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2020 Minerals Yearbook

ZIRCONIUM AND HAFNIUM [ADVANCE RELEASE]

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Zirconium and Hafnium

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In 2020, production and consumption of zirconium mineral concentrates in the United States were reported as less than 100,000 metric tons (t) to avoid disclosing company proprietary data. (table 1). Production of milled zircon decreased by 28% from that in 2019. U.S. imports of zirconium ore and mineral concentrates decreased by 31% and exports were less than one-third of those in 2019 (tables 1, 3, 4). World production of zirconium mineral concentrates in 2020 (excluding domestic production) was 1.19 million metric tons (Mt), a 17% decrease from the 2019 revised production total (table 5). Global and domestic consumption were influenced by the global coronavirus disease 2019 (COVID-19) pandemic and related manufacturing shutdowns.

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 oxide (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 to 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 the United States. In 2020, The Chemours Co. (Wilmington, DE) produced separated zircon mineral concentrates. Twin Pines Minerals, LLC (Starke, FL) produced mineral concentrates containing zircon and other heavy minerals.

Iluka Resources, Inc. (a wholly owned subsidiary of Iluka Resources Ltd., Perth, Western Australia, Australia) terminated its mining operations near Stony Creek, VA, at the end of 2015 but continued intermittent processing of material. In 2020, Iluka reported sales of 4,900 t of remaining stockpiled material (Iluka Resources Ltd., 2021, p. 31).

U.S. producers of zirconium and hafnium metal were Allegheny Technologies, Inc. near 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 on the basis of prior-year levels. Domestic production of milled zircon was 35,000 t in 2020 (table 1). Insufficient data were available to determine stocks of zirconium mineral concentrates or production of zirconium chemicals and zirconium metal.

Consumption

Globally, the leading end uses for zircon were, in descending order of quantity, ceramics, refractories and foundry, zirconium-based chemicals and fused zirconium, and other applications (Zircomet 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 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 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 greater strength compared with 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

The 2020 annual average price for China standard-grade bulk zircon concentrate was $1,370 per metric ton, a decrease from $1,490 per metric ton in 2019 (table 2). The average unit value of imported zirconium ore and concentrates in 2020 was $1,490 per metric ton, a 5% decrease from that in 2019 (table 4). The published yearend price of fused zirconia ex-works China was $3,580 per metric ton, a significant decrease from $4,270 per metric ton in 2019 (table 2).

In 2020, the annual average unit value of imported unwrought zirconium (including sponge and powder) from China, the leading source of United States unwrought zirconium imports, decreased to $6 per kilogram from $14 per kilogram in 2019. The annual average unit value of other zirconium metal imported from France, a major producer of nuclear-grade zirconium, was $141 per kilogram, a slight decrease from $144 per kilogram in 2019. The annual average unit value of imported unwrought hafnium was $645 per kilogram in 2020, 5% lower than that in 2019 (table 4).

Foreign Trade

In 2020, exports of zirconium ore and concentrates fell to 18,700 t, 70% lower than those in 2019 (table 3). Imports of zirconium ore and concentrates totaled 24,000 t, a 31% decrease from those in 2019. South Africa, Australia, and Senegal supplied most of the zirconium ore and concentrates (39%, 36%, and 23%, respectively) into the United States (table 4).

Most zirconium metal, excluding ferrozirconium, was exported in wrought products classified as "Other zirconium and articles thereof" under the Harmonized System-based Schedule B number 8109.90.0000 (table 3). Exports of zirconium wrought products totaled 838 t in 2020, a 3% decrease from those in 2019 (table 3). Unlike exports, 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 1,780 t of unwrought zirconium in 2020, 22% more than that in 2019 (table 4). Imports of hafnium metal, HTS code 8112.92.2000, totaled 16 t, a 50% decrease from those in 2019 and the fourth year in a row of decreased imports (tables 1, 4). Imports of ferrozirconium alloys were 184 t in 2020, an increase of 8% compared with those in 2019 (table 4).

World Review

Owing to the global economic conditions, global zircon production and consumption decreased in 2020. COVID-19 pandemic-related restrictions, lower sales of downstream products, and trade tensions were often noted from varied sources as reasons for the declines.

