S. Department of Commerce, International Trade Administration (ITA) published the final results of an antidumping review for imports of titanium sponge from Russia. The review covered imports from Berezniki Titanium-Magnesium Works (AVISMA), Interlink Metals and Chemicals, Inc., and Cometals Inc. during the period August 1, 1994, through July 31, 1995. Under the review, the ITA concluded that AVISMA, a producer of titanium sponge, would continue to be subject to the Russia-wide 83.96% antidumping margin. However, the ITA determined the margin for the two trading companies, Interlink and Cometals, would be revised to 0% and 28.31%, respectively (U.S. Department of Commerce, International Trade Administration, 1996).

Production

Ores and Concentrates.—Commercial forms of titanium ores and concentrates include ilmenite, leucoxene, rutile, titanium slag, and synthetic rutile. Australia, Canada, Norway, and South Africa are the major producing countries of titanium ores and concentrates. U.S. producers of titanium concentrates include E. I. du Pont de Nemours & Co. Inc. (DuPont), Kerr-McGee Chemical Corp., RGC (USA) Mineral Sands, Inc. (RGC), and P.W. Gillibrand Co. DuPont's Trail Ridge mining operations in Starke, FL, produce a mixed product containing rutile, leucoxene, and ilmenite that is used as a feedstock in DuPont's titanium pigment operations. RGC's mining operation in Green Cove Springs, FL, produces both rutile and ilmenite concentrates. P.W. Gillibrand produces ilmenite concentrate as a byproduct of its sand and gravel operation in Simi Valley, CA. Kerr McGee's operation in Mobile, AL, produces synthetic rutile from purchased ilmenite concentrate. Titanium slag is not produced in the United States.

RGC announced plans to proceed with the development of the Old Hickory deposit located south of Richmond, VA. RGC plans included new capacity to produce up to 100,000 tons per year of ilmenite (59% to 60% TiO_2), 3,500 tons per year of a "high grade" titanium feedstock (85% TiO_2), and 30,000 tons per year of zircon. Construction of mining and separation facilities was expected to be completed in 1997 (RGC Ltd., 1997).

Metal.—Titanium sponge is the elemental form of titanium metal. Production involves the chlorination of titanium-containing ores to produce titanium tetrachloride. Titanium tetrachloride is purified and then reacted with magnesium to produce titanium sponge. Titanium sponge is produced in China, Japan, Kazakstan, Russia, and the United States. U.S. producers of titanium sponge include Oregon Metallurgical Corp. (Oremet), Albany, OR, and Titanium Metals Corp. (Timet), Henderson, NV. Domestic sponge production capacity is estimated to be 29,500 tons per year. However, only 21,300 tons per year is currently active because of Timet's ability to recycle magnesium is smaller than required to utilize its full production capacity. In 1996, U.S. production of titanium sponge was withheld to avoid disclosing company proprietary data. (*See table 2.*)

Titanium ingot is produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements such as vanadium and aluminum. Electron-beam, plasma, and vacuum-arc-reduction are the current commercial melting methods used to produce ingot. Currently, ingot production capacity exists in France, Germany, Japan, Russia, the United Kingdom, and the United States. In the United States, ingot is produced by the two sponge producers, Oremet and Timet, and by seven other firms. U.S. production and shipments of ingot increased by 29% and 26%, respectively,

compared with those of 1995. *(See table 3.)*

Titanium mill products result from the drawing, forging, and rolling of titanium ingots or slabs into products of various sizes and grades. These mill products include titanium billet, bar, rod, wire, plate, sheet, strip, extrusions, pipe and tube, etc. Producers of titanium mill products are located primarily in the China, Europe, Japan, Russia and the United States. Over 30 companies are known to produce titanium mill products and castings in the United States. In 1996, U.S. production of mill products increased by 32%, compared with the 1995 level.

Titanium castings are produced by melting titanium ingot or billet and then pouring the molten metal into a mold. U.S. producers of titanium castings include Coastcast Corp., Rancho Dominguez, CA; Duriron Co., Dayton, OH; Howmet Corp., Whitehall, MI; Investicast, Ltd., Sweet Home, OR; Precision Cast Parts Corp., Portland, OR; Selmet Inc., Albany, OR; Timet Castings Corp., Albany, OR; and Wyman-Gordon Investment Castings, Inc., Groton, CT.

Ferrotitanium is produced through induction melting of titanium scrap with iron or steel. U.S. producers of ferrotitanium include Galt Alloys Inc., Canton, OH, and Shieldalloy Metallurgical Corp., Newfield, NJ. The two standard grades of ferrotitanium contain 40% and 70% titanium. Data on production of ferrotitanium were not available.

In 1996, Johnson Matthey Electronics' Alta Group commissioned a 340-ton-per-year titanium sponge manufacturing facility in Salt Lake City, UT. Unlike other domestic producers, the Alta facility uses sodium rather than magnesium to reduce titanium tetrachloride to titanium sponge. Sponge production from the facility will supply the electronic industry with raw material for the production of electronic-quality, high-purity, titanium crystal (The Alta Group, 1996).

