



2019 Minerals Yearbook

ZIRCONIUM AND HAFNIUM [ADVANCE RELEASE]

ZIRCONIUM AND HAFNIUM

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In 2019, production of zirconium mineral concentrates and estimated production of milled zircon in the United States decreased slightly from that in 2018 (table 1). U.S. imports of zirconium ores and mineral concentrates decreased by 14%, and exports decreased by 48% compared with those in 2018 (tables 3, 4). World production of zirconium mineral concentrates in 2019 was 1.42 million metric tons (Mt), a 5% decrease from the 2018 revised production total (table 5).

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 zirconia [zirconium dioxide (ZrO_2)] recovered from a single source in Kovdor, Russia. In 2019, 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 34:1 (Jones and others, 2017, p. V5). Zirconium and hafnium metals were produced in China, France, India, Russia, and the United States.

Production

Zircon is a coproduct of the mining and processing of heavy-mineral sands for the titanium minerals ilmenite and rutile. In 2019, the U.S. producers of zircon were The Chemours Co. (Wilmington, DE), Southern Ionics Minerals, LLC (Jacksonville, FL) for part of the year, and Twin Pines Minerals, LLC (Starke, FL). In August, Chemours acquired Southern Ionics Minerals, LLC (a wholly owned subsidiary of Southern Ionics Inc.). Chemours produced zirconium mineral concentrates from its operation near Starke, FL, and produced zirconium mineral concentrates from the Southern Ionics operation it acquired near Nahunta, GA. Twin Pines Minerals processed existing Chemours mine tailings for zircon in Starke, FL. Iluka Resources, Inc. (a wholly owned subsidiary of Iluka Resources Ltd., Perth, Western Australia, Australia) had terminated its mining operations near Stony Creek, VA, at the end of 2015 but continued processing material until the end of 2018. Iluka Resources, Inc. reported no zircon production in 2019 (Iluka Resources Ltd., 2019). Data on domestic production and consumption of zirconium mineral concentrates were rounded to one significant digit to avoid disclosing company proprietary data.

U.S. producers of zirconium and hafnium metal were Allegheny Technologies, Inc. based in Albany, OR, and Western Zirconium Inc. (a subsidiary of Westinghouse Electric Co.) in Ogden, UT.

Data for zirconium and hafnium manufactured materials were collected from a voluntary survey of domestic operations. Of the 38 operations surveyed, 10 responded, and data for nonrespondents were estimated based on prior-year levels. Domestic production of milled zircon was 48,500 metric tons (t)

in 2019. Insufficient data were available to determine stocks of zirconium mineral concentrates and production of zirconium chemicals and zirconium metal (table 1).

Consumption

Globally, the leading end uses for zircon, in descending order, were ceramics, refractories and foundry, zirconium-based chemicals and fused zirconium, and other applications (Zirconet Ltd., 2020). Zircon sand was preferred in casting applications where high-quality finishes and tight tolerances were required owing to its lower expansion coefficient and greater stability at high temperatures compared with other materials. In the gemstone industry, zircon recovered from hard-rock mining was valued as a natural gemstone, and zirconia powder in minor quantities was processed to produce cubic zirconia, a synthetic gemstone and diamond simulant.

Zirconium metal was 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.

Zirconia exhibits high light reflectivity and good thermal stability and was used primarily as an opacifier and pigment in glazes and colors used for pottery and other ceramic products. Yttria-stabilized zirconia (YSZ) was used in the manufacture of oxygen sensors that controlled combustion in automobile engines and furnaces. YSZ also was 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 biomedical applications, such as dental bridges, crowns, and inlays, because it has two to three times the fracture resistance and 1.4 times the strength of alternative 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. Refractory bricks and blocks containing zircon were used in furnaces and hearths for containing molten metals. Fused-cast and bonded alumina-zirconia-silica-base refractories were used in glass-tank furnaces.

