USGS
science for a changing world

2008 Minerals Yearbook

ZIRCONIUM AND HAFNIUM [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

November 2009

Zirconium and Hafnium

By Joseph Gambogi

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production table was prepared by Linder Roberts, international data coordinator.

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 2008, the leading producers of zircon were Australia and South Africa. Baddeleyite was produced from a single source at Kovdor, Russia. The leading producers of zirconium metal were France, Russia, and the United States.

World production of zirconium mineral concentrates in 2008, excluding U.S. production, was about 1.28 million metric tons (Mt) compared with 1.38 Mt in 2007. Domestic production of zircon increased slightly compared with that of 2007.

Because of a slowing global economy, U.S. production of milled zircon and zirconium oxide decreased significantly compared with that of 2007. The United States remained a net exporter of zirconium ore and concentrates. U.S. exports of zirconium ore and concentrate decreased by 38%, and imports of zirconium ore and concentrates increased by 72% compared with those of 2007. Consumer inventories and prices for zirconium mineral concentrates rose compared with those in 2007.

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

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.

In 2008, U.S. producers of zircon were DuPont Titanium Technologies (DuPont) (a subsidiary of E.I. du Pont de Nemours & Co.) 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 sands operations at Stony Creek, VA.

Data for zirconium and hafnium manufactured materials were developed by the U.S. Geological Survey (USGS) from a voluntary survey of domestic operations. Of the 46 operations surveyed, 21 responded. Data for nonrespondents were estimated on the basis of prior-year levels adjusted for the effect of global economic conditions.

Data for zircon concentrates were developed from a second voluntary survey of domestic mining operations. The two domestic zircon producers responded. Data on domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data.

Domestic production of milled zircon and zirconium oxide was 61,500 metric tons (t) and 18,100 t, respectively (table 1). Milled zircon production data for 2007 were significantly revised based on new information and estimates provided by several respondents. Domestic production of zircon concentrate in 2008 decreased compared with that of 2007 because of dwindling production in Florida.

Iluka was in the process of developing the Brink deposit in Virginia to support the continued operation of its Stony Creek mining operations. The Brink deposit is about 48 kilometers (km) south of the Stony Creek mining operations. The development of the Brink deposit was expected to extend the life of the Virginia operations from ending in 2012 to 2014. Iluka's Green Cove Springs, FL, operation in 2008 was restricted to reprocessing stockpiled tailings (Iluka Resources Ltd., 2009a, b, p. 14, 23.)

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

After restarting idle zirconium sponge capacity in 2007, Wah Chang was expanding zirconium sponge production and vacuum arc remelting (VAR) capacity at its Albany facility. The company cited anticipated growth in consumption in the chemical processing industry and nuclear energy industries as the motivation to increase capacity. In the nuclear industry, zirconium and hafnium alloys are used in nuclear fuel cladding and structural components (Allegheny Technologies Inc., 2009).

Industrial Minerals Corp. (IMC) continued design and engineering studies for construction and commissioning of the mineral separation plant for its Coos Bay, OR, heavy-minerals project. As part of the preproduction development of the project, IMC also was seeking equipment that required long lead times. In 2008, the company operated a pilot plant that produced heavy-mineral concentrates of chromite, garnet, magnetite, and zircon for evaluation. IMC raised its estimate of ore reserves at Coos Bay to 7.9 Mt with a zircon grade of 0.4% (Industrial Minerals Corp. Ltd., 2009, p. 9, 10, 12).

Consumption

Global consumption of zircon was estimated to be 1.3 Mt in 2008, nearly unchanged compared with consumption in 2007. Major end uses of zircon were ceramics, zirconia and zirconium

chemicals, and foundry and refractories. Globally, the leading end use for zircon was ceramics, but in the United States, the major end uses were foundry and refractories (TZ Mineral International Pty. Ltd., 2009, p. 32).

Zircon is also used as a natural gemstone and may be processed to produce cubic zirconia, a synthetic gemstone and diamond simulant.

Zirconium metal is used in corrosive environments, nuclear fuel cladding, and various specialty alloys. The principal uses of hafnium were in high-temperature ceramics, nickel-base superalloys, nozzles for plasma arc metal cutting, and nuclear control rods.