A 50-50 joint venture between Sturm, Ruger & Co. and Callaway Golf Co. named Antelope Hills, LLC, was in the process of constructing a titanium foundry in Prescott, AZ. The new foundry was scheduled to be completed in 1997 and was expected to produce titanium golf club heads (Sturm, Ruger, & Company, Inc., 1997).

Owing to increased demand for titanium sponge, Timet reactivated the idle Kroll plant at its Henderson, NV, facility. In 1993 the Kroll plant was idled when Timet opened its 10,000-ton-per-year vacuum distillation process plant at Henderson (Titanium Metals Corp., 1997).

Timet acquired nearly all of the assets of Axel Johnson Metals Inc. (AJM), a subsidiary of Axel Johnson Inc. Consequently, Titanium Hearth Technologies (THT), the joint venture between Timet and AJM, is now wholly owned by Timet. In addition to the THT melting operations, Timet acquired AJM melting and scrap processing operations in California and Pennsylvania. The acquired THT and AJM melting facilities produce titanium ingot via electron- beam and vacuum-arc-reduction melting. In a separate acquisition, Timet acquired IMI plc.'s titanium castings operations in Albany, OR, and Pomona, CA (Titanium Metals Corp., 1997).

Pigment.—Titanium dioxide pigment is produced using either the chloride process or the sulfate process. Either route may be used to produce rutile-grade or anatase-grade pigments. U.S. producers of titanium dioxide pigments are DuPont, Kemira Inc., Kerr-McGee, Louisiana Pigment Co. LP, and SCM Chemicals Inc. U.S. production of TiO_2 pigment in 1996 decreased slightly compared with that of 1995. Capacity utilization for the domestic pigment industry was about 83%. *(See tables 4 and 5.)*

In 1996, SCM Chemicals announced plans to curtail sulfate-route capacity in Baltimore, MD, to 44,000 tons per year. Capacity of the 51,000-ton-per-year chloride-route plant at the Baltimore facility was not expected to be affected (Millennium Chemicals Inc., 1997).

Consumption

Ores and Concentrates.—On a gross weight basis, U.S. reported consumption of TiO_2 in ilmenite and titanium slag was 1.4 million tons, a slight decrease compared with the 1995 level. Meanwhile, consumption of natural and synthetic rutile decreased 17%.

Consumption data for titanium concentrates are developed by the U.S. Geological Survey (USGS) from one voluntary survey of domestic operations. Of the 28 operations canvassed, 22 responded, representing 99% of the data in table 6. Data for nonrespondents were estimated based on prior-year consumption levels. *(See table 6.)*

Metal.—Increased ingot production caused titanium sponge and scrap consumption to increase by 32% and 28%, respectively, compared with those of 1995. Scrap supplied a calculated 51% of ingot feedstock. Increased demand for titanium mill products by the commercial aerospace and nonaerospace markets resulted in a 25% increase in ingot consumption and a 31% increase in mill product shipments. Reported shipments of titanium castings increased 42%. Estimated U.S. mill product usage by application was as follows: commercial aerospace, 45%; military aerospace, 15%; and nonaerospace uses, 40%. Nonaerospace uses include those in the specialty chemical, pulp and paper, oil and gas, marine, medical, and consumer goods industries. Reported consumption of titanium products in steel and other alloys increased significantly compared with 1995. *(See tables 3 and 7.)*

Pigment.—Rutile-grade and anatase-grade are the two crystal forms of titanium pigment. The three largest end uses are paint and coatings, paper, and plastics. Other consuming industries included ceramics, fabrics and textiles, floor coverings, printing ink, and rubber. Apparent domestic consumption of TiO_2 pigments was about 1.07 million tons, nearly unchanged compared with that of 1995. *(See tables 5 and 8.)*

Stocks

Based on TiO_2 content, consumer inventories of titanium ores and concentrates increased 82% compared with that of 1995. On a gross weight basis, producer stocks of TiO_2 pigment were about 107,000 tons, an 11% decrease from the 1995 level.

Industry stocks of sponge decreased 17% while stocks of titanium ingot and scrap increased 32% and 69%, respectively. *(See table 9.)*

Prices

Published prices for titanium concentrates, pigments, and metal are presented in table 10. Prices for bulk natural rutile concentrates decreased about 6% compared with those of 1995. However, bagged rutile concentrates used in the welding rod coatings market increased 8%. Ilmenite prices also increased moderately. Published prices for titanium slag were not available. However, based on the U.S. Customs value of imports, prices for Canadian slag increased 20% while prices for South African slag increased slightly. Although there was increased demand for titanium products, published prices for titanium sponge were unchanged. While demand for titanium pigment was nearly unchanged, published prices for titanium pigment increased significantly compared with those of 1995. *(See table 10.)*

Foreign Trade

Ores and Concentrates.—The United States is highly import dependent for titanium concentrates. During 1996 the largest import sources of titanium concentrates were Australia, India, and South Africa. Annual imports of ilmenite, slag, and synthetic rutile concentrates increased 10%, 9%, and 12%, respectively, compared with those of 1995. Meanwhile, imports of natural rutile decreased 5%. *(See tables 11 and 12.)*

