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2011 Minerals Yearbook

ZIRCONIUM [ADVANCE RELEASE]

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Zirconium and Hafnium

By Patricia J. Loferski

Domestic survey data and tables were prepared by Lisa A. Mersdorf, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2011, although the global economy continued to struggle, consumption of zirconium ores and concentrates increased owing to increased standards of living in emerging economies such as China and India. In response to increased demand, producers revisited expansion and development programs. World production of zirconium mineral concentrates in 2011, excluding U.S. production, was about 1.62 million metric tons (Mt) compared with 1.25 Mt in 2010. The primary source of zirconium was the mineral zircon ($ZrSiO_4$), principally found in heavy-mineral sands. A relatively small quantity of zirconium was derived from the mineral baddeleyite, a natural form of zirconium oxide (ZrO_2) produced from a single source in Kovdor, Russia. In 2011, the leading producers of zircon were Australia and South Africa. Zircon was also the primary source of hafnium; zirconium and hafnium are contained in zircon at a ratio of about 50 to 1. The leading producers of zirconium and hafnium metal were France, Russia, and the United States.

U.S. production of milled zircon increased by 14% compared with that of 2010. The United States was a net importer of zirconium ore and concentrates for the first time since 1998. U.S. exports of zirconium ore and concentrate decreased by 49%, and imports of zirconium ore and concentrates increased by 16% compared with those of 2010. 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 a coproduct of the mining and processing of heavy-mineral sands for the titanium minerals ilmenite and rutile. In 2011, 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 wholly owned 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 near 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 41 operations surveyed, 20 responded, representing 87% of milled zircon production. Data for nonrespondents were estimated on the basis of prior-year levels adjusted for the effect of economic conditions. Domestic production of milled zircon was 53,600 metric tons (t). Domestic production of zircon concentrate in 2011 increased compared with that of 2010. Insufficient data were available to determine stocks of zircon and zirconium oxide as well as production of zirconium oxide (table 1).

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. 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. Milled zircon (flour) was produced from zircon sand by at least five companies, and zirconium chemicals were produced by about a dozen companies.

Industrial Minerals Corp. Ltd. (IMC) began production of a mineral concentrate containing chromite, ilmenite, and zircon at its Coos Bay, OR, heavy-minerals project at the South Seven Devil's Mine site. The mineral separation and processing facility at the site was largely completed. Ore was processed through the wet plant and stockpiled for dry plant commissioning, which began in the last quarter and continued past yearend (Industrial Minerals Corp. Ltd., 2012, p. 4).

Consumption

Global consumption of zircon increased in 2011 largely as a result of increased demand in developing economies in Asia and the Middle East. Globally, the leading end uses for zircon were ceramics, zirconia, zirconium-based chemicals, refractories, and foundry and casting applications. 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 engineering 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 is used in the chemical process industries because of its excellent corrosion resistance. Hafnium metal also is used as an alloy addition in superalloys.

Prices

Rising consumption and constrained supply in the first half of 2011 caused prices of zirconium ores and concentrates to increase dramatically in 2011. At yearend, the published price range of standard grade, bulk, domestic zircon was $2,550 to $2,750 per metric ton, up from $830 to $890 per ton at yearend 2010 (table 2). The unit value of imports also increased, and the import quantity increased by 16%. The average unit value of imported zirconium ore and concentrates (primarily zircon sand) was $2,170 per ton in 2011.

No published prices were available for zirconium metal. In 2011, the average unit value of imported unwrought powder globally was $64 per kilogram, a 16% decrease from that in 2010. The average duty-paid unit value of imported unwrought hafnium including sponge and powder was $464 per kilogram, a 4% increase from that in 2010.

