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2005 Minerals Yearbook

ZIRCONIUM AND HAFNIUM

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Zirconium and Hafnium

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In 2005, global demand for zirconium minerals continued to exceed supply. The cause of the shortage was the result of several factors, including increased demand, the closure of some zircon-producing mines, and reduced zircon grades at a few mines. China's tremendous economic growth significantly influenced the price and availability of zirconium minerals. Although domestic list prices of standard-grade zircon decreased, domestic premium-grade zircon prices reflected the increase in global demand.

The principal economic source of zirconium is the zirconium silicate mineral zircon ($ZrSiO_4$). A relatively small quantity of zirconium is derived from the mineral baddeleyite, a natural form of zirconium oxide or zirconia (ZrO_2). In 2005, zircon, the principal ore material, was mined at many locations worldwide, primarily Australia, South Africa, and the United States. Baddeleyite was produced from a single source at Kovdor, Russia.

Zircon is the primary source of hafnium. Zirconium and hafnium are contained in zircon at a ratio of about 50 to 1. Zircon is a coproduct or byproduct of the mining and processing of heavy-mineral sands for the titanium minerals ilmenite and rutile or for tin minerals. The major end uses of zircon, in descending order of quantity, are refractories, foundry sands (including investment casting), and ceramic opacification. Zircon is also marketed as a natural gemstone and is processed to produce cubic zirconia, a diamond and colored gemstone simulant. Zirconium metal is used in nuclear fuel cladding, chemical piping, pumps, and valves in corrosive environments, heat exchangers, and various specialty alloys.

The principal uses of hafnium are in nuclear control rods, nickel-base superalloys, nozzles for plasma arc metal cutting, and high-temperature ceramics.

World production of zirconium mineral concentrates in 2005, excluding U.S. production, was estimated to be about the same level as it was in 2004. Domestic production of zircon increased moderately in 2005 compared with production in 2004. In 2005, production of milled zircon and zirconium oxide increased when compared with that of 2004. The United States was a net exporter of zirconium ore and concentrates. U.S. imports of zirconium ore and concentrates in 2005 increased by 8% compared with those of 2004, and domestic exports of zirconium ore and concentrate increased by 47%.

With the exception of prices and referenced data, all survey data in this report have been rounded to no more than three significant digits. Totals and percentages were calculated from unrounded numbers.

Production

Data for zirconium and hafnium manufactured materials are developed by the U.S. Geological Survey from a voluntary survey of domestic operations. Of the 43 operations surveyed, 31 did not respond. Data for nonrespondents were estimated on the basis of prior-year levels.

Data for zircon concentrates are developed by a second voluntary survey of domestic mining operations. Of the two domestic zircon producers, which had four mining and processing operations, 100% responded. Data on domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data.

Domestic production of milled zircon was unchanged and of zirconium oxide decreased by 6% from their 2004 levels (table 1). Domestic production of zircon concentrate in 2005 decreased by about 6% compared with that of 2004.

Zircon is normally produced as a byproduct of the mining and processing of heavy-mineral sands containing the titanium minerals ilmenite and rutile. In 2005, U.S. producers of zircon were DuPont Titanium Technologies [a subsidiary of E.I. du Pont de Nemours & Co. (DuPont)] and Iluka Resources, Inc. (a subsidiary of Australian company Iluka Resources Ltd.). DuPont produced zircon from its heavy-mineral sands operation near Starke, FL. Iluka produced zircon from its heavy-mineral sand operations at Green Cove Springs, FL, Lulaton, GA, and Stony Creek, VA.

In December, Iluka announced plans for a staged closure of its Florida and Georgia mining operations beginning in 2006. The closure was attributed in part to financial losses from mining small, thin, and disparate low-grade deposits and rising operating costs. Although the Florida operations had been producing heavy minerals since 1972, the Georgia operations were commissioned in 2004.

U.S. producers of zirconium and hafnium metal were Wah Chang (an Allegheny Technologies, Inc. company), Albany, OR, and Western Zirconium (a subsidiary of Westinghouse Electric Co.), Ogden, UT. Primary zirconium chemicals, those produced directly from zircon, were produced by Wah Chang and Magnesium Elektron Inc., Flemington, NJ. Secondary zirconium chemicals, produced from intermediate zirconium chemicals, were produced by about 10 companies. Zirconia was produced from zircon sand at plants in several States.