Metal.—U.S. import reliance extends to titanium metal, primarily in the form of titanium sponge and scrap. Although a significant quantity of imported titanium scrap is consumed by the iron and steel industry, nearly all of the imported sponge is consumed by the titanium industry. Sponge and scrap imports increased significantly in 1996. The leading import sources of titanium sponge were China, Japan, Kazakstan, and Russia. The leading import sources of titanium waste and scrap were Italy, Japan, Russia, and the United Kingdom. *(See table 13.)*

Pigment.—The United States is a net exporter of titanium pigments. However, a significant quantity of titanium pigments is imported. During 1996, the leading import sources of titanium pigments were Canada and Germany. Imports of titanium pigments containing more than 80% TiO_2 and other pigments decreased 14% and 2%, respectively, compared with those of 1995. Imports of titanium oxide increased 8%. *(See table 14.)*

World Review

World production of titanium concentrates, excluding the United States, was estimated to have increased slightly compared with that of 1995. However, the absence of Sierra Leone as a major producer of natural rutile continued to affect world markets. Increased production of ilmenite and titaniferous slag, primarily from Australia and Canada, offset the depressed rutile production. Slag production increased 7% on a gross weight basis. *(See table 15.)*

Australia.—Australian titanium mineral sands producer RGC Ltd. acquired controlling interest in Cudgen RZ Ltd. Through the acquisition, RGC now holds controlling interest in fellow mineral sands producer Consolidated Rutile Ltd (CRL). CRL is one of the largest titanium mineral producers in Australia. In April, RGC commissioned its Synthetic Rutile Enhancement Process (SREP) at its Narngulu synthetic rutile plant. The SREP is a modification of the Becher process through the introduction of flux as a kiln additive. The SREP decreases radioactivity and increases the TiO_2 content of synthetic rutile production (RGC Ltd., 1997).

After 8 years of production, CRL's dredging operations on North Stradbroke Island, Australia, exhausted the Bayside deposit. CRL planned to begin production from the Ibis-Alpha deposit on North Stradbroke Island in 1997 (RGC Ltd., 1997).

Tioxide closed its Burnie, Tasmania, TiO_2 pigment facility. The sulfate-route plant had been in operation for 48 years with a recent capacity of 26,000 tons per year. Owing to poor market conditions, the company postponed plans to construct a 20,000-ton-per-year plant in Whyalla, Western Australia (Sulphur, 1996).

Canada.—Solv-Ex Corp. obtained permits from the Alberta Ministry of Energy to proceed with a project to produce 14,000 barrels per day of oil with coproduction of minerals from the Athabasca tar sands deposit in northern Alberta. According to Solv-Ex, mineral production from the operation could be a significant source of TiO_2 (North American Minerals News, 1996).

Tiomin Resources Inc. completed preliminary reserve estimates in the North Zone area of the Natashquan deposit. According to the company, proven reserves in two blocks of the concession area are 277 million tons with 5.9% heavy minerals. Several geophysical and drilling programs were underway during the year (Tiomin Resources Inc., 1996).

Finland.—The Ministry of Trade of Finland offered an invitation to tender for the rights to conduct investigations and commercial development of the Kalvia ilmenite deposit near Kokkola. According to the Geological Survey of Finland, the deposit contains 44 million tons of resources to a depth of 150 meters with 15% ilmenite and 5% to 6% magnetite (Industrial Minerals, 1996c).

Japan.— According to the Japan Titanium Society, Japan's titanium sponge and ingot production in 1996 were 21,062 tons and 13,887 tons, respectively. Exports of titanium sponge were 10,637 tons, a 98% increase compared with those of 1995. Mill product shipments were 9,555 tons of which 5,218 tons was exported.

Kenya.—Tiomin Resources Inc. acquired an 80% interest in the licensed mineral rights of four prospecting areas along the Kenyan coast. According to the company, drilling in the four areas has delineated a resource of 3 billion tons of titanium-bearing sands. A prefeasibility study was scheduled to be completed by midyear 1997 (Tiomin Resources Inc., 1996).

Mozambique.—Kenmare Resources and BHP Minerals

signed a joint-venture agreement to explore and possibly develop the Congolone deposit in Mozambique. During work performed under a previous memorandum of understanding between the two companies, the deposit was estimated to contain a resource of 50.5 million tons of ilmenite (Industrial Minerals, 1996a).

Sierra Leone.—In 1996, mining operations at Sierra Rutile Ltd.'s (SRL) mining operations at Moyamaba remained idle. In 1995, rebel forces overtook SRL mining operations. Although Government forces later regained control of the operation, mining operations were suspended indefinitely. At that time the operation was the largest single producer of rutile in the world with a capacity of 150,000 tons per year.