Foreign Trade

In 2011, Australia (53%) and South Africa (43%) supplied most of the imports of ores and concentrates (table 4). Exports of zirconium ore and concentrates decreased by 49% (table 3). The majority of zirconium metal was exported in wrought products classified as "Other zirconium" in the Harmonized Tariff Schedule (HTS) category 8109.90.0000. Imports of zirconium metal in the HTS category 8109 totaled 852 t, a 27% decrease compared with those of 2010. Imports of hafnium metal in HTS category 8112 totaled 10 t, which was 25% more than that of 2010. Imports of germanium and zirconium oxides increased by 3%, with China (47%) the leading import source of oxides. Domestic imports of ferrozirconium alloys increased to 88 t from 45 t in 2010. China (81%) and Indonesia (19%) were the leading import sources of ferrozirconium.

World Review

Excluding U.S. production, world production of zirconium mineral concentrates in 2011 was about 1.62 Mt, a 30% increase compared with revised 2010 data (table 5). Australia and South Africa supplied about 71% of all production outside the United States. The leading zircon producers were Iluka, Richards Bay Minerals, and Exxaro Resources Ltd. China was the leading consuming country. In 2011, producers continued to increase production and exploration and development efforts.

Australia.—Iluka produced 541,000 t of zircon from its operations in Australia, an increase of 53% compared with that of 2010. Production included 314,000 t from its Jacinth-Ambrosia operations in the Eucla Basin, South Australia, the highest production to date for that deposit and more than double production in 2010. The increased production was the result of higher ore grade and improved throughputs and recovery at Iluka's mineral processing plant in Narngulu, Western Australia. Production from Iluka's operations in the Murray Basin, Victoria, totaled 218,000 t, a 38% increase compared with that of 2010. Production from the Perth Basin, Western Australia, was 9,300 t, an 80% decrease compared with that of 2010. Iluka planned to expand operations at Twin Hills and Depot Hill North near Eneabba and planned to produce 25,000 metric tons per year (t/yr) of zircon. A prefeasibility study for the Cataby Mine was expected to be completed by mid-2012 (Iluka Resources Ltd., 2012, p. 15–18).

In New South Wales, Alkane Resources Ltd. continued to develop its Dubbo Zirconia project. In 2011, the company completed a definitive feasibility study of an operation with 400,000 t/yr of ore throughput for an initial 20-year period. The company also began a preliminary assessment of a 1-million-metric-ton-per-year (Mt/yr) operation, expected to be completed in the first half of 2012. Potential production from the initial project included as much as 6,280 t/yr (ZrO_2 equivalent) zirconia, zirconium basic sulfate, zirconium hydroxide, and zirconium oxychloride. Owing to high demand for rare earths, the company was also researching the recovery of rare-earth elements (Alkane Resources Ltd., 2012, p. 2–4).

Astron Ltd. (Sydney) submitted a work plan for its Donald mining project to Victorian Department of Primary Industries and continued work on a feasibility study that would more accurately define operating and capital expenditures. Astron expected to make a final decision on the location of the processing plants by the end of 2012 (Astron Ltd., 2012, p. 6).

Gunson Resources Ltd. was seeking financing to develop its Coburn heavy-minerals project in Western Australia. Reserves in the Amy zone of the Coburn deposit were estimated to be 308 Mt averaging 1.2% heavy minerals, of which 23% was zircon. The reserves could support a mine life of 17.5 years, with a target production rate of 17.5 Mt/yr of heavy minerals (Gunson Resources Ltd., 2012, p. 2, 14).

Matilda Zircon Ltd. continued the development of the Keysbrook deposit, 70 kilometers south of Perth. The development approvals passed through the State Administrative Tribunal of the Western Australia Department of Planning. Matilda planned to begin mine construction in 2012 and to begin mining in 2013. The Keysbrook project was expected to operate for 8 years. The Keysbrook project had a resource of 66 Mt of ore containing 12 weight-percent zircon. Production from the company's new Lethbridge South project in the Tiwi Islands was expected to begin in early 2012 after the fire-damaged concentrator and preconcentrator were rebuilt. A second project on the Tiwi Islands, the Kilimirka project, was expected to begin production in 2013, subject to economic assessment (Matilda Zircon Ltd., 2012, p. 1).