Consumption

Approximately 95% of the consumption of zirconium is as zircon, zirconium oxide, or other zirconium chemicals. The remainder is consumed as zirconium metal and zirconium-containing alloys.

Zircon, used for facings on foundry molds, increases resistance to metal penetration and gives a uniform finish to castings. Milled or ground zircon is used in refractory paints for coating the surfaces of molds. In the form of refractory bricks

and blocks, zircon is used in furnaces and hearths for containing molten metals. Glass tank furnaces use fused-cast and bonded alumina-zirconia-silica-base refractories. Baddeleyite is used principally in the manufacture of alumina-zirconia abrasive and in ceramic colors and refractories.

Stabilized zirconium oxide exhibits high light reflectivity and good thermal stability and is primarily used as an opacifier and pigment in glazes and colors for pottery and other ceramic products. Yttria-stabilized zirconia (YSZ) is used in the manufacture of oxygen sensors that control combustion in furnaces and automobile engines. YSZ is also used in the manufacture of a diverse array of products, including high-temperature, high-strength structural ceramics, heat- and break-resistant shirt buttons, golf shoe spikes, golf putters, fiber optic connector components, refractory coatings for jet engines, and cubic zirconia, a gemstone simulant for diamonds and colored gemstones. YSZ is increasingly used in dental applications as inlays, crowns, and bridges as it has two to three times the fracture resistance and 1.4 times the strength of similar alumina products.

Ammonium- and potassium-zirconium carbonates are used as paper and board coatings or insolubilizers for high-quality print performance. Zirconium chemicals are also used in inks to promote adhesion to metals and plastics and as crosslinkers in polymers and printing inks.

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal is used as cladding for nuclear fuel rods. Commercial-grade zirconium, unlike nuclear grade, contains hafnium and is used in the chemical process industries because of its excellent corrosion resistance.

Hafnium is used in nuclear control rods because of its high thermal neutron absorption cross section. However, the leading end use for hafnium metal is as an alloy addition in superalloys.

Prices

In 2005, increased demand for zircon concentrates resulted in increased prices. The average value of imported ore and concentrates increased to $674 per metric ton in 2005 from $477 per ton in 2004. The average value of zircon ore and concentrates exports increased to $734 per ton in 2005 from $661 per ton in 2004.

Published prices for bulk grades of zircon, free on board, increased for ceramic, refractory, and foundry grades (Industrial Minerals, 2005). Australian zircon prices increased to $620 to $700 per ton at yearend 2005 from $450 to $550 per ton at yearend 2004. U.S. prices for premium-grade zircon concentrate increased to $562 per ton in 2005 from a revised $462 per ton in 2004 (table 2). In contrast to all other zirconium concentrate prices, the published price for standard grade zircon decreased to $415 per ton in 2005 from $455 per ton in 2004.

Foreign Trade

The United States was a net exporter of zirconium ore and concentrates in 2005. U.S. exports of zirconium ore and concentrates were 101,000 metric tons (t), a 47% increase from those of 2004 (table 3). The United States was a net exporter of zirconium and hafnium metal in 2005. U.S. exports of zirconium metal were 1,970 t, a 16% increase in quantity from the 2004 level. U.S. zirconium metal exports and imports are classified under the Harmonized Tariff Schedule of the United States (HTS) with tariff numbers falling under the 8109 prefix. In 2005, the majority (84%) of zirconium metal was exported in wrought products.

U.S. imports of zirconium ore and concentrates were 38,200 t, an increase of 8% from the 35,200 t imported in 2004 (table 4). Australia and South Africa supplied 93% of the imports of ores and concentrates. Imports of unwrought zirconium were 269 t in 2005, and the leading sources, in descending order of quantity, were France (86%), Germany (10%), and Japan (4%). Imports of zirconium waste and scrap were 14 t in 2005, and the leading sources, in descending order of quantity, were Japan (57%), Germany (29%), and Canada (14%). Domestic imports of ferrozirconium alloys were 306 t in 2005, a 85% increase from the 165 t imported in 2004. In 2005, ferrozirconium imports originated primarily from Brazil (99%). U.S. imports of hafnium were 4 t in 2005, unchanged compared with those of 2004.