South Africa.—In the fourth quarter, an explosion halted production at Namakwa Sands Ltd.'s titanium slag facility at Brand-se-Baai. The explosion was caused by water coolant leaking into roof of the plasma-arc furnace. Production of rutile and zircon concentrates from Namakwa's nearby minerals separation plant was not affected, and slag production was expected to resume in early 1997 following repairs to the furnace lining (Industrial Minerals, 1997d).

United Kingdom.—SCM Chemicals announced plans to close 10,000 tons per year of sulfate-route TiO_2 pigment capacity but expand the chloride-route capacity at its Stallingworth facility to 150,000 tons per year by 1998. This expansion follows a recent expansion that brought the facility to 109,000 tons per year (Chemical Week, 1996).

Vietnam.—Bimal Minerals Co. completed construction and commenced production of heavy minerals concentrate at its wet separation plant at Cat Khahn in the Binh Dinh Province. Bimal is a joint venture between Binh Dinh Minerals Co., Malaysia Mining Co., and Pendorong Co. Bimal plans to truck the concentrate from the wet separation plant to its existing dry separation plant in Degi. Initial production was expected to be 4,000 tons per month of ilmenite (Industrial Minerals, 1996b).

Outlook

Ores and Concentrates.—The demand for titanium ores and concentrates is largely driven by the demand for titanium pigments, which follows general economic growth. Requirements by the pigment industry point toward an increased reliance on high-grade feedstocks (high-grade ilmenite, rutile, and slag) suitable for use in chloride-route pigment production. In addition, growing concern over the presence of naturally occurring radioactivity in mineral deposits will affect exploration efforts in the coming years. In the short term, the loss of Sierra Leone as a major supplier of natural rutile is expected to affect the availability and price of high-grade ores and concentrates. However, the development of new deposits and processing technology should provide for moderate growth over the next decade.

Pigment.—Since TiO_2 pigments are used in paints and coatings, paper, and plastics, demand for TiO_2 pigment generally follows the growth of the economy as a whole. However, trends within individual market sectors affect demand for TiO_2 pigments. In the paint and coatings industry, expected growth in home ownership and increased use of bright glossy finishes are expected to increase demand for TiO_2 pigments. In the paper industry, demand for lighter paper and increased paper recycling are expected to increase demand for pigments. Increased substitution by plastics for traditional materials is expected to increase demand for TiO_2 pigments by the plastics industry. Although global consumption of TiO_2 was nearly unchanged in 1996 compared with that of 1995, pigment demand is forecast to grow by 3% over the next several years.

Metal.—Demand for titanium metal products historically has been driven by the commercial and military aerospace markets. Since 1995, demand for titanium metal has increased significantly. The titanium industry has improved due to a combination of factors including a surge in commercial aerospace demand, moderate growth in industrial demand, and the new use of titanium in golf club heads. Demand for new aircraft and replacement parts should continue to drive demand for titanium metal over the next few years. However, long-term growth rates are expected to be dependent on nonaerospace markets such as consumer goods, medical, oil and gas, and military armor.

References Cited

Chemical Week, 1996, SCM to cut back production as TiO2 market flounders: Chemical Week, v. 158, no. 30, August 7, p. 8.

U.S. Department of Commerce, International Trade Administration, 1996, Titanium sponge from the Russian Federation; Notice of final results of antidumping duty administrative review: Federal Register, v. 61, no. 222, November 15, p. 58525-58531.

Industrial Minerals, 1996a, BHP/Kenmare commit to minsands jv: Industrial Minerals, no. 348, September, p. 31.

———1996b, Bimal minsands jv on course for start up: Industrial Minerals, no. 346, July, p. 17-18.

———1996c, Kalvia ilmenite deposit up for tender: Industrial Minerals, no. 348, September, p. 28.

———1997d, Namakwa's TiO_2 slag production interrupted: Industrial Minerals, no. 352, January, p. 12.

Millennium Chemicals Inc., 1997, Form 10-K-1996: Securities Exchange Commission, p. 19.16.

RGC Ltd., 1997, RGC Ltd., annual report 1996: Sydney, Australia, p. 6-8.

Sturm, Ruger, & Company, Inc., 1997, Form 10-K-1996: Securities and Exchange Commission, p. 24.

Sulphur, 1996, Tioxide shifts focus: Sulphur, no. 242, January-February, p. 11.

The Alta Group, 1996, Johnson Matthey Electronics' Alta Group opens titanium sponge plant: The Alta Group press release., March 8, 4 p.North American Minerals News, 1996, Solv-Ex tar sands pushes ahead: North American Minerals News, February, p.

Tiomin Resources Inc., 1996, RGC Ltd., Tiomin Resources Inc. annual report 1996: Toronto, Canada, p. 8-12.

Titanium Metals Corp., 1997, Form 10-K-1996: Securities and Exchange Commission, 18 p.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

Ch. in United States mineral resources, U.S. Geological Survey Professional Paper 820.

Force, E.R., Geology of Titanium-Mineral Deposits, U.S. Geological Survey Special Paper 259, 1991.