Canada.—Titanium Corp. continued its research into the recovery of bitumen, volatile organic compounds, and heavy minerals, including zircon, from mined oil sand tailings. In 2011, Titanium Corp. completed a demonstration pilot and recovered 95% of the heavy minerals as a concentrate. Titanium Corp. was continuing with a precommercialization phase (Titanium Corp., 2012, p. 1–2).

China.—Inner Mongolia Western Zirconium Co. Ltd. (Shu Lin Zhao Town, Ordos, Inner Mongolia) planned to build a 100,000-t/yr zirconium oxychloride plant, which would bring the total zirconium oxychloride capacity in China to 400,000 t/yr. No timeframe was given for plant commissioning (Mineral Sands Report, 2011b.)

Indonesia.—In 2011, Matilda Zircon sold its Kalimantan heavy-mineral concentration plant owing to restrictive Government regulations. No information was given on the sale (Matilda Zircon Ltd., 2012, p. 9).

Kenya.—Base Resources Ltd. released an enhanced definitive feasibility study of its Kwale Mineral Sands project, which incorporated improvements and simplification of the mining and processing systems. Proven and probable ore reserve estimates were 140.6 Mt, containing 0.29% or 0.4 Mt of zircon. At yearend, development was underway, and the company expected the Kwale operation to be in production during the second half of 2013, with a mine life of 13 years and a production capacity of 30,000 t/yr of zircon (Base Resources Ltd., 2012, p. 12).

Mozambique.—Kenmare Resources plc's production of heavy-mineral concentrates was 843,000 t, a decrease of 12% relative to that of 2010 owing to elevated clay content in part of the ore body. In 2011, zircon production was 43,600 t, an increase of 18% relative to that of 2010. The zircon production increased owing to inclusion of stockpiled zircon-rich concentrate that had been processed in the early stage of commissioning of the plant (Kenmare Resources plc, 2012, p. 3).

Pathfinder Minerals Plc (London, United Kingdom) acquired IM Minerals Ltd. and its Moebase and Naburi titanium-zircon sands deposits, completed a scoping study that addressed optimum mining methods and necessary infrastructure development to bring the deposits into production, and began a definitive feasibility study, which was expected to take 12 months to complete. Pathfinder had expected to begin mine construction in 2013 and to begin production in 2014. However, a legal dispute regarding ownership of the deposits began in November and continued beyond yearend. Expected annual production included 65,000 t of zircon (Pathfinder Minerals Plc, 2011, p. 2; 2012, p. 4–8).

Russia.—ARZM Uranium Holding Co. completed a feasibility study of the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. In 2012, the company planned to launch a pilot development program by hydraulic bore-hole mining. No update on production plans were given (ARZM Uranium Holding Co., 2012, p. 66).

Senegal.—Mineral Deposits Ltd. continued with development and construction of the mine and separation plants at its Grande Cote heavy-minerals deposit, and initial production was scheduled for 2013. Mineral Deposits entered into a joint-venture agreement with ERAMET SA (Paris, France), whereby Mineral Deposits 90% stake in the Grande Cote deposit was combined with ERAMET's 100% stake in the Tyssedal ilmenite upgrading plant in Norway to form a new entity, TiZir Ltd. Once the Grande Cote mine and separation plants are fully commissioned, TiZir expected to produce an average of 575,000 t/yr of ilmenite, 85,000 t/yr of zircon, and small amounts of rutile and lucoxene during a mine life of 20 years (Mineral Deposits Ltd., 2012, p. 11).

South Africa.—Exxaro Resources Ltd. increased zircon production in South Africa to 163,000 t in 2011 from 161,000 t in 2010 from its KZN Sands and Namakwa Sands operations. Exxaro's Hillendale Mine neared the end of its life, and decommissioning was expected to take place at the end of 2012. However, owing to increased demand for zircon, plans were underway to develop the Fairbreeze Mine at the KZN operation as a substitute for the waning production from the Hillendale Mine. Exxaro was in the process of obtaining regulatory and environmental approvals, and operations at Fairbreeze were expected to start in 2014, with a life expectancy of 15 years. No annual production estimate was given. Exxaro and Tronox Inc. (Stamford, CT) announced that New Tronox, an Australian holding company, would acquire Exxaro's mineral sands operations including Exxaro's 50% interest in the Tiwest joint venture with Tronox in Western Australia, and 74% of Exxaro's operations in South Africa. In exchange, Exxaro would acquire a 38.5% shareholding in New Tronox (Exxaro Resources Ltd., 2012, p. 4, 5, 31).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam continued to suspend a ban on exports of titanium and zirconium mineral concentrates designed to encourage the production of value-added products. Producers were permitted to export through the end of 2011 (Mineral Sands Report, 2012).