World Industry Structure

Excluding U.S. production, world production of zirconium mineral concentrates in 2005 was estimated to be 881,000 t, essentially the same as that of the revised 2004 data (table 5). An Australian publication estimated that world zirconium mineral production increased to 1.18 million metric tons (Mt) in 2005 from 1.15 Mt in 2004 (Mineral Sands Report, 2006).

Australia and South Africa supplied about 69% of all production outside the United States. World reserves of zircon are estimated to be 38 Mt of zirconium oxide. During 2005, because of increased demand for zircon, the heavy-mineral sands industry continued to be active in the exploration and development of mineral deposits on a global basis, particularly in Australia, Kenya, Mozambique, South Africa, and the United States. Major zircon producers, in order of decreasing production capacity, were Iluka (Australia/United States), Richards Bay Minerals (RBM) (South Africa), Namakwa Sands (Pty.) Ltd. (South Africa), Tiwest Joint Venture (Australia), DuPont (United States), Ticor South Africa (Ticor SA) (South Africa), Consolidated Rutile Ltd. (CRL) (Australia), Vilnohirsk State Mining & Metallurgical (Ukraine), Bemax Resources NL (Australia), and Millenium Inorgânica Chemicals do Brasil S/A (Brazil).

Global fused zirconia production was estimated to be in range of 45,000 to 55,000 metric tons per year (t/yr). Capacity was estimated to be 65,000 t/yr. China, India, and the Republic of Korea were identified as major growth markets for stabilized zirconia (Industrial Minerals, 2006a).

World Review

Australia.—Astron Ltd. made plans to proceed with the development of its Donald Heavy Mineral Sands Project in Victoria. Production was scheduled to begin in 2007. Initial mine capacity was expected to be up to 500,000 t/yr of heavy minerals, including 86,000 t/yr of zircon concentrate (Astron Ltd., 2006§)

Australian Zircon NL completed a drilling program at its Mindarie mineral sands project in the western Murray Basin. The deposit was estimated to have 1.6 Mt of measured heavy-mineral resources. Australian Zircon expected to commence production near yearend 2006 (Australian Zircon NL, 2005§[1]).

In December, Bemax began mining at the Pooncarie mineral sands project in the Murray Basin. The company planned to begin trucking heavy-mineral concentrate from the Ginko mine to the Broken Hill mineral separation plant in 2006. The Ginkgo mine was reported to contain 5.8 Mt of heavy minerals, with a mine life of more than 25 years. During 2005, Bemax upgraded its Bunbury mineral separation plant to allow it to simultaneously process feedstock from its Western Australia (Cable Sands) and Murray Basin operations as well as toll feedstock (Bemax Resource NL, 2006§).

Iluka continued work on the development of heavy-mineral deposits in the Murray and Eucla Basins. In 2004, Iluka started stockpiling ore for its Douglas project in the Murray Basin, Victoria. By yearend 2005, Iluka had completed mine construction and was preparing to commission the wet concentration plant for the Douglas project. A mineral separation plant located near Hamilton was expected to be completed in mid-2006. In the first year of operation, production was expected to be 180,000 t of rutile and zircon. In the northern Murray Basin, Iluka was in the prefeasibility phase in the development of its Euston and Ouyen deposits. In the Eucla Basin, Iluka continued the delineation of its Ambrosia, Jacinth, and Tripitaka deposits (Iluka Resources Ltd., 2006§).

Olympia Resources Ltd. announced the completion of a bankable feasibility study for its Keysbrook mineral sands project, south of Perth. Keysbrook was expected to have a mine life of 11 years (Olympia Resources Ltd., 2005§). Olympia has identified a reserve of 1.2 Mt of heavy minerals at Keysbrook with startup scheduled for 2007 (Olympia Resources Ltd., 2006§).

Canada.—Titanium Corp., Inc. continued efforts to commercialize the recovery of heavy-minerals from the oil sands tailings of Syncrude Canada Ltd. in Alberta. In 2005, Titanium Corp. used its pilot facility to optimize the recovery of heavy minerals and improve product quality. At yearend, the company began a drill core analysis program to quantify the heavy-mineral resource in the oil sands project (Titanium Corp., Inc., 2006§).