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) was used in the manufacture of oxygen sensors that control combustion in automobile engines and furnaces. YSZ was also used in the manufacture of a diverse array of products, including cubic zirconia, fiber optic connector components, refractory coatings, and structural ceramics. YSZ was used in dental applications, such as bridges, crowns, and inlays, because it has two to three times the fracture resistance and 1.4 times the strength of similar alumina products.

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

Ammonium- and potassium-zirconium carbonates were used as paper and board coatings or insolubilizers for high-quality print performance. Zirconium chemicals were 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 rod tubes. Hafnium is used in nuclear control rods because of its high thermal neutron absorption cross section. Commercial-grade zirconium, unlike nuclear grade, contains hafnium and was used in the chemical process industries because of its excellent corrosion resistance. Hafnium metal also is used as an alloy addition in superalloys. The French zirconium metal producer Cezus-Areva has estimated the global zirconium metal consumption to be about 5,000 t (Desai, 2009a).

Prices

Prior to the fourth quarter of 2008, zirconium prices were rising because of strong demand and production difficulties in Australia and South Africa. After increasing by 10% in 2007, the average value of imported zirconium ore and concentrates was $878 per metric ton in 2008, nearly unchanged from that in 2007. The average value of zircon ore and concentrates exports increased by 23% to $1,214 per ton in 2008 from $987 per ton in 2007. At yearend, Australian bulk free on board zircon prices were $725 to $820 per ton, a slight increase from $725 to $800 per ton (revised) at yearend 2007 (table 2).

Foreign Trade

In 2008, the United States remained a net exporter of zirconium ore and concentrates. Net exports of zirconium ore and concentrates were 6,380 t, an 86% decrease from those of 2007 (table 3). Australia and South Africa supplied 94% of the imports of ores and concentrates (table 4).

The United States also was a net exporter of zirconium in 2008. Strengthening demand in the nuclear industry caused U.S. imports of zirconium and hafnium metal to significantly rise. The majority of zirconium metal was exported in wrought products. Imports of zirconium and hafnium metal increased by 32% and 200%, respectively, compared with those of 2007.

As domestic production of zirconium oxide decreased, imports of germanium and zirconium oxides rose to 5,060 t in 2008, a 35% increase compared with those in 2007. China (47%) was the leading import source of oxides, which increased by 57% compared with those in 2007.

Because of weakening demand in the steel industry, domestic imports of ferrozirconium alloys fell to 129 t in 2008, a 68% decrease from the 400 t imported in 2007. In 2007 and 2008, all ferrozirconium imports originated from Brazil.

World Review

Excluding U.S. production, world production of zirconium mineral concentrates in 2008 was about 1.3 Mt, a 7% decrease compared with revised 2007 data (table 5). Australia and South Africa supplied about 74% of all production outside the United States. World reserves of zircon were estimated to be 51 Mt of zirconium oxide content. In 2008, mine production was curtailed, and mining difficulties limited heavy-mineral sands production, but the industry continued to explore and develop mineral deposits, particularly in Australia, Mozambique, South Africa, and the United States. Major zircon producers were Iluka Resources Ltd., Richards Bay Minerals (BHP Billiton plc/Rio Tinto plc), Exxaro Resources Ltd., The National Titanium Dioxide Co. Ltd. (Cristal Global), and DuPont.

Australia.—Alkane Resources Ltd. commissioned a pilot plant at its Dubbo zirconia project in New South Wales. The company planned to use a sulfuric acid leach followed by solvent extraction recovery and refining to recover a suite of zirconium chemicals, zirconia, a niobium-tantalum concentrate, and yttrium-rare earth concentrates. Identified mineral resources included about 2 Mt of contained ZrO_2. In 2008, the pilot plant produced zirconium and niobium products for potential customers. A feasibility study was expected to be completed in 2009 (Alkane Resources Ltd., 2009, p. 16–18).

Iluka announced it was proceeding with the second stage of its Murray Basin project. The project included the construction of a mobile concentrator and the expansion of the Hamilton mineral separation plant. When completed, production capacity from the first and second stages was expected to be about 180,000 metric tons per year (t/yr) of rutile, and 150,000 t/yr of zircon. The development of the second stage was expected to begin with

the Kulwin deposit, but would include the Pirro, Rownack, and Woornack deposits (Iluka Resources Ltd., 2008).

In the Eucla Basin, South Australia, Iluka committed to proceeding with the development of the Jacinth Ambrosia project. The mine was expected to brought online in 2010 and produce 300,000 t/yr of zircon for at least 10 years (Iluka Resources Ltd., 2009a).