Outlook

Zirconium mineral concentrate consumption was expected to increase owing to increased demand from consumers such as the ceramics, metals, and chemicals industries. Increased demand was expected to be led by developing economies, particularly China and India. Growth in these economies was expected to substantially increase zircon consumption during the long term. In recent years, new mines were bought online in Australia, Mozambique, and South Africa; however, the global financial situation curtailed production and delayed the development of several mining projects. This constricted supply together with rising demand is likely to create a scarcity of zircon though 2014.

Construction and operation of new nuclear powerplants throughout the world were expected to increase future demand for zirconium and hafnium metal. China's medium-to-long term nuclear power development program called for an increase in its nuclear power capacity from the current level of 9 million kilowatts (kW) to 86 million kW. About 30 t of zirconium is required for each million kW and one-third of the zirconium would need to be replaced annually. China expected the demand for zirconium by its nuclear power industry to exceed 8,000 t/yr during the next decade (Mineral Sands Report, 2011a).

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

(Metric tons)

	2007	2008	2009	2010	2011
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon	64,600	61,500	38,400	46,900	53,600
Exports	66,200	42,100	39,600	47,400	24,300
Imports for consumption[2]	20,000	34,400	14,400	22,900	26,500
Consumption, apparent[3]	W	W	W	W	W
Stocks, December 31, dealers and consumers[4]	18,000	26,600	NA	NA	NA
Zirconium oxide:					
Production[5]	25,600	18,100	NA	NA	NA
Exports[6]	2,400	2,970	3,050	5,630	6,710
Imports for consumption[6]	3,740	5,060	2,810	2,920	3,020
Consumption, apparent[3]	26,900	20,400	NA	NA	NA
Stocks, December 31, dealers and consumers[4]	1,880	1,670	NA	NA	NA
Zirconium, unwrought, waste and scrap, other:					
Exports	2,160	2,670	2,300	2,060	2,010
Imports	784	1,030	977	1,160	878
Ferrozirconium:					
Exports	259	316	566	569	2,680
Imports	400	129	(7)	45	88
Hafnium, unwrought, waste and scrap, other, imports	4	12	5	8	10

NA Not available. 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.
[7]Less than ½ unit.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM MATERIALS

(Dollars per metric ton)

Material	2010	2011
Zircon:		
Domestic, standard-grade, bulk	830–890	2,550–2,750
Australian, standard-grade, free on board, bulk	850–890	2,400–2,600
Zirconia, fused, monoclinic, refractory/abrasive	4,400–5,200	6,500–7,800

Source: Industrial Minerals.