Baddeleyite was used principally in the manufacture of alumina-zirconia abrasives and in ceramic colors and refractories. Ammonium- and potassium-zirconium carbonates were used as antiperspirants, paper and board coatings, and in printing and paper manufacturing. Zirconium chemicals also were used in inks to promote adhesion to metals and plastics.

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal was used as cladding for nuclear fuel rod tubes. Hafnium was 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 chemical process industries because of its excellent corrosion resistance. Hafnium metal also was used as an additive in superalloys.

Prices

In 2018, prices from Industrial Minerals for domestic standard-grade bulk zircon concentrate and Australia standard-grade, free on board bulk zircon concentrate were discontinued. The average of 2019 published prices for China standard-grade bulk zircon concentrate was \$1,400 to \$1,600 per metric ton. The average unit value of imported zirconium ores and concentrates in 2019 was \$1,490 per metric ton, a 16% increase from that in 2018 (table 4). The published yearend price range of abrasive and refractory zirconia was \$6,500 to \$7,500 per metric ton, an increase from that of the previous year (table 2).

In 2019, the average duty-paid unit value of imported unwrought zirconium (including powder) from China, the leading source of United States unwrought zirconium imports, increased to \$14 per kilogram from \$13 per kilogram in 2018. The average duty-paid unit value of other zirconium metal from France, a major producer of nuclear-grade zirconium, was \$144 per kilogram, a slight increase from \$142 per kilogram in 2018. The average value of unwrought hafnium was \$671 per kilogram in 2019, 10% lower than that in 2018 (table 4).

Foreign Trade

In 2019, exports of zirconium ores and concentrates totaled 62,200 t, 48% lower than those in 2018 (table 3). Imports of zirconium ore and concentrates totaled 34,800 t, a 14% decrease from those in 2018 (table 4). South Africa, Australia, and Senegal supplied most of the zirconium ore and concentrates (64%, 17%, and 17%, respectively) into the United States.

Most zirconium metal, excluding ferrozirconium, was exported in wrought products classified as “Other zirconium and articles thereof” under the U.S. Census Bureau’s Schedule B code 8109.90.0000 (table 3). Exports of zirconium wrought products totaled 862 t in 2019, a 25% decrease from those in 2018. Most zirconium metal was imported as unwrought zirconium or zirconium metal powder under Harmonized Tariff Schedule of the United States (HTS) code 8109.20.0000. The United States imported 1,520 t of unwrought zirconium in 2019, 11% less than that in 2018 (table 4). Imports of unwrought hafnium metal, including powder, HTS code 8112.92.2000, totaled 33 t, a 24% decrease from those in 2018 and the third consecutive year of decreased imports (tables 1, 4). Imports of ferrozirconium were 219 t in 2019, an increase of 15% compared with those in 2018.

World Review

Global zircon consumption decreased in 2019. Decreased sales of downstream products, inventory clearing, and trade tensions were noted from varied sources as reasons for the decline in consumption.

Australia.—Iluka produced 322,000 t of zircon from its operations in Australia, a slight decrease from that in 2018. Iluka completed several projects and operational changes and started several projects in Australia. The Cataby Mine in Western

Australia started up operations in April 2019 and ramped up to full production by yearend. With a projected mine life of 8.5 years, zircon production was anticipated to average about 50,000 metric tons per year (t/yr). Iluka completed the move from mining the Jacinth deposit to mining the Ambrosia deposit in South Australia. In Western Australia, construction began on the Eneabba mineral sands project, which would process and recover stockpiled tailings to produce mixed zircon and monazite concentrates (Iluka Resources Ltd., 2019, p. 6–7, 11, 26).

Tronox Holdings plc produced 50,000 t of zircon from its Western Australia operations and 63,000 t from its eastern Australia operations (Tronox Holdings plc, 2020, p. 34).

China.—As the leading consumer of zirconium mineral concentrates, China imported 1.18 Mt in 2019, essentially unchanged from that in 2018 (United Nations Statistical Division, 2020).