Ilmenite. Ch. in Mineral Commodity Summaries, annual.[1]

Rutile. Ch. in Mineral Commodity Summaries, annual.[1]

Titanium. quarterly in Mineral Industry Surveys.[1]

Titanium and Titanium Dioxide. Ch. in Mineral Commodity Summaries, annual.[1]

Other

American Metal Market, daily.

American Paint & Coatings Journal, weekly.

Chemical Engineering, biweekly.

Chemical Week, weekly.

Engineering and Mining Journal, monthly.

Industrial Minerals (London), monthly.

Inorganic Chemicals. U.S. Bureau of Census Current Industrial Reports, quarterly and annual.

International Titanium Association (Boulder, CO).

Japan Metal Journal, weekly.

Japan Titanium Society (Tokyo, Japan).

Metal Bulletin (London), semiweekly.

Mining Engineering, monthly.

Mining Magazine and Mining Journal (London), monthly and weekly.

Platt's Metals Week, weekly.

Roskill Information Services Ltd. (London).

---

[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT TITANIUM STATISTICS 1/

(Metric tons unless otherwise specified)

	1992	1993	1994	1995	1996
United States:					
Ilmenite and titanium slag:					
Imports for consumption	832,000	777,000	808,000	861,000	939,000
Consumption 2/	1,220,000	1,240,000	W	1,410,000	1,400,000
Rutile concentrate, natural and synthetic:					
Imports for consumption	317,000	371,000	332,000	318,000	324,000
Consumption	461,000	465,000	510,000	480,000	398,000
Sponge metal:					
Production	W	W	W	W	W
Imports for consumption	684	2,160	6,470	7,560	10,100
Consumption	14,200	15,100	17,200	21,500	28,400
Price, Dec. 31, per pound	$3.50-$4.00	$3.50-$4.00	$3.75-$4.25	$4.24-$4.50	4.25-$4.50
Titanium dioxide pigment:					
Production	1,140,000	1,160,000	1,250,000	1,250,000	1,230,000
Imports for consumption	169,000	172,000	176,000	183,000	167,000
Consumption, apparent 3/	1,000,000	1,030,000	1,090,000	1,080,000	1,070,000
Price, Dec. 31, cents per pound:					
Anatase	99	99	94-96	92-96	1.06-1.08
Rutile	92-95	92-95	92-94	99-103	1.08-1.10
World production:					
Ilmenite concentrate 4/	3,920,000 r/	4,000,000 r/	3,050,000 r/	3,970,000 r/	3,990,000 e/
Rutile concentrate, natural 4/	491,000 r/	501,000 r/	546,000 r/	416,000 r/	415,000 e/
Titaniferous slag	1,640,000	1,550,000	1,510,000	1,810,000	1,940,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits; except prices.

2/ Includes consumption to produce synthetic rutile.

3/ Production plus imports minus exports plus stock decrease or minus stock increase.

4/ Excludes U.S. production data to avoid disclosing company proprietary data.

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 1996 1/

		Yearend capacity (metric tons)	
Company	Plant location	Sponge	Ingot 2/
Allvac	Monroe, NC	--	9,500 3/
Howmet Corp.,Titanium Ingot Div.	Whitehall, MI	--	3,200
Lawrence Aviation Industries Inc.	Port Jefferson, NY	--	1,400
Oregon Metallurgical Corp. (Oremet)	Albany, OR	6,800	10,000
RMI Titanium Co.	Niles, OH	--	16,300
Titanium Hearth Technologies Inc.	Morgantown, PA	--	13,600 4/
	Verdi, NV	--	2,700 4/
Titanium Metals Corp.	Henderson, NV	22,700	15,900
	Pomona, CA	--	2,000
Wah Chang	Albany, OR	--	900
Wyman-Gordon Co.	Worcester, MA	--	2,300
Total		29,500	77,800

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Based on 7-day-per-week full production. Includes 59,200 tons vacuum-arc double-triple melt, of which triple melt generally ranged from 10% to 30%. The remaining 18,600 tons was cold hearth (electron-beam and plasma) capacity.

3/ Includes 2,300 tons of cold hearth capacity.

4/ Cold hearth.

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

(Metric tons)

Component	1995	1996
Production:		
Sponge	W	W
Ingot	39,800	51,400
Mill products	23,300	30,700
Exports:		
Sponge	225	528
Other unwrought	603	471
Scrap	3,420	3,410
Ingot, slab, sheet bar, etc.	1,960	3,820
Other articles of titanium	4,580	4,530
Total	10,800	12,800
Imports:		
Sponge	7,560	10,100
Scrap	11,100	16,400
Ingot and billet	1,880	2,590
Other unwrought	1,180	595
Other wrought (mill products)	1,600	5,890
Other articles of titanium	272	261
Total	23,600	35,800
Stocks, yearend:		
Government: Sponge (total inventory)	33,400	33,200
Industry:		
Sponge	5,270	4,390
Scrap	9,430	15,900
Ingot	3,560	4,710
Other	W	W
Total industry	18,300	25,000
Reported consumption:		
Sponge	21,500	28,400
Scrap	20,500	26,300
Receipts:		
Home	11,800	14,400
Purchased	18,000	24,500
Ingot	30,600	38,300
Mill products (net shipments):	19,800	25,900
Forging and extrusion billet	8,820	11,200
Rod and bar	2,770	3,100
Other 2/	8,180	11,600
Castings (shipments)	479	680

W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Data for sheet and strip, plate, extrusions (other than tubing), pipe and tubing, and other have been combined to avoid disclosing company proprietary data.