Matilda Minerals suspended production from its Tiwi mineral sands operation in Northern Territory. Poor profitability was cited as the cause of the shutdown. Matilda began mining heavy minerals in 2006 (Industrial Minerals, 2008b).

Cristal Global's Australian subsidiary Cristal Australia Pty Ltd. acquired more than 90% of Australian mineral sands producer Bemax Resources Ltd. Bemax's operations were in the Murray Basin and Western Australia. In 2007, Bemax produced 66,000 t of zirconium mineral concentrate. Cristal Global did not plan to idle any of the existing operations (Millennium Inorganic Chemicals, 2008).

Canada.—Titanium Corp. Inc. was awarded a $3.5 million energy innovation grant for research into the recovery of bitumen and volatile organic compounds from mined oil sand tailings. The grant was provisional based on the company providing matching funds. For several years, Titanium Corp. has operated a pilot plant in Regina, Saskatchewan, treating Athabasca oil sand tailings from Syncrude Corp.'s operation in Alberta. Titanium Corp. aimed to recover heavy minerals, including zircon, contained in the oil sands tailings (Titanium Corp. Inc., 2008).

China.—China's Nuclear Power Technology Corp. and Baoji Titanium Corp. formed an agreement to allow Baoji to become the first producer of nuclear grade zirconium sponge. By 2020, China was projected to raise nuclear capacity to 40 gigawatts (GW) from 8 GW. China's demand for nuclear-grade sponge was estimated to be about 200 t in 2008. Baoji was expected to construct zirconium sponge plants in the Provinces of Liaoning and Shaanxi (Mineral Sands Report, 2008c).

China Zirconium Ltd. (Hong Kong) was constructing a zirconium chemical plant near Yixing, Jiangsu Province. At full capacity, the facility was expected to produce 30,000 t/yr of zirconium oxychloride and 2,000 t/yr of zirconium sulfate; the plant was scheduled to be commissioned by yearend 2009 (Mineral Sands Report, 2008b).

Zirconium chemical producer Guandong Orient acquired Lechang Zirconium Products' zirconium oxychloride and zirconia facilities in Lechang City, Guangdong Province. In 2008, Guangdong Orient Zirconium Co. Ltd. was constructing a 2,000-t/yr zirconia plant in Shantou, Guangdong Province. The new plant was expected to be commissioned by yearend and would bring the company's total capacity to 2,300 t/yr (Mineral Sands Report, 2008e).

In February, Imerys SA completed the acquisition of Astron China, the leading Chinese producer of zircon products. Astron operated five zircon processing plants in China producing primarily zircon sand and flour, fused zirconia, and zirconium chemicals (Imerys SA, 2008).

Gambia, The.—In January, Carnegie Minerals Plc withdrew from its mining interests in The Gambia after the Gambian Government accused the company of illegal mining and canceled its mining license. The company subsequently sold its mining interests in The Gambia and Senegal to Astron Ltd. In November, the Carnegie Minerals changed its name to Beacon Hill Resources Plc. At yearend, the company planned to pursue a cooperative research and development agreement with the USGS to test and improve modeling capabilities for mineral deposits (Beacon Hill Resources Plc, 2008).

India.—In January, the Indian Government modified rules concerning foreign investment that would allow foreign companies to hold 100% interest in the development of domestic mineral deposits. In addition, foreign ownership was also expected to create "local added value" and be accompanied by technology transfer. India's reserves of ZrO_2 were estimated to be 3.4 Mt, one of the leading global sources (Mineral Sands Report, 2008d).

Indonesia.—China Zirconium Ltd. and PT Indra Putra Mega formed a 51:49 joint venture to develop and process mineral sands. The joint venture planned to construct a mineral separation plant in Kalimantan that would source mineral concentrates from local miners. Zircon produced from the joint venture was expected to be shipped to China Zirconium's zirconium chemicals production facilities in China. Because of reduced consumption in China and variations in the amount of mineral processing, Indonesian zircon production fell significantly in 2008 (Mineral Sands Report, 2008a).

