

ZIRCONIUM AND HAFNIUM

By Joseph M. Gambogi

Zirconium and hafnium are relatively abundant in the Earth's crust, however, zircon (zirconium silicate) is the only naturally occurring mineral of commercial significance. Zirconium and hafnium are both contained in zircon at a ratio of about 50 to 1. Zircon is a byproduct of the mining and processing of heavy mineral sands for the titanium minerals rutile and ilmenite. The major end uses of zircon are refractories, foundry sands (including investment casting), and ceramic opacification.

World zircon production was estimated to have increased significantly in 1994. Worldwide, zircon consumption was estimated to have increased by 4%. The growth in demand for zircon was primarily attributed to increased consumption by the ceramic tile industry. In response to increased demand and a limited supply of material, prices for zircon concentrates increased moderately.

U.S. production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data. Domestic production of milled zircon increased 14% in 1994. According to U.S. Customs trade statistics, the United States was a net importer of zircon, and imports of zircon increased 17%.

With the exception of prices, all data in this report have been rounded to three significant digits. Totals and percentages were calculated from unrounded numbers.

Production

Data for zirconium and hafnium materials are developed by the U.S. Bureau of Mines from one voluntary survey of domestic operations. Of the 33 operations surveyed, 23 responded, representing 75% of the domestic production data in table 1. Data for nonrespondents were estimated based on prior year levels. Domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data. Milled zircon production increased 14% from that of 1993, while zirconium oxide production increased 21% from the revised 1993 level. (See table 1.)

U.S. mine producers of zircon in 1993 were RGC (USA) Mineral Sands, Inc., and E. I. du Pont de Nemours & Co. Inc. (Du Pont). Both producers mined heavy mineral sand deposits in Florida.

Prices

Countless end products were produced from zircon. High-volume production included refractory bricks and shapes, alumina-zirconia abrasives, foundry sands and investment castings, milled and micronized zircon, zirconium chemicals, and zirconia. Examples of high-unit-value products include cubic zirconia, technical zirconia ceramics, superalloy castings, zirconia textile refractories, and specialty chemicals. Zirconium-clad fuel rods and hafnium control rods make up the core of nuclear reactors. Commercial-grade zirconium, unlike nuclear grade, contains hafnium and is used in the chemical process industries because of its excellent corrosion resistance. Increased demand from the ceramic industry caused prices of zircon-base concentrates to increase by about 10% from the 1993 level. However, published prices for zirconium, hafnium, and zirconia-base products were reportedly unchanged. (See table 2.)

Foreign Trade

In 1994, the United States was a net importer of zircon. The two leading import sources were Australia and South Africa. Imports of zircon increased about 17% from those of 1993. The United States is a net exporter of zirconium and hafnium metal. Mexico and Germany were the largest importers of domestic zirconium. Exports of zirconium decreased about 11% compared with those of 1993.

World Review

Australia.—Cable Sands Ltd. commissioned its Jangarup mineral sands operation near Nannup, Western Australia. The operation was expected to produce 230,000 tons per year of heavy mineral concentrate.¹

In March, production from one of Consolidated