Kenya.—Base Resources Ltd. produced 31,900 t of zircon from its Kwale operation in the reporting year ending June 30, 2019, a decrease of 17% from that in the same time period in 2018. During the year, the Kwale Phase 2 mine project was ongoing. This work involved shutting down the mining and wet concentrator plant for the month of March to complete equipment installation and starting up a second hydraulic unit (Base Resources Ltd., 2019, p. 8).

Madagascar.—Base Resources continued development of the Toliara Project. In 2019, a prefeasibility study was completed, and the definitive feasibility study was started. The company projected construction would begin in 2020 and production would follow in 2021. It was estimated that 54,000 t/yr of zircon would be produced (Base Resources Ltd., 2019, p. 13).

Mozambique.—Kenmare Resources plc produced 87,100 t of what it described as primary and secondary zircon including concentrates in 2019. The company continued optimization projects to convert secondary zircon to primary zircon and increase recovery rates of the zircon recovery circuits (Kenmare Resources plc, 2019, p. 32).

Senegal.—Eramet Group reported zircon sales of 58,000 t in 2019. Decreased consumption by China and the global ceramics sector was cited for reduced sales (Eramet Group, 2020, p. 37).

South Africa.—Tronox produced 121,000 t of zircon from its Namakwa Sands operation and 55,000 t of zircon from its KZN Sands operation in South Africa, for a total of 176,000 t, a slight increase from that in 2018 (Tronox Holdings plc, 2020, p. 34).

In 2019, Mineral Commodities Ltd. produced 9,940 t of zircon-rutile concentrate, containing 68% zircon and 16% to 20% rutile, at its Tormin Mine in Western Cape Province. This was a 42% decrease from that in 2018 (Mineral Commodities Ltd., 2020).

Outlook

Zircon consumption was lower in 2019 primarily owing to reduced demand from China. Several mineral sands projects were in the development stage, but funding had not been fully secured. It is expected that established mines will have lower production owing to lower zircon grades. The United States is expected to be a net exporter of zirconium ores and concentrates, while remaining a net importer of zirconium metal.

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GENERAL SOURCES OF INFORMATION

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TABLE 1
SALIENT U.S. ZIRCONIUM AND HAFNIUM STATISTICS¹

(Metric tons, gross weight)

	2015	2016	2017	2018	2019
Zircon:					
Production:					
Concentrates	80,000 ²	W	100,000 ²	100,000 ²	100,000 ³
Milled zircon ^c	46,000	49,000	49,900	49,200	48,500
Exports	4,920	5,050	48,400	119,000	62,200
Imports for consumption ⁴	32,000	38,400	37,300	40,600	34,800
Consumption, apparent ⁵	100,000 ²	W	100,000 ²	100,000 ²	100,000 ³
Zirconium oxide: ⁶					
Production	NA	NA	NA	NA	NA
Exports	5,700	5,420	5,110	4,070	3,420
Imports for consumption	4,140	2,620	3,380	2,730 ^r	2,860
Zirconium, metal, including waste and scrap:					
Production	NA	NA	NA	NA	NA
Exports	1,530	1,150	1,600	1,700	1,760
Imports for consumption	1,330	1,240	1,180	2,190 ^r	2,140
Ferrozirconium:					
Production	NA	NA	NA	NA	NA
Exports	973	476	63 ^r	424	359
Imports for consumption	158	59	161	191	219
Hafnium, unwrought, including powder, imports for consumption	72	180	113	44 ^r	33

^cEstimated. ^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through July 23, 2020. Data are rounded to no more than three significant digits.

²Data are rounded to one significant digit to avoid disclosing company proprietary data.

³Data are rounded to the nearest 100,000 metric tons.

⁴Includes insignificant amounts of baddeleyite.

⁵Defined as production plus imports for consumption minus exports plus or minus Government shipments.