Madagascar.—QIT Madagascar Minerals SA (QMM) commenced production at its mineral sands project at Fort Dauphin. The first production of ilmenite from the operation was scheduled to be shipped to Canada in March 2009 for processing into titanium dioxide slag. The project also was expected to include 40,000 t/yr of zircon, sillimanite, and quartz mixed concentrate, known as Zirsill. QMM was a joint venture between Rio Tinto plc. (80%) and the Madagascar Government (20%) (Rio Tinto plc., 2009, p. 63).

Senegal.—Mineral Deposits Ltd. (MDL) completed an initial mine plan for the Diogo deposit at its Grande Cote heavy-mineral sands project. In 2008, MDL was seeking financing and conducting metallurgical work aimed at increased zircon and ilmenite recovery. Mine construction was targeted for 18 months following the completion of project financing. When completed, production capacity was expected to be 85,000 t/yr of zircon and 675,000 t/yr of ilmenite (Mineral Deposits Ltd., 2008, p. 20).

South Africa.—Carborundum Universal Ltd. acquired a 51% interest in fused zirconia producer Foskor Zirconia Ltd. from Foskor (Pty) Ltd. Carborundum Universal was founded as a venture between Murugappa Group (India), Carborundum Co. (United States), and Universal Grinding Wheel Co. Ltd. (United Kingdom). Carborundum owned a fused zirconia operation in Huntsville, AL. In 2008, Foskor's zirconia production in South Africa reached a record 4,412 t of fused zirconia (Chuturgoon, 2008, p. 2).

Mineral Sands Resources Pty (a subsidiary of Australia-based Mineral Commodities Ltd.) was granted mining rights for the Tormin mineral sands project 400 km north of Cape Town. A previously completed feasibility study was based on production of 40,000 t/yr of zircon. Mine construction was scheduled to begin in 2009. At yearend, the company was waiting for

approval of its Xolobeni mineral sands project north of East London and south of Durban (Mineral Commodities Ltd., 2009).

Richards Bay Minerals was proceeding with the construction of a tailings treatment plant to recover valuable minerals contained in tailings from past and ongoing mineral separation plant operations. Construction was expected to be completed in 2010 and was expected to extend the mine life by 5 years (Prinsloo, 2008).

Exxaro Resources completed the acquisition of West African mineral sands producer Namakwa Sands Pty Ltd. from Anglo American Corp. The acquisition included a mineral sands mine at Brand-se Baai, a mineral separation plant at Koekenaap, and a titanium smelter at Saldanha Bay. Namakwa Sands produced 130,000 t of zircon in 2008, a 13% increase compared with production in 2007. The acquisition was an option granted to Exxaro when Kumba Resources Ltd. was unbundled in 2006 (Industrial Minerals, 2008a).

Vietnam.— At yearend, the Government of Vietnam implemented a ban on all heavy-mineral concentrate exports. Previously, the Government of Vietnam had announced plans to discourage mineral exports by raising tariffs (including zircon) effective in June 2009. If the ban were lifted, the export tariff for zircon ore would be raised to 20% from 15% (Mineral Sands Report, 2008f).

Outlook

For most of 2008, consumption and prices for zirconium mineral concentrates were rising, but faltered in the fourth quarter along with the global economy. Global consumption of zirconium mineral concentrates was expected to decrease by as much as 10% in 2009. Subsequently, growth in the consumption of zirconium concentrates was expected to increase coincident with demand from the ceramics, steel, and chemical industries. New mine production was expected to ensure adequate supply for several years. Additional expansions in supply are expected in Australia, Madagascar, Mozambique, and South Africa.

Rising fuel prices in recent years have renewed global interest in nuclear energy. According to the World Nuclear Association, on a global basis, 47 nuclear powerplants were under construction in June 2009, and another 133 were planned. Although the amount of zirconium metal varies, boiling water reactors were estimated to contain about 44 t of zirconium, and pressurized heavy water reactors require about 12.5 t. Zirconium metal consumption was projected to reach 6,500 t by 2015, a small fraction of the global consumption of zirconium mineral concentrates (Desai, 2009b).

References Cited

Alkane Resources Ltd., 2009, Annual report 2008: Perth, Western Australia, Australia, Alkane Resources Ltd., April 19, 68 p. (Accessed May 8, 2009, at http://www.alkane.com.au/reports/annual/pdf/2008_Alkane_AR.pdf.)

Allegheny Technologies Inc., 2009, Seeing through the fog—Annual report 2008: Pittsburgh, PA, Allegheny Technologies Inc., March 19, 110 p. (Accessed June 19, 2009, at http://www.investquest.com/iq/a/ati/fin/annual/08/2008_ATI_Annual_Report.pdf.)

Beacon Hill Resources Plc, 2008, Successful sale of west African assets: London, United Kingdom, Beacon Hill Resources Plc, December 22, 1 p. (Accessed July 8, 2009, via http://www.bhrplc.com/news/announcements.html.)

Chuturgoon, Shanilla, 2008, Dilution of Foskor shareholding in Foskor Zirconia (Pty) Ltd: Phalaborwa, South Africa, Focus [Foskor (Pty) Ltd.], August. (Accessed May 12, 2009, at http://www.foskor.co.za/library/FOCUS August 2008.pdf.)

Desai, Pratima, 2009a, Factbox—Nuclear industry and zirconium: Thomson Reuters, April 23. (Accessed July 21, 2009, at http://uk.reuters.com/article/idUKLN78747920090423.)

Desai, Pratima, 2009b, Zirconium in pole position in nuclear boom: Thomson Reuters, April 24. (Accessed July 21, 2009, at http://uk.reuters.com/article/idUKLNE53N00Q20090424.)

Iluka Resources Ltd., 2008, Commitment to Murray Basin stage 2 development: Perth, Western Australia, Iluka Resources Ltd. Australian Securities Exchange notice, February 21, 7 p. (Accessed July 21, 2009, via http://www.iluka.com/Default.aspx?page=130&did=244.)

Iluka Resources Ltd., 2009a, December quarter 2008 production and development report: Perth, Western Australia, Australia, Iluka Resources Ltd. Australian Securities Exchange notice, January 21, 12 p. (Accessed July 7, 2009, via http://www.iluka.com/Default.aspx?page=130&did=432.)

Iluka Resources Ltd., 2009b, Progress towards creating and delivering shareholder value—Annual report 2008: Perth, Western Australia, Australia, Iluka Resources Ltd., April 11, 105 p. (Accessed April 1, 2009, via http://www.iluka.com/Default.aspx?page=130&did=455.)

Imerys SA, 2008, 1st quarter 2008 results: Paris, France, Imerys SA, April 30, 7 p. (Accessed July 17, 2009, at http://www.imerys.com/scopi/Group/imeryscom/imeryscom.nsf/pagesref/MLEN-7E2HT4/$File/CPQ12008vo.pdf.)

Industrial Minerals Corp. Ltd., 2008, 2008 annual report: Perth, Western Australia, Industrial Minerals Corp. Ltd., October 10, 86 p. (Accessed May 8, 2009, at http://www.industrialmineralscorp.com.au/pdfs/annualreports/AnnualReport2008.pdf.)

Industrial Minerals, 2008a, Exxaro's Namakwa Sands buy finally approved: Industrial Minerals, no. 494, November, p. 22.

Industrial Minerals, 2008b, Matilda halts minsands sales: Industrial Minerals, no. 494, November, p. 23.

Millennium Inorganic Chemicals, 2008, Cristal acquires over 90% of Bemax Resources Limited: Hunt Valley, MD, Millennium Inorganic Chemicals press release, July 9. (Accessed July 24, 2009, at http://www.millenniumchem.com/News+and+Events/_News/Press+Release+-+Cristal+acquires+Bemax+Resources+Limited.htm.)

Mineral Commodities Ltd., 2009, 2008 annual report: Welshpool, Western Australia, Australia, Mineral Commodities Ltd., April 13, 64 p. (Accessed August 5, 2009, at http://www.mineralcommodities.com.au/2008AnnualReport.pdf.)

Mineral Deposits Ltd., 2008, Business review 2008: Melbourne, Victoria, Australia, Mineral Deposits Ltd., 25 p. (Accessed May 11, 2009, via http://www.mineraldeposits.com.au/publication/annual_reports/2008.)

Mineral Sands Report, 2008a, China Zirconium concludes Indonesian JV: Mineral Sands Report, no. 148, February, p. 21.

Mineral Sands Report, 2008b, China Zirconium to list on TSX: Mineral Sands Report, no. 152, June, p. 20.

Mineral Sands Report, 2008c, Chinese forms set up nuclear-grade zirconium joint venture: Mineral Sands Report, no. 147, January, p. 24.

Mineral Sands Report, 2008d, Further relaxation of ownership restrictions on Indian titanium resources: Mineral Sands Report, no. 148, February, p. 5.

Mineral Sands Report, 2008e, Guangdong Orient zirconia project almost complete: Mineral Sands Report, no. 156, October, p. 23.

Mineral Sands Report, 2008f, Vietnam to increase export tariffs: Mineral Sands Report, no. 156, October, p. 6.

Prinsloo, Loni, 2008, Richards Bay Minerals approves R1-billion project: Mining Weekly, July 4. (Accessed May 12, 2009, at http://www.miningweekly.com/article/richards-bay-minerals-approves-r1billion-project-2008-07-04.)

Rio Tinto plc., 2009, Focusing on our strengths—Annual report 2008: London, United Kingdom, Rio Tinto plc., March 10, 180 p. (Accessed July 21, 2009, at http://www.riotinto.com/documents/Investors/Rio_Tinto_2008_Annual_report.pdf.)

Titanium Corp. Inc., 2008, Titanium Corporation receives $3.5 million grant from the province of Alberta: Toronto, Ontario, Canada, Titanium Corp. Inc. news release, March 31. (Accessed May 8, 2009, via http://www.titaniumcorporation.com/s/NewsReleases.asp.)

TZ Mineral International Pty. Ltd., 2009, Mineral sands annual review 2008 interim update: Perth, Western Australia, Australia, TZ Mineral International Pty. Ltd., December, 303 p.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Zirconium. Ch. in Metal Prices in the United States Through 1998, 1999.
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 Week, weekly.
Engineering and Mining Journal, monthly.
Industrial Minerals, monthly.
International Titanium Association.
Metal Bulletin, weekly and monthly.
Mineral Sands Report, bimonthly and monthly.
Mining Magazine and Mining Journal, monthly and weekly.
Roskill Information Services Ltd.
U.S. Census Bureau trade statistics, monthly.
Zirconium and Hafnium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

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

(Metric tons)

	2004	2005	2006	2007	2008
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon	44,100 r	46,300 r	50,800 r	64,600 r	61,500
Exports	68,800	101,000	76,300	66,200	40,800
Imports for consumption[2]	35,200	38,200	36,200	20,000	34,400
Consumption, apparent[3]	W	W	W	W	W
Stocks, December 31, dealers and consumers[4]	16,700	16,100	17,600	18,000	26,600
Zirconium oxide:					
Production[5]	21,300	19,900	21,700	25,600	18,100
Exports[6]	1,600	2,260	3,340	2,400	2,970
Imports for consumption[6]	3,960	3,160	2,820	3,740	5,060
Consumption, apparent[3]	23,700	21,000	24,200	26,900	20,400
Stocks, December 31, producers[5]	2,070	2,210	1,560	1,880	1,670
Zirconium; unwrought powder, waste and scrap, other:					
Exports	1,700	1,970	1,880	2,160	2,670
Imports	796	1,020	748	784	1,030
Ferrozirconium:					
Exports	913	65	491	259	316
Imports	165	306	196	400	129
Hafnium, unwrought powder, waste and scrap, other, imports	4	4	4	4	12

[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.
[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 MATERIALS

(Dollars per metric ton)

Material	2007	2008
Zircon:[1]		
Domestic, standard-grade, bulk	725–800 [r]	775–800
Australian, standard-grade, free on board, bulk	725–800	725–820
Baddeleyite, contract price, cost, insurance, and freight main European port:[1]		
Refractories/abrasive grade	2,200–2,800	2,500–3,100
Ceramic grade (98% zirconium oxide and hafnium oxide)	2,800–3,200	3,000–3,300
Zirconium oxide lot size of 1 to 10 metric tons[2]	6,480–12,200	6,480–12,200

[r]Revised.
[1]Source: Industrial Minerals.
[2]Source: Stanford Materials Corp.