China.—Astron Ltd. announced plans to increase production capacity of its range of monoclinic zirconia at its Bayuchuan operation to 16,000 t/yr from 13,000 t/yr though process improvements. In addition, two new 3,000-t/yr furnaces dedicated to stabilized zirconia were expected to begin production by yearend 2006. The new furnaces were expected to raise the operation's stabilized zirconia capacity to 7,000 t/yr (Industrial Minerals, 2005).

Gambia,The.—Carnegie Corp. Ltd. completed a trial dredge program at the Sanyang heavy-mineral sands deposit. In 2004, the company completed an environmental impact assessment and received approval for its environmental management plan. At yearend 2005, the company was waiting for the approval of the mining lease (Carnegie Corp. Ltd., 2005§). The project is a joint venture with Aston Ltd. and could yield 20,000 t/yr of zircon (Industrial Minerals, 2005).

Kenya.—Tiomin Resources Inc. continued the development of its Kwale heavy-mineral sands project located 40 kilometers south of Mombasa. In 2005, Tiomin was engaged in project financing and announced it had secured sales agreements with two Chinese firms for future output from the mine. The construction phase of the project was expected to begin in 2006. When completed, the project was expected to produce about 330,000 t/yr of ilmenite, 75,000 t/yr of rutile, and 40,000 t/yr of zircon (Tiomin Resources Inc., 2005§).

Madagascar.—In August, Rio Tinto plc announced the approval to fund the development of the Fort-Dauphin mineral sands project. The project was being developed by QIT Madagascar Minerals (QMM) [a Malagasy subsidiary of Rio Tinto (80%) and the Government of Madagascar (20%)]. Part of the project requires the construction of a deep-sea port funded by public and private interests. Mine production was expected to reach 750,000 t/yr of ilmenite and 25,000 t/yr of zircon. Mining startup was scheduled for 2008. The mine life could extend for 40 years (Rio Tinto plc, 2005§).

Mozambique.—At yearend, Kenmare Resources plc. was midway through the construction phase of its Moma heavy-mineral sands project. Commissioning of the wet and dry separation plants was expected by yearend 2006. Production capacity from the mine was expected to reach 701,000 t/yr of ilmenite, 17,000 t/yr of rutile, and 60,000 t/yr of zircon (Kenmare Resources plc., 2006§).

In March, BHP Billiton Ltd. acquired Australian-based WMC Resources Ltd. The acquisition brought BHP's interest in the Corridor Sands project in southern Mozambique to 90%. In 2005, BHP was reviewing and updating previously conducted feasibility studies prior to making a decision whether to move into the feasibility phase during 2006. In 2004, BHP also held a 100% interest in the TiGen heavy-minerals project in Moebase. A prefeasibility study was completed for the TiGen project, and market studies were being examined to determine when the project should move into the feasibility phase (BHP Billiton plc, 2005§).

Russia.—In 2005, production of baddeleyite at Kovdorsky GOK reached 6,700 t, a record level. The company had completed a program to upgrade and modernize the operation. Baddeleyite shipments in 2004 were 6,470 t (Industrial Minerals, 2006b).

Senegal.—Mineral Deposits Ltd. (MDL) made plans to relocate its Australian-based dredge and wet concentration plant to its Grande Côte heavy-mineral sands project. The project is located within the Senegal-Mauritania Basin along the northwestern coast of Senegal, south of St. Louis. MDL hoped to commence production in 2007 with a mine capacity of about 75,000 t/yr of zircon and 14,000 t/yr of leucoxene (Mineral Deposits Ltd., 2005§).

South Africa.—Australian-based Kumba Resources Ltd. acquired the outstanding 40% interest in the heavy-mineral producer Ticor SA. In 2005, Ticor SA's heavy minerals operation near Empangeni, KwaZulu-Natal Province, produced 47,000 t of zircon, a 4% decrease compared with output in 2004 (Kumba Resources Ltd., 2006§).

[1]References that include a section mark (§) are found in the Internet References Cited section.

In parallel with the production of titanium heavy minerals, zircon production at RBM in KwaZulu-Natal Province, increased significantly. In 2005, zircon production increased by 16% compared with that of 2004. RBM is the trading name for two companies, Tisand (Pty) Ltd. and Richards Bay Iron and Titanium (Pty) Ltd. Ownership interest in RBM is shared equally between Rio Tinto plc and BHP Billiton plc. (Rio Tinto plc, 2006§).