TABLE 4
CAPACITIES OF U.S. TITANIUM DIOXIDE PIGMENT PLANTS ON DECEMBER 31, 1996 1/ 2/

		Yearend capacity (metric tons per year)		
Company	Plant location	Sulfate process	Chloride process	Total
E. I. du Pont de Nemours & Co. Inc.:	Antioch, CA	--	36,000	36,000
	De Lisle, MS	--	280,000	280,000
	Edge Moor, DE	--	128,000	128,000
	New Johnsonville, TN	--	320,000	320,000
Kemira, Inc.	Savannah, GA	54,000	91,000	145,000
Kerr-McGee Chemical Corp.	Hamilton, MS	--	145,000	145,000
Louisiana Pigment Co. LP	Lake Charles, LA	--	110,000	110,000
SCM Chemicals Inc.	Ashtabula, OH	--	190,000	190,000
Do.	Baltimore, MD	66,000	51,000	117,000
Total		120,000	1,350,000	1,470,000

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Table does not include Hitox Corp.'s Corpus Christi, TX, production capacity of about 16,400 tons per year of buff TiO2 pigment that is produced by refining and fine grinding of synthetic rutile.

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

(Metric tons unless otherwise specified)

		1995		1996	
		Gross weight	TiO2 content	Gross weight	TiO2 content
Production 2/		1,250,000	1,180,000	1,230,000	1,160,000
Shipments: 3/					
Quantity		1,330,000	1,210,000	1,330,000	1,250,000
Value	thousands	$2,540,000	$2,540,000	$2,520,000	$2,520,000
Exports		342,000	321,000 e/	332,000	312,000 e/
Imports for consumption		183,000	172,000 e/	167,000	157,000 e/
Stocks, yearend		120,000	113,000 e/	107,000	100,000 e/
Consumption, apparent 4/		1,080,000	1,020,000 e/	1,070,000	1,010,000 e/

e/ Estimated.

1/ Data are rounded to three significant digits.

2/ Excludes production of buff pigment.

3/ Includes interplant transfers.

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

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

TABLE 6
U.S. CONSUMPTION OF TITANIUM CONCENTRATES 1/

(Metric tons)

	Ilmenite and titanium slag 2/ 3/		Rutile (natural and synthetic)	
	Gross weight	TiO2 content	Gross weight	TiO2 content
1995:				
Pigments	1,410,000 r/	1,010,000 r/	453,000	417,000
Miscellaneous 4/	(5/)	(5/)	27,300	22,300
Total	1,410,000	1,010,000	480000	439000
1996:				
Pigments	1,400,000	1,010,000	372,000	341,000
Miscellaneous 4/	(5/)	(5/)	26,400	24,200
Total	1,400,000	1,010,000	398000	365000

r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

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

3/ Includes ilmenite consumed to produce synthetic rutile.

4/ Includes alloys, carbide, welding-rod coatings and fluxes, ceramics, chemicals, glass fibers, synthetic rutile, and titanium metal.

5/ Included with "Pigments" to avoid disclosing company proprietary data.

TABLE 7
U.S. CONSUMPTION OF TITANIUM PRODUCTS 1/ 2/
IN STEEL AND OTHER ALLOYS

(Metric tons)

	1995	1996
Carbon steel	2,340	3,090
Stainless and heat-resisting steel	1,600	1,550
Other alloy steel (includes HSLA)	533 r/	690
Tool steel	W	W
Total steel	4,460 r/	5,330
Cast irons	W	W
Superalloys	734	747
Alloys, other than above	384	63
Miscellaneous and unspecified	132	1,170
Total consumption	5,710 r/	7,310

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

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

2/ Data are rounded to three significant digits; may not add to totals shown.

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

(Percent)

Industry	1995	1996
Ceramics	0.3	W
Coated fabrics and textiles	.3	W
Floor coverings	1.0	0.3
Paint, varnish, lacquer	46.9	48.1
Paper	24.8	W
Plastics	17.7	19.0
Printing ink	1.3	.4
Roofing granules	W	W
Rubber	1.5	1.2
Other 1/	6.2	31.0
Total	100.0	100.0

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Includes agricultural, building materials, ceramics, coated fabrics and textiles, cosmetics, food, and paper.

TABLE 9
U.S. STOCKS OF TITANIUM CONCENTRATES AND PIGMENT,
DECEMBER 31 1/

(Metric tons)

	1995		1996	
	Gross weight	TiO2 content	Gross weight	TiO2 content
Concentrates: 2/				
Ilmenite and titanium slag	201,000	137,000	353,000	267,000
Rutile	54,700	52,300	85,100	77,100
Titanium pigment 3/	120,000	113,000 e/	107,000	100,000 e/

e/ Estimated.