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

Class and country	HTS[2]	2007 Quantity (metric tons)	2007 Value (thousands)	2008 Quantity (metric tons)	2008 Value (thousands)
Ore and concentrates:	2615.10.0000				
Belgium		4,240	$3,160	2,530	$2,940
Brazil		2,590	3,260	2,920	4,070
Canada		10,100	9,310	2,560	2,700
Colombia		3,380	3,150	1,550	2,000
Germany		881	1,620	2,090	2,980
Italy		3,830	3,300	355	395
Japan		1,880	2,970	2,040	4,060
Korea, Republic of		1,310	3,720	1,090	3,130
Mexico		10,200	8,150	9,860	7,000
Netherlands		19,200	12,000	11,200	9,590
United Kingdom		2,310	5,210	2,070	4,870
Other		6,250 r	9,490 r	2,480	7,420
Total		66,200	65,400	40,800	51,100
Ferrozirconium:	7202.99.1000				
Canada		5	14	72	167
Costa Rica		2	3	41	51
Guatemala		80	108	19	25
Mexico		91	184	128	253
Nicaragua		39	54	39	52
Other		42 r	50 r	16	27
Total		259	414	316	574
Unwrought zirconium, powders:	8109.20.0000				
France		13	769	16	1,020
Germany		6	327	11	347
Japan		7	250	12	501
Mexico		22	711	5	214
Russia		60	3,250	49	2,740
United Kingdom		105	2,040	211	4,190
Other		15	585 r	40	1,420
Total		228	7,930	344	10,400
Zirconium waste and scrap:	8109.30.0000				
Canada		26	1,480	49	2,790
France		13	203	13	171
Germany		--	--	36	581
Japan		15	345	29	783
Netherlands		--	--	44	507
Sweden		28	362	35	618
United Kingdom		11	273	27	705
Other		5	153	13	561
Total		99	2,820	247	6,720
Other zirconium:	8109.90.0000				
Canada		445	32,500	446	32,500
China		467	35,400	698	60,000
France		179	10,800	129	8,720
Japan		268	19,600	316	22,200
Korea, Republic of		184	21,400	136	15,700
Spain		73	9,680	92	13,600
Sweden		46	6,130	95	7,510
Other		171 r	11,700 r	167	13,100
Total		1,830	147,000	2,080	173,000

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.

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]	2007 Quantity (metric tons)	2007 Value (thousands)	2008 Quantity (metric tons)	2008 Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		8,320	$6,520	12,700	$9,530
South Africa		10,400	7,650	19,600	14,900
Other		1,250	3,270	2,010	5,790
Total		20,000	17,400	34,400	30,200
Ferrozirconium, Brazil	7202.99.1000	400	1,070	129	594
Unwrought zirconium, powder:	8109.20.0000				
France		125	3,590	8	332
Germany		105	2,340	66	2,330
Other		33	270	20	121
Total		263	6,190	94	2,790
Zirconium waste and scrap:	8109.30.0000				
Australia		--	--	88	103
Canada		8	80	7	54
France		21	154	49	674
Japan		5	21	70	69
Other		2	23	11	141
Total		36	278	224	1,040
Other zirconium:	8109.90.0000				
Belgium		24	704	21	708
Canada		39	2,740	40	4,400
France		351	40,000	335	39,800
Germany		40	7,420	40	11,300
South Africa		--	--	240	280
Other		32	1,350 r	39	1,690
Total		485	52,300	715	58,200
Unwrought hafnium including powders:	8112.92.2000				
France		2	565	6	1,410
Germany		(3)	13	5	1,770
United Kingdom		1	141	1	564
Other		1 r	231 r	(3)	111
Total		4	951	12	3,850

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 5

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

(Metric tons)

Country[3]	2004	2005	2006	2007	2008
Australia	441,000 4	427,000 4	492,000 4	601,000 r	550,000 4
Brazil[5]	25,263 4	25,657 4	25,120 r, 4	26,739 r, 4	26,800 p
China	120,000 r	120,000 r	135,000 r	140,000 r	140,000
India	25,400	26,700	28,000	29,000	30,000
Indonesia	500	2,600	65,000	111,000	65,000
Malaysia	6,886 4	4,954 4	1,690 4	7,393 r, 4	7,000
Russia[6]	5,500	6,700	7,500	7,136 4	7,000 4
South Africa[7]	368,000	376,000	398,000	400,000	400,000
Ukraine	35,000	35,000	35,000	35,000	35,000
United States	W	W	W	W	W
Vietnam	39,400	32,500	26,100	22,000 r	22,000
Total[8]	1,070,000 r	1,060,000 r	1,210,000 r	1,380,000 r	1,280,000

pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data; not included in total.

[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 1, 2009.

[3]Small amounts of zirconium concentrates were produced in various countries; however, information is not sufficient 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 from Palabora Mining Co. Ltd.

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