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

Class and country	HTS[2]	2010 Quantity (metric tons)	2010 Value (thousands)	2011 Quantity (metric tons)	2011 Value (thousands)
Ore and concentrates:	2615.10.0000				
Brazil		352	$544	1,860	$3,390
Canada		2,340	3,350	1,310	2,680
China		359	223	2,750	3,580
Colombia		1,390	1,290	1,270	2,700
El Salvador		3,210	898	--	--
France		862	1,980	651	1,570
Germany		1,970	4,500	496	1,480
Italy		18,200	15,800	1,010	2,100
Japan		1,470	3,080	1,240	1,850
Korea, Republic of		2,080	1,870	1,040	1,420
Mexico		3,560	3,970	3,570	6,790
Netherlands		5,280	4,610	2,420	5,030
Spain		2,000	1,660	2,040	3,770
United Kingdom		1,660	3,350	1,130	2,110
Other		2,640 r	3,960 r	3,490	6,740
Total		47,400	51,100	24,300	45,200
Ferrozirconium:	7202.99.1000				
Canada		109	276	68	180
Mexico		394 r	791	2,380	6,000
Other		65	128	237	539
Total		569	1,200	2,680	6,720
Unwrought zirconium, including powder:	8109.20.0000				
China		61	2,570	37	1,850
France		75	3,260	231	14,800
Germany		52	1,670	16	1,100
Mexico		35	1,270	32	1,140
Russia		65	3,230	17	780
United Kingdom		109	2,650	102	3,520
Other		41	1,800	93	3,740
Total		438	16,400	528	26,900
Zirconium waste and scrap:	8109.30.0000				
Belgium		--	--	34	551
Canada		42	2,570	33	2,150
Hong Kong		--	--	18	621
Italy		7	155	19	455
Japan		7	192	25	556
Netherlands		10	107	7	100
Other		16 r	206 r	13	571
Total		82	3,230	149	5,000
Other zirconium:	8109.90.0000				
Canada		420	33,600	316	26,900
China		328	33,800	150	12,800
France		41	3,220	92	8,100
Japan		62	5,490	89	7,980
Korea, Republic of		276	23,500	349	32,600
Spain		89	14,400	93	16,300
Sweden		143	13,000	131	13,000
Other		180	16,300	110	9,890
Total		1,540	143,000	1,330	127,000

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]	2010 Quantity (metric tons)	2010 Value (thousands)	2011 Quantity (metric tons)	2011 Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		16,100	$16,000	13,900	$30,800
South Africa		5,550	7,730	11,300	22,800
Other		1,220	3,790	1,240	3,940
Total		22,900	27,500	26,500	57,600
Ferrozirconium:	7202.99.1000				
China		43	232	71	391
Indonesia		--	--	17	12
Other		2	14	(3)	3
Total		45	246	88	406
Unwrought zirconium, including powder:	8109.20.0000				
Germany		13	2,050	41	2,870
Japan		--	--	6	105
Kazakhstan		15	168	--	--
Other		3 r	112 r	5	304
Total		31	2,330	52	3,280
Zirconium waste and scrap:	8109.30.0000				
Australia		--	--	191	357
France		83	710	4	74
Korea, Republic of		15	152	15	101
United Kingdom		578	1,270	216	451
Other		20 r	253 r	8	539
Total		695	2,390	435	1,520
Other zirconium:	8109.90.0000				
Canada		8	974	27	3,200
France		397	64,600	301	46,700
Other		29	2,700	64	5,300
Total		435	68,300	392	55,200
Unwrought hafnium, including powder:	8112.92.2000				
France		7	3,120	8	4,580
Other		1 r	272	2	183
Total		8	3,390	10	4,760

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

(Metric tons)

Country and grade[3]	2007	2008	2009	2010	2011[e]
Australia	601,000	550,000	476,000	540,000 [r]	762,000 [4]
Brazil	26,739	17,682	18,134	18,150	18,200
China[e]	140,000	140,000	130,000	140,000	150,000
India[e]	29,000	30,000	37,000	38,000	39,000
Indonesia[e]	111,000 [4]	65,000	63,000	50,000 [r]	130,000
Malaysia	7,393	948	1,145	1,261 [r]	1,300
Mozambique	26,347	32,985	19,101	37,100	43,600 [4]
Russia[5]	7,136	7,000	5,000	8,000 [r]	12,000
Sierra Leone	--	--	5,560	7,092	8,496 [4]
South Africa[e]	405,000	405,000	390,000	381,000 [r]	383,000
Sri Lanka	11,000	41,000	9,000	11,000	30,000
Ukraine[e]	37,000	36,000	31,000	30,000	26,400
United States	W	W	W	W	W
Vietnam	22,000	36,000 [r]	6,800 [r]	6,900 [r]	14,000
Total	1,420,000 [r]	1,360,000 [r]	1,190,000 [r]	1,270,000 [r]	1,620,000

[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]Table includes data available through May 16, 2012.

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

[4]Reported figure.

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