Namakwa Sands improved recovery and raised rutile and zircon production at the Namakwa Sands heavy-mineral sands operation near Brand se Baai. In 2005, Namakwa Sands began an expansion project to increase rutile output by 26% and zircon production by approximately 20%. Namakwa Sands is wholly owned by Anglo American plc (Anglo American plc, 2006§).

Outlook

The global shortage of zirconium materials was expected to continue in 2006. Growth in demand of 3% to 5% per year through the next decade was expected, and new deposits were expected to come online to improve the supply. Increased demand relative to the available supply will contribute to continued pressure for price increases in the short term, especially in the spot market.

Beyond the next few years, supply and demand for zircon are expected to be in closer balance as new deposits and plant expansions come online. Expansions in supply are expected in Australia, Madagascar, Mozambique, and South Africa.

A new trend in the heavy-mineral sands industry appears to be the sale of semiprocessed concentrates. In 2005, several projects were underway that did not include an integrated facility for mineral separation.

References Cited

BHP Billiton plc, 2005, Form 20-F/A—2005: Securities and Exchange Commission, 207 p.

Industrial Minerals, 2005, Astron expands fused zirconia capacity: Industrial Minerals, no. 457, October, p. 7.

Industrial Minerals, 2006a, Fused zirconia—Growth with stability: Industrial Minerals, no. 460, January, p. 20-28.

Industrial Minerals, 2006b, Kovdor ups baddeleyite output: Industrial Minerals, no. 462, March, p. 19.

Mineral Sands Report, 2006, The 18th Industrial Minerals Congress: Mineral Sands Report, no. 126, April, p. 10.

Internet References Cited

Anglo American plc, 2006 (March 8), Annual report 2005, accessed July 12, 2006, at URL http://www.angloamerican.co.za/static/uploads/Anglo%20American_Fact_Book%2005-06.pdf.

Astron Ltd., 2006, Astron announces resource estimate increase, accessed July 18, 2006, at URL http://www.astronchem.com/english/investors/200601/Resource%20Estimate%20Increase%20at%20Donald%20Mineral%20Sands%20Project.pdf.

Australian Zircon NL, 2005 (October 12), Annual report 2005, accessed July 12, 2006, at URL http://www.auzircon.com.au/mmedia/Annual%20Reports/2005%20AZC%20Ann%20Rep.pdf.

Bemax Resources NL, 2006 (April 19), Annual report 2005, accessed July 12, 2006, at URL http://www.bemax.com.au/annual/2005AnnualReport.pdf.

Carnegie Corp. Ltd., 2005 (September 22), Annual report 2005, accessed July 12, 2006, at URL http://www.carnegiecorp.com.au/news/reports/2005/CNM_Annual_Report_2005.pdf

Iluka Resources Ltd., 2006 (March 24), Concise annual report 2005, accessed June 27, 2006, via URL http://www.iluka.com/content/investor/publications.asp?type=repo.

Kenmare Resources plc., 2006 (June 14), Annual report 2005, accessed July 12, 2006, at URL http://www.kenmareresources.com/pdf/kenmare_annual_report_05.pdf.

Kumba Resource Ltd., 2006 (March 17), Annual report 2005, accessed July 17, 2006, at URL http://www.kumbaresources.com/contents/results/kumbaannualreport2005/pdf/Kumba%20A4%20AR%202005.pdf.

Mineral Deposits Ltd., 2005 (October 17), Annual report, accessed August 10, 2006, via URL http://www.mineraldeposits.com.au/2005AnnualReport.html.

Olympia Resources Ltd., 2005 (September 16), Keysbrook mineral sands project bankable feasibility study complete, accessed July 17, 2006, via URL http://www.olympiaresources.com/News/CustomerandProductNews.aspx.

Olympia Resources Ltd., 2006 (February 1), Olympia Resources signs long-term zircon contract, accessed July 18, 2006, via URL http://www.olympiaresources.com/News/CustomerandProductNews.aspx.

Rio Tinto plc, 2005 (September), New projects in new places, at URL http://www.riotinto.com/library/reviewmagazine/75/article1-1.aspx.

Rio Tinto plc, 2006 (February 24), Annual report—2005, accessed July 17, 2006, at URL http://www.riotinto.com/library/reports/PDFs/2005_Annualreview.pdf.