1/ Data are rounded to three significant digits.

2/ Consumer stocks.

3/ Data from Bureau of the Census. Producer stocks only.

TABLE 10
YEAREND PUBLISHED PRICES OF TITANIUM CONCENTRATES AND PRODUCTS

		1995	1996
Concentrates:			
Ilmenite, f.o.b. Australian ports	per metric ton	$81.00-$85.00	$82.00-$92.00
Rutile, bagged, f.o.b. Australian ports	do.	650.00-800.00	700.00-800.00
Rutile, bulk, f.o.b. Australian ports	do.	550.00-650.00	525.00-600.00
Titanium slag, 80% TiO2, Canada e/	do.	244.00	292.00
Titanium slag, 85% TiO2, South Africa e/	do.	349.00	353.00
Metal:			
Sponge	per pound	4.25- 4.50	4.25- 4.50
Ferrotitanium	do.	1.73- 1.76	1.68- 1.75
Scrap; turnings, unprocessed	do.	0.90- 0.95	0.85- 0.90
Pigment:			
Titanium dioxide pigment, f.o.b. U.S. plants, anatase	do.	.92- .96	1.06- 1.08
Titanium dioxide pigment, f.o.b. U.S. plants, rutile	do.	.99- 1.03	1.08- 1.10

e/ Estimated.

Sources: American Metal Market, American Paint and Coatings Journal, Chemical Market Reporter, Industrial Minerals (London), Metal Bulletin, Platt's Metals Week, and industry contacts.

TABLE 11
U.S. EXPORTS OF TITANIUM PRODUCTS, BY CLASS 1/

Class	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Metal:				
Sponge	255	$1,090	528	$2,820
Scrap	3,420	9,120	3,410	9,050
Other unwrought:				
Billet	343	5,740	489	11,300
Blooms and sheet bars	1,130	25,500	3,060	59,300
Ingot	483	7,860	269	4,520
Other	603	7,370	471	9,140
Wrought:				
Bars and rods	2,030	45,700	1,400	46,100
Other	2,560	117,000	3,130	157,000
Total	10,800	219,000	12,800	299,000
Ores and concentrates	32,300	12,000	15,500	5,890
Pigment and oxides:				
Titanium dioxide pigments	306,000	524,000	292,000	499,000
Titanium oxides	36,000	65,600	40,600	73,800
Total	342,000	589,000	332,000	572,000

1/ Data are rounded to three significant digits, may not add to totals shown.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATES, BY COUNTRY 1/

Concentrate and country	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Ilmenite:				
Australia	294,000	$19,100	359,000	$23,200
India	62,100	9,660	114,000	8,390
Other	117,000	5,300	45,300	3,050
Total	473,000	34,000	518,000	34,600
Titanium slag:				
Canada	41,200	11,300	11,500	3,370
South Africa	347,000	121,000	410,000	146,000
Total	388,000	132,000	421,000	149,000
Rutile, natural:				
Australia	61,700	25,200	46,000	18,700
Sierra Leone	10,600	4,040	--	--
South Africa	114,000	41,600	135,000	52,100
Other	5,460	2,780	1,180	961
Total	192,000	73,600	182,000	71,800
Rutile, synthetic:				
Australia	122,000	53,900	108,000	41,200
Malaysia	4,940	2,960	6,850	3,850
Other	43	26	27,200	1,640
Total	127,000	56,900	142,000	46,700
Titaniferous iron ore: 2/				
Canada	88,400	5,200	90,200	7,920

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregated and steel-furnace flux.

Source: Bureau of the Census. Data adjusted by the U.S. Geological Survey.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY 1/

Class and country	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Unwrought:				
Sponge:				
China	478	$2,860	833	$5,790
Japan	1,140	9,100	4,400	36,000
Russia	5,490	21,200	3,570	21,200
United Kingdom	37	205	71	502
Other	415	1,770	1,230	7,370
Total	7,560	35,200	10,100	70,800
Waste and scrap:				
Canada	368	1,050	408	1,400
France	364	1,370	847	4,650
Germany	613	2,720	559	3,000
Japan	1,830	6,540	2,620	11,600
Russia	3,800	15,600	5,490	32,000
United Kingdom	2,350	9,480	3,770	18,400
Other	1,780	6,700 r/	2,680	11,000
Total	11,100	43,500	16,400	82,100
Ingot and billets:				
Russia	918	6,150	1,550	17,200
United Kingdom	622	7,040	635	9,910
Other	342	5,950	409	7,750
Total	1,880	19,100	2,590	34,800
Powder	238	1,720	240	3,180
Other: 2/				
Russia	430	2,870	289	3,370
Other	511 r/	1,190 r/	66	260
Total	941	4,070	355	3,790
Wrought products and castings: 3/				
Japan	515 r/	15,700 r/	306	13,900
Russia	1,010 r/	10,900 r/	4,730	51,200
United Kingdom	468 r/	8,900 r/	564	14,900
Other	320	9,230 r/	545	15,300
Total	2,310 r/	44,700 r/	6,140	95,300

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Includes blooms, sheet, bars, slabs, and other unwrought.
3/ Includes bars, castings, foil, pipes, plates, profiles, rods, sheet, strip, tubes, wire, and other.