Australia.—Iluka reported that it had produced less heavy-mineral concentrates to be in line with market conditions. In 2020, Iluka produced 174,000 t of zircon from its mining and concentrating operations in Australia, a decrease from 314,000 t in 2019. At Iluka's Eneabba mineral sands operations in Western Australia, a project to recover a mixed monazite and zircon concentrate from stockpiled mine tailings entered production, sales of monazite-zircon mixed concentrate in 2020 were reported to be 44,000 t, and the second phase of the project was under construction. Once completed, the project was expected to increase the monazite fraction of the concentrate from the initial 20% to 90% (Iluka Resources Ltd., 2021, p. 10–11, 26, 28–29, 156).

Tronox Holdings plc reported 117,000 metric tons per year (t/yr) of zircon production capacity from its operations in the States of New South Wales and Western Australia. In New South Wales, Tronox was developing its Atlas and Campaspe mining projects that were expected to replace feedstock supply from its existing Snapper and Ginkgo Mines, which were nearing the end of their lives. Production from the new mines was expected to begin in 2022. At yearend, the company's reserves in Australia were 590 Mt containing 18 Mt of heavy minerals including 2.1 Mt of zircon (Tronox Holdings plc, 2021, p. 33, 36, 38).

China.—As the leading consumer of zirconium mineral concentrates, China imported 1.09 Mt in 2020, a 7% decrease compared with those in 2019. China's leading import sources of zirconium mineral concentrates were Australia (58%) and South Africa (18%) (Zen Innovations AG, 2022).

Kenya.—Base Resources Ltd. produced 31,700 t of zircon from its Kwale operation in 2020. A prefeasibility study for mining the Kwale North Dune mineral resource area concluded that it was not viable to mine the entirety of these deposits. A feasibility study for mining a smaller portion of the North Dune and Bumamani deposits was expected in 2021 (Base Resources Ltd., 2021). In March, the measured and indicated resource estimates for the Kwale South Dune deposits were updated to a total of 88 Mt containing about 160,000 t of zircon (Base Resources Ltd., 2020, p. 1).

Madagascar.—Base Resources continued to pursue the development of the Toliara project. In November 2019, the Government of Madagascar requested on-the-ground activities to be suspended. Work on the project was reported to be ongoing in 2020; however, a decision to proceed with development of the project was delayed (Base Resources Ltd., 2021).

Mozambique.—At Kenmare Resources plc's Moma mining and processing operations, zircon production decreased 10% compared with the previous year. The Moma operations produced a total of 78,100 t of what the company described as standard zircon, secondary zircon, special zircon, and zircon included in concentrates. In 2020, Kenmare relocated one of its mining dredges 23 kilometers from the Namalope deposit to the Pilivili deposit (Kenmare Resources plc, 2021, p. 33, 42).

Senegal.—Eramet Group reported zircon production of 59,000 t in 2020 from its Grande Côte mining operations. Compared with that in 2019, increased production of mineral concentrates was attributed to improved operational performance despite slightly lower ore grades mined (Eramet Group, 2021, p. 11).

South Africa.—Tronox reported zircon production capacities of 125,000 t/yr at its Namakwa Sands operation and 55,000 t/yr from its KwaZulu-Natal (KZN) Sands operations, for a total of 180,000 t/yr. At yearend, the combined proven and probable reserves at the Namakwa Sands and KZN Sands operations were 950 Mt containing 5.6 Mt of zircon (Tronox Holdings plc, 2021, p. 33, 37).

In 2020, Mineral Commodities Ltd. (MCL) produced 10,100 t of mixed heavy-mineral concentrate, containing primarily zircon (68%) and rutile (16%), at its Tormin mining operations in Western Cape Province. The Tormin operations included mining several placer beach and inland heavy-mineral-sand deposits. Tormin's beach deposits were periodically replenished with heavy minerals through storm surges and wave activity. In 2020, MCL began mining its Northern Beaches and Inland Strand deposits. In 2021, MCL planned to complete compliant reserve estimates at its inland Western Strandline deposit and expand its mining efforts at Tormin (Mineral Commodities Ltd., 2021, p. 9, 18).

Outlook

Global production and consumption of zircon were less in 2020 compared with those in 2019 primarily owing to reduced demand related to the global COVID-19 pandemic. Although numerous mineral sands projects are in various stages of development, most project timelines have been extended. Short-term supply deficits may ensue if increased demand is not matched with additional mine production. If recent import and export trends continue, the United States is expected to be become a net importer of zirconium ores and concentrates and remain a net importer of zirconium metal.

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

(Metric tons, gross weight)

	2016	2017	2018	2019	2020
Zircon:					
Production:					
Concentrates	W	100,000 [2]	100,000 [2]	100,000 [2]	<100,000 [3]
Milled zircon[e]	49,000	49,900	49,200	48,500	35,000
Exports	5,050	48,400	119,000	62,200	18,700
Imports for consumption[4]	38,400	37,300	40,600	34,800	24,000
Consumption, apparent[5]	W	100,000 [2]	100,000 [2]	100,000 [2]	100,000 [2]
Zirconium oxide:[6]					
Production	NA	NA	NA	NA	NA
Exports	5,420	5,110	4,070	3,420	4,710
Imports for consumption	2,620	3,380	2,690 [r]	2,790 [r]	3,560
Zirconium, metal, including waste and scrap:					
Production	NA	NA	NA	NA	NA
Exports	1,150	1,600	1,700	1,710 [r]	1,500
Imports for consumption	1,240	1,180	2,160 [r]	2,110 [r]	2,340
Ferrozirconium:					
Production	NA	NA	NA	NA	NA
Exports	476	62 [r]	424	359	63
Imports for consumption	59	161	191	170 [r]	184
Hafnium, unwrought, including powder, imports for consumption	180	113	42 [r]	32 [r]	16

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

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

[2]Data reported to the nearest 100,000 metric tons to avoid disclosing company proprietary data.

[3]Reported as less than 100,000 metric tons to avoid disclosing company proprietary data.

[4]Includes insignificant amounts of baddeleyite.

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

[6]Includes germanium oxides and zirconium dioxides.

TABLE 2
AVERAGE PRICES OF ZIRCONIUM MATERIALS[1]

(Dollars per metric ton)

Material	2019	2020
Zircon:		
China, standard grade, cost insurance and freight, bulk[2]	1,490 [r]	1,370
Zirconium ore and concentrates:[3]		
Australia, exports, bags, drums, and similar containers, unit value[3]	1,500	1,290
United States, imports, unit value[4]	1,550	1,400
Zirconia, fused, ex-works China[5]	4,270	3,580

[1]Table includes data available through July 12, 2021. Data are rounded to no more than three significant digits.

[2]Source: Fastmarkets IM.

[3]Source: Zen Innovations AG, Global Trade Tracker

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

[5]Source: Argus Media group—Argus Metals International

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

Class and country or locality	Schedule B number	2019 Gross weight (metric tons)	2019 Value (thousands)	2020 Gross weight (metric tons)	2020 Value (thousands)
Ore and concentrates:	2615.10.0000				
Canada		1,730	$4,150	1,280	$2,900
China		52,300	31,700	2,870	4,360
France		1,450 r	2,780 r	561	1,560
India		2,480	3,810	5,670	7,190
Mexico		1,300	2,520 r	3,760	6,470
Other		2,970 r	9,520 r	4,590	8,590
Total		62,200	54,500	18,700	31,100
Ferrozirconium:	7202.99.1000				
Mexico		318	641	59	114
Poland		40	79	--	--
Other		1 r	12 r	4	12
Total		359	732	63	126
Unwrought zirconium, including powder:	8109.20.0000				
France		80	5,210	98	7,050
Germany		83	2,350	73	1,430
Netherlands		17	377	18	360
Russia		96	5,890	79	3,820
Sweden		98	5,580	73	4,350
United Kingdom		103	4,310	101	4,030
Other		58 r	2,270 r	31	1,060
Total		534	26,000	473	22,100
Zirconium waste and scrap:	8109.30.0000				
Belgium		158	1,790	80	986
Canada		12	550	4	183
China		36	384	8	81
Estonia		6	200	14	468
Italy		11	180	14	191
Japan		25	560	43	1,190
Spain		23	208	5	164
United Kingdom		54	761	10	209
Other		37 r	1,280 r	15	236
Total		363	5,920	191	3,710
Other zirconium:	8109.90.0000				
Argentina		12	1,470	50	5,150
Canada		380 r	45,200 r	430	44,900
China		126	10,100	20	2,210
France		27	3,280	47	4,080
Japan		57	4,480	57	4,120
Korea, Republic of		64	10,800	138	22,300
Sweden		60	6,170	11	2,240
United Kingdom		34	3,610	32	2,590
Other		56 r	4,350 r	54	5,090
Total		816 r	89,400 r	838	92,700

rRevised. -- Zero.
[1]Table includes data available through June 29, 2021. Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4

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

Class and country or locality	HTS[2] code	2019 Gross weight (metric tons)	2019 Value (thousands)	2020 Gross weight (metric tons)	2020 Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		5,870	$9,190	8,640	$13,000
Senegal		5,890	9,920	5,460	8,100
South Africa		22,300	31,600	9,240	11,100
Other		745 r	3,910 r	622	3,490
Total		34,800	54,600	24,000	35,700
Ferrozirconium:	7202.99.1000				
Brazil		54	118	36	70
Canada		16	37	20	70
China		100	277	90	202
Hong Kong		--	--	38	95
Total		170 r	432 r	184	436
Unwrought zirconium, including powder:	8109.20.0000				
China		1,320	18,000	1,710	10,200
Other		141 r	5,000 r	72	3,400
Total		1,460 r	23,000 r	1,780	13,600
Zirconium waste and scrap:	8109.30.0000				
Canada		59	309	63	197
France		24 r	370 r	14	705
Germany		125 r	1,590 r	109	973
Japan		67	293 r	57	494
United Kingdom		46	431	11	81
Other		33 r	266 r	(3)	10
Total		354 r	3,260 r	255	2,460
Other zirconium:	8109.90.0000				
Belgium		9	501	14	314
China		5	423	25	2,620
France		192	27,600	193	27,200
Germany		58	6,630	45	5,230
Other		24 r	4,490 r	26	4,790
Total		289	39,600	302	40,200
Unwrought hafnium, including powder:	8112.92.2000				
China		5 r	3,320 r	1	435
France		9	7,510	8	5,470
Germany		15	9,160	6	3,830
Other		2	1,680	1	579
Total		32 r	21,700 r	16	10,300

[r]Revised. -- Zero.

[1]Table includes data available through June 29, 2021. 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 OR LOCALITY[1]

(Metric tons, gross weight)

Country or locality[2]	2016	2017	2018	2019	2020
Australia	600,000	505,300 r	530,000	470,000	400,000
Brazil	21,302	21,000 e	21,000 e	11,695 r	7,225
China[e]	140,000	140,000	140,000	140,000	133,000
India	18,437	30,351	13,951	18,000 e	18,000 e
Indonesia[e, 3]	34,800	29,000 r	54,000 r	73,000 r	64,000
Kenya	39,687	42,217	36,387	30,350 r	31,730
Madagascar	15,582 r	26,040 r	22,757 r	29,473 r	26,029
Malaysia	653	1,595	509 r	449 r	157
Mozambique	215,222	124,022	202,022 r	121,768 r	104,076
Nigeria	1,073 r	1,799 r	120 r	8,161 r	700 e, 4
Russia[5]	7,704	7,200	7,400	6,300 r	2,400 e
Senegal	52,627	81,749	64,278	65,000 e	60,200
Sierra Leone	1,500 e	3,000	11,400	9,000 e	6,600
South Africa	377,430	361,813	341,308 r	324,000 r	310,000 e
Sri Lanka	628 r	1,061 r	1,500 r, e	2,089 r	1,600 e, 6
Turkey	500	1,200	1,950 r	1,900 r, e	--
Ukraine	22,200	26,500	21,614	17,000 e, 3	16,000 e, 3
United States	W	100,000 [7]	100,000 [7]	100,000 [7]	<100,000 [8]
Vietnam[e, 6]	9,500	5,400	11,000	6,200 r	11,000
Total	1,560,000 r	1,510,000 r	1,580,000 r	1,430,000 r	1,190,000 [9]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]Table includes data available through June 15, 2023. All data are reported unless otherwise noted; totals may include estimated data. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

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

[3]Based on exports of zirconium ore and concentrates.

[4]Estimated based on China's imports of zirconium ore and concentrates.

[5]Production of baddeleyite concentrate averaging 96% zirconium oxide.

[6]Estimated based on global imports of zirconium ore and concentrates from the source country.

[7]Rounded to the nearest 100,000 metric tons to avoid disclosing company proprietary data.

[8]Reported as less than 100,000 metric tons to avoid disclosing company proprietary data.

[9]Excludes the United States.