Tiomin Resources Inc., 2005 (December 31), Annual report—2005, accessed July 13, 2006, at URL http://www.tiomin.com/i/pdf/2005AR.pdf.

Titanium Corp., Inc., 2006 (January 12), Annual report 2005, accessed August 10, 2006, at URL http://www.titaniumcorporation.com/i/pdf/2005AR.pdf.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Zirconium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Zirconium. International Strategic Minerals Inventory Summary Report, Circular 930-L, 1992.

Zirconium and Hafnium. Ch. in Mineral Commodity Summaries, annual.

Other

American Metal Market, daily.

Chemical Engineering, biweekly.

Chemical Week, weekly.

Engineering and Mining Journal, monthly.

Industrial Minerals, monthly.

International Titanium Association.

Metal Bulletin, semiweekly.

Mineral Sands Report, bimonthly and monthly.

Mining Engineering, monthly.

Mining Magazine and Mining Journal, monthly and weekly.

Roskill Information Services Ltd.

U.S. Department of Commerce, U.S. Census Bureau, monthly trade statistics.

Zirconium and Hafnium. Ch. In Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

TABLE 1
SALIENT U.S. ZIRCONIUM STATISTICS[1]

(Metric tons)

	2001	2002	2003	2004	2005
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon (ZrO_2 content)	59,100	37,000	35,200	31,400	31,400
Exports[r]	66,900	47,100	70,600	68,800	101,000
Imports for consumption[r, 2]	60,600	35,300	37,400	35,200	38,200
Consumption, apparent[2, 3]	W	W	W	W	W
Stocks, December 31 (ZrO2 content), dealers and consumers[4]	37,700	21,600	27,900	16,700	16,100
Zirconium oxide:					
Production (ZrO_2 content)[5]	21,500	17,600	20,400	21,300	19,900
Exports[6]	2,400	1,950	1,520	1,600	2,260
Imports for consumption[6]	2,950	2,900	2,350	3,960	3,160
Consumption, apparent[3]	24,600	18,300	20,700	23,700	21,000
Stocks, December 31, producers[5]	2,730	2,490	2,030	2,070	2,210
Zirconium; unwrought powder, waste and scrap, other:					
Exports	1,380	1,640	1,700	1,700	1,970
Imports	659	556	542	796	1,020
Ferrozirconium:					
Exports	251	868	1,930	913	65
Imports	240	167	154	165	306
Hafnium; unwrought powder, waste and scrap, other, imports	5	5	5	4	4

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Includes insignificant amounts of baddeleyite.
[3]Defined as production plus imports for consumption minus exports plus or minus government shipments plus or minus stock changes.
[4]Excludes foundries.
[5]Excludes intermediate oxides associated with metal production.
[6]Includes germanium oxides and zirconium dioxides.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM AND HAFNIUM MATERIALS

Specification of material		2004	2005
Zircon:			
Domestic, standard-grade, bulk[1]	dollars per short ton	455.00	415.00
Domestic, premium-grade zircon[1]	do.	462.00 [r]	562.00
Imported sand, ceramic-grade, free on board, bulk[2]	dollars per metric ton	460.00-550.00	620.00-700.00
Imported sand, refractory-grade, free on board[2]	do.	450.00-550.00	620.00-700.00
Imported sand, foundry sand-grade, free on board, bulk[2]	do.	450.00-550.00	620.00-700.00
Baddeleyite, contract price, cost, insurance, and freight main European port:[3]			
Refractories/abrasive grade	dollars per metric ton	2,000-2,400	2,200-2,600
Ceramic grade (98% zirconium oxide and hafnium oxide)	do.	2,600-3,000	2,800-3,200
Zirconium oxide:[4]			
100 kilograms:[5]			
Calcia stabilized zirconia	dollars per kilogram	20.70	20.70
Magnesia stabilized zirconia	do.	21.00	21.00
Yttria (3 mole%) stabilized zirconia	do.	22.40	22.40
Yttria (8 mole%) fully stabilized zirconia	do.	24.10	24.10
1,000 kilograms:[5]			
Calcia stabilized zirconia	dollars per kilogram	18.10	18.10
Magnesia stabilized zirconia	do.	19.40	19.40
Yttria (3 mole%) stabilized zirconia	do.	18.80	18.80
Yttria (8 mole%) fully stabilized zirconia	do.	20.10	20.10

[r]Revised.
[1]Domestic average price.
[2]Source: Industrial Minerals, no. 446, December 2004, p. 73; no. 459, December 2005, p. 71.
[3]Source: Industrial Minerals, no. 446, December 2004, p. 72; no. 459, December 2005, p. 70.
[4]Source: Stanford Materials Corp., [undated], Zirconium (Zr), accessed July 19, 2006, at URL http://www.stanfordmaterials.com/zr.html.
[5]Prices are for bulk quantities; nominal, free on board California.

TABLE 3
U.S. EXPORTS OF ZIRCONIUM, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2004 Quantity (metric tons)	2004 Value (thousands)	2005 Quantity (metric tons)	2005 Value (thousands)
Ore and concentrates:	2615.10.0000				
Argentina		563	$495	1,260	$1,510
Belgium		2,540	1,290	2,330	1,690
Brazil		1,190	1,060	2,380	2,220
Canada		7,750	4,320	12,500	7,390
China		1,380	1,930	873	1,720
Colombia		2,470	2,320	2,600	2,790
Dominican Republic		207	191	85	92
Ecuador		202	184	113	126
France		560	437	1,380	1,010
Georgia		11	10	--	--
Germany		3,850	2,270	622	563
Guyana		--	--	1	5
Hong Kong		6	3	1	4
India		294	391	477	907
Indonesia		14	19	18	27
Ireland		36	52	34	52
Israel		256	330	159	205
Italy		17,700	7,790	25,600	16,600
Japan		2,580	2,800	2,660	3,570
Korea, Republic of		1,480	2,500	1,280	2,970
Malaysia		--	--	73	36
Mexico		11,800	6,620	19,400	11,500
Netherlands		10,100	4,280	23,000	13,700
Pakistan		428	351	68	68
Portugal		9	4	--	--
South Africa		10	21	--	--
Spain		--	--	368	282
Sweden		69	51	69	61
Taiwan		30	115	27	24
Turkey		--	--	1,000	554
United Kingdom		2,880	5,220	2,180	3,970
Venezuela		394	349	312	392
Vietnam		126	109	--	--
Other		7	6	32	24
Total		68,800	45,500	101,000	74,000
Ferrozirconium:	7202.99.1000				
Canada		7	13	6	14
China		18	64	--	--
Germany		8	8	9	9
Japan		--	--	27	27
Korea, Republic of		(3)	7	--	--
Mexico		881	1,210	24	51
Total		913	1,310	65	100
Unwrought zirconium, powder:	8109.20.0000				
Brazil		(3)	10	4	29
Canada		2	65	3	132
Costa Rica		--	--	4	86
France		11	357	4	235
Germany		2	89	6	188
Hungary		4	118	12	407
Italy		1	34	(3)	28
Japan		23	565	24	649
Korea, Republic of		1	13	8	72
Mexico		2	52	3	124
Nicaragua		--	--	3	62
Norway		1	33	4	158
United Kingdom		90	1,250	97	1,390
Other		(3)	14	1	60
Total		138	2,600	175	3,620

See footnotes at end of table.

TABLE 3—Continued
U.S. EXPORTS OF ZIRCONIUM, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2004 Quantity (metric tons)	2004 Value (thousands)	2005 Quantity (metric tons)	2005 Value (thousands)
Zirconium waste and scrap:	8109.30.0000				
Austria		--	--	19	277
Belgium		--	--	19	83
Brazil		--	--	2	30
Canada		21	937	28	1,410
China		4	41	--	--
France		7	81	10	106
Germany		--	--	23	249
Israel		(3)	4	--	--
Italy		14	117	5	49
Japan		48	537	24	422
Korea, Republic of		(3)	3	--	--
Philippines		--	--	2	36
Singapore		(3)	12	--	--
Taiwan		(3)	6	--	--
United Kingdom		2	54	16	419
Total		96	1,790	146	3,080
Other zirconium:	8109.90.0000				
Argentina		32	1,870	39	1,830
Belgium		4	435	2	330
Brazil		6	806	9	175
Canada		379	19,400	268	17,500
China		175	11,100	164	11,700
Finland		1	124	5	291
France		34	2,440	80	4,450
Germany		62	3,830	36	2,340
Italy		4	255	15	1,050
Japan		238	14,800	683	15,000
Korea, Republic of		150	16,000	179	18,400
Malaysia		4	48	(3)	13
Mexico		28	782	21	693
Spain		54	8,040	50	7,240
Sweden		7	637	7	841
Taiwan		29	2,030	15	243
United Kingdom		99	6,040	52	4,490
Other		162 r	1,950	25	711
Total		1,470	90,600	1,650	87,200

rRevised. -- Zero.
[1]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]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF ZIRCONIUM AND HAFNIUM, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2004 Quantity (metric tons)	2004 Value (thousands)	2005 Quantity (metric tons)	2005 Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		23,600	$9,450	20,500	$11,200
Canada		1,310	718	161	118
China		1,050	1,770	2,000	4,240
Germany		28	45	157	151
India		12	67	32	122
Italy		39	24	--	--
Japan		3	21	5	22
Russia		422	985	266	675
South Africa		8,700	3,690	15,000	9,160
United Kingdom		--	--	3	18
Other		20	16	5	17
Total		35,200	16,800	38,200	25,700
Ferrozirconium:	7202.99.1000				
Brazil		124	234	304	662
China		(3)	3	(3)	4
Norway		37	34	--	--
United Kingdom		4	47	1	9
Total		165	318	306	675
Unwrought zirconium, powder:	8109.20.0000				
China		41	388	--	--
France		5	185	230	4,300
Germany		19	1,650	28	1,680
Other		9	99	11	24
Total		75 r	2,320	269	6,000
Zirconium waste and scrap:	8109.30.0000				
Japan		14	64	8	70
Other		1	6	6	94
Total		15	70	14	164
Other zirconium:	8109.90.0000				
Australia		6	244	17	680
Belgium		14	190	13	290
Canada		35	4,460	63	3,790
China		7	201	3	212
Denmark		(3)	31	(3)	23
France		423	36,400	588	51,600
Germany		16	3,200	43	7,600
Japan		3	196	6	96
Sweden		(3)	131	6	248
United Kingdom		200	205	(3)	66
Other		3	280	1	105
Total		707	45,600	741	64,700
Unwrought hafnium powder and waste and scrap:	8112.92.2000				
Canada		1	173	(3)	14
China		--	--	(3)	4
France		2	670	4	827
Germany		(3)	37	(3)	44
Other		(3)	16	(3)	42
Total		4	895	4	931

-- Zero.

[1]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]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
ZIRCONIUM MINERAL CONCENTRATES: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2001	2002	2003[e]	2004[e]	2005[e]
Australia	393,000	412,000	462,000 [4]	441,000 [4]	445,000 [4]
Brazil[e, 5]	20,553 [r]	20,000 [r]	29,900 [r, 4]	34,855 [r, 4]	35,000
China[e]	15,000	15,000	15,000	17,000	17,000
India[e]	19,000	19,000	20,000	20,000	20,000
Indonesia[e]	250	250	250	200	200
Malaysia	3,768	5,293	3,456 [4]	6,886 [r, 4]	3,500
Russia[e, 6]	6,500	6,500	6,500	6,500	6,500
South Africa[e, 7]	245,000 [r]	274,000	300,000 [r]	302,000 [r]	305,000
Thailand	-- [r]	--	--	--	--
Ukraine[e]	33,600	34,300	35,000	35,000	35,000
United States	W	W	W	W	W
Vietnam[e]	8,000 [e]	11,000 [e]	13,000	14,000	14,000
Total[8]	745,000 [r]	797,000 [r]	885,000 [r]	877,000 [r]	881,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in total. -- Zero.

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

[2]Includes data available through May 9, 2006.

[3]Small amounts of zirconium concentrates were procuded in various countries; however, information is not sufficent to estimate output.

[4]Reported figure.

[5]Includes production of baddeleyite-caldasite.

[6]Production of baddeleyite concentrate averaging 98% ZrO_2.

[7]Includes production of byproduct zircon from titanium sands mining and, until 2002, 15,000 to 20,000 metric tons per year of baddeleyite from Palabora Mining Co. Ltd.

[8]Does not include U.S. data, which are withheld to avoid disclosing company proprietary data.