Source: Bureau of the Census.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENTS, BY COUNTRY 1/

Country	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
80% or more titanium dioxide:				
Belgium	792	$1,230	1,020	$1,640
Canada	61,600	102,000	64,900	103,000
China	3,620	3,820	771	961
Finland	2,430	4,900	966	1,970
France	5,560	9,840	2,830	4,920
Germany	21,300	45,700	14,500	34,000
Japan	6,000	13,900	4,210	10,600
Norway	4,400	6,690	5,410	8,540
Singapore	4,450	7,020	4,340	6,990
United Kingdom	1,680	2,770	202	369
Other	8,950	14,200	5,010	8,050
Total	121,000	212,000	104,000	181,000
Other titanium dioxide:				
Canada	17,000	27,800	989	1,970
France	8,120	13,000	9,780	12,900
Germany	1,260	7,140	1,330	10,100
South Africa	6,280	9,760	5,790	7,900
Spain	1,250	2,390	13,900	18,000
United Kingdom	3,300	5,890	3,540	7,120

See footnotes at end of table.

TABLE 14--Continued
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENTS, BY COUNTRY 1/

Country	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Other titanium dioxide--Continued:				
Other	3,180	$7,920	4,100	$7,750
Total	40,400	73,900	39,400	65,700
Titanium oxide:				
Belgium	2,610	4,060	2,290	3,470
Canada	8,560	13,700	2,930	4,920
France	6,740	9,550	5,230	7,520
Germany	654	1,160	8,230	15,100
Norway	68	131	19	30
Other	3,210	9,410	4,800	12,200
Total	21,800	38,000	23,500	43,200
Grand total	183,000	323,000	167,000	290,000

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 15
TITANIUM: WORLD PRODUCTION OF CONCENTRATES (ILMENITE, LEUCOXENE, RUTILE AND TITANIFEROUS SLAG), BY COUNTRY 1/ 2/

(Metric tons)

Concentrate type and country	1992	1993	1994	1995	1996 e/
Ilmenite and leucoxene: 3/					
Australia:					
Ilmenite	1,786,000	1,804,000	1,782,000	1,980,000 r/	2,028,000 4/
Leucoxene	20,000	21,000	35,000	31,000	30,000 4/
Brazil 5/	76,558	90,567	97,439	102,125	105,000
China e/	150,000	155,000	155,000	160,000	165,000
India e/	300,000	320,000	300,000	300,000	300,000
Malaysia	337,744	288,950	115,885	151,680	244,642 4/
Norway	708,000	713,000	826,000	833,000 r/	750,000
Portugal e/	30	25	20	--	--
Sierra Leone	60,331	62,900	47,400	-- e/	--
Sri Lanka	33,283	76,930	60,445	49,655 r/	62,810 4/
Thailand	2,967	20,821	1,677	33	--
Ukraine	450,000 r/	450,000 r/ e/	530,000 r/	359,000 r/	300,000
United States	W	W	W	W	W
Total	3,920,000 r/	4,000,000 r/	3,950,000 r/	3,970,000 r/	3,990,000
Rutile:					
Australia	183,000	186,000	233,000	195,000 r/	180,000 4/
Brazil	1,798	1,744	1,911	1,985 r/	2,000
India e/	10,000	13,900	14,000	14,000	14,000
Sierra Leone	148,990	152,000	137,000	-- e/	--
South Africa e/	84,000	85,000	78,000	90,000	115,000
Sri Lanka	2,741	2,643	2,410	2,697 r/	3,532 4/
Thailand	281	87	49	--	--
Ukraine	60,000 r/	60,000 r/ e/	80,000 r/	112,000 r/	100,000
United States	W	W	W	W	W
Total	491,000 r/	501,000 r/	546,000 r/	416,000 r/	415,000
Titaniferous slag: 6/					
Canada 7/	753,000	653,000	764,000	815,000 e/	950,000
South Africa 8/ 9/	884,000	892,000	744,000 e/	990,000 e/	990,000
Total	1,640,000	1,550,000	1,510,000	1,810,000	1,940,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

1/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through July 22, 1997.

3/ Ilmenite is also produced in Canada and South Africa, but this output is not included here because an estimated 90% 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.

4/ Reported figure.

5/ Excludes production of unbeneficiated anatase ore.

6/ Slag is also produced in Norway but is not included under "Titaniferous slag" to avoid duplicative reporting. Beginning in 1990, about 25% of Norway's ilmenite production was used to produce slag containing 75% TiO_2.

7/ TiO_2 content in 1992-96 is not reported.

8/ Contains 85% TiO_2.

9/ Excludes 42,000 to 48,000 metric tons of titanium slag from Highveld Steel.