⁶Includes germanium oxides and zirconium dioxides.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM MATERIALS¹

(Dollars per metric ton)

Material	2018	2019
Zircon:		
Domestic, standard-grade, bulk	NA	NA
Australia, standard-grade, free on board, bulk	NA	NA
China, standard grade, cost insurance and freight, bulk ²	1,400–1,550	1,400–1,600
Zirconium ores and concentrates ³	1,290	1,490
Zirconia, fused, monoclinic, refractory and abrasive	6,150–7,150	6,500–7,500

NA Not available.

¹Table includes data available through July 23, 2020. Data are rounded to no more than three significant digits.

²Source: Industrial Minerals.

³Source: U.S. Census Bureau. Unit value based on landed-duty-paid United States imports for consumption from Australia, Senegal, and South Africa.

TABLE 3
U.S. EXPORTS OF ZIRCONIUM, BY CLASS AND COUNTRY OR LOCALITY¹

Class and country or locality	Schedule B number	2018		2019	
		Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Ores and concentrates:	2615.10.0000				
Belgium		595	\$1,520	741	\$2,120
Brazil		6	59	4	31
Canada		1,920	4,310	1,730	4,150
Chile		283	479	360	669
China		104,000	61,900	52,300	31,700
France		5,850	9,010	1,440	2,750
Germany		19	61	65	261
India		2,970	4,520 [†]	2,480	3,810
Italy		74	213	151	316
Japan		876	3,470	678	3,660
Mexico		1,390	2,330	1,300	2,510
United Kingdom		552	1,640	311	936
Other		496 [‡]	1,140 [‡]	658	1,520
Total		119,000	90,700	62,200	54,500
Ferrozirconium:	7202.99.1000				
Israel		52	74	--	--
Mexico		362	756	318	641
Other		11	31	41	91
Total		424	861	359	732
Unwrought zirconium, including powder:	8109.20.0000				
Germany		69	1,980	83	2,350
Japan		--	--	9	721
Netherlands		--	--	17	377
Russia		26	1,740	96	5,890
Sweden		47	2,600	98	5,580
United Kingdom		62	2,760	103	4,310
Other		63 [‡]	2,240	128	6,760
Total		268	11,300	534	26,000
Zirconium waste and scrap:	8109.30.0000				
Belgium		50	584	158	1,790
Canada		34	1,580	12	550
Italy		12	208	11	180
Japan		12	399	25	560
United Kingdom		48	786	54	761
Other		132	1,510	102	2,080
Total		288	5,070	363	5,920
Other zirconium:	8109.90.0000				
Argentina		22	2,080	12	1,470
Canada		365	38,000	426	44,700
China		156	13,200	126	10,100
France		164	18,900	27	3,280
Germany		9	1,100	3	720
Japan		45	5,180	57	4,480
Korea, Republic of		180	27,100	64	10,800
Sweden		69	7,750 [‡]	60	6,170
United Arab Emirates		(2)	13	(2)	16
United Kingdom		32	1,510	34	3,610
Other		105	6,650	53	3,620
Total		1,150	121,000	862	88,900

[†]Revised. -- Zero.

¹Table includes data available through May 12, 2020. Data are rounded to no more than three significant digits, may not add to totals shown.

²Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF ZIRCONIUM AND HAFNIUM, BY CLASS AND COUNTRY OR LOCALITY¹

Class and country or locality	HTS ² code	2018		2019	
		Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Zirconium ores and concentrates:	2615.10.0000				
Australia		3,440	\$5,090	5,870	\$9,190
China		449	1,420	129	827
Russia		624	3,100	481	2,700
Senegal		13,300	19,100	5,890	9,920
South Africa		22,500	26,500	22,300	31,600
Other		293	762	135	378
Total		40,600	55,900	34,800	54,600
Ferrozirconium:	7202.99.1000				
Brazil		--	--	54	118
Canada		76	358	16	37
China		115	323	100	277
Germany		--	--	49	51
Total		191	682	219	483
Unwrought zirconium, including powder:	8109.20.0000				
China		1,480	18,800	1,320	18,000
France		--	--	16	1,120
Germany		127	5,150	99	3,580
Japan		54 ^r	310 ^r	56	366
Korea, Republic of		14	172	--	--
Other		33	130	24	280
Total		1,710 ^r	24,600 ^r	1,520	23,300
Zirconium waste and scrap:	8109.30.0000				
Canada		33	59	59	309
France		17 ^r	293 ^r	1	15
Germany		68	411 ^r	123	1,470
Japan		51	299	67	294
Korea, Republic of		18	273	9	59
Other		11	151	70	638
Total		197 ^r	1,490 ^r	329	2,790
Other zirconium:	8109.90.0000				
Canada		16	1,190	9	987
France		181	25,600	192	27,600
Germany		47	5,420	58	6,630
Other		40 ^r	5,150	29	4,430
Total		285 ^r	37,300	289	39,600
Unwrought hafnium, including powder:	8112.92.2000				
China		21 ^r	14,800 ^r	6	3,870
France		12	9,990	9	7,510
Germany		8 ^r	5,670 ^r	15	9,160
Other		4 ^r	2,170	2	1,680
Total		44 ^r	32,600 ^r	33	22,200

^rRevised. -- Zero.

¹Table includes data available through May 12, 2020. Data are rounded to no more than three significant digits, may not add to totals shown.

²Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau.

TABLE 5
ZIRCONIUM MINERAL CONCENTRATES: WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons, gross weight)

Country or locality ²	2015	2016	2017	2018	2019
Australia	601,000	600,000	505,300	530,000 ^r	470,000
Brazil	22,647	21,302 ^r	21,000 ^{r,c}	21,000 ^c	21,000 ^c
China ^c	150,000	140,000	140,000	140,000	140,000
India	18,891	18,437	30,351	13,951	18,000 ^c
Indonesia ^c	30,900	34,800	30,400	53,700 ^r	33,600
Kenya	25,951	39,687	42,217	36,387 ^r	28,909
Madagascar	11,879	15,600 ^{r,3}	27,800 ^{r,3}	22,400 ^r	22,000 ^c
Malaysia	826	653	1,595	1,000 ^c	1,000 ^c
Mozambique	57,900 ^e	215,222	124,022	105,000	100,000 ^c
Nigeria	1,050 ^{r,c}	1,070 ^{r,3}	1,800 ^{r,3}	1,421 ^r	1,000 ^c
Russia ⁴	8,180	7,704	7,200	7,400 ^r	7,400 ^c
Senegal	45,248	52,627	81,749	64,278	65,000 ^c
Sierra Leone	1,326	1,500 ^e	3,000	11,400	9,000 ^c
South Africa	377,767	377,430	361,813 ^r	350,000 ^c	370,000 ^c
Sri Lanka	38,000 ^r	25,000 ^{r,5}	4,800 ^{r,5}	4,800 ^{r,c}	5,000 ^c
Turkey	1,500	500	1,200	1,000 ^c	1,000 ^c
Ukraine	25,000	22,200	26,500	21,614 ^r	21,000 ^c
United States	80,000 ⁶	W	100,000 ⁶	100,000 ⁶	100,000 ⁷
Vietnam ³	4,300	9,500	5,400 ^r	11,000 ^r	10,000
Total	1,500,000	1,580,000	1,520,000 ^r	1,500,000 ^r	1,420,000

²Estimated. ^rRevised. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through June 1, 2020. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²In addition to the countries and (or) localities listed, various countries may have produced small amounts of zirconium mineral concentrates, but available information was inadequate to make reliable estimates of output.

³Estimated figures based on exports of zirconium ore to China.

⁴Production of baddeleyite concentrate averaging 98% ZrO₂.

⁵Estimated figures based on exports of zirconium ore to China and Malaysia.

⁶Rounded to one significant digit.

⁷Rounded to the nearest 100,000 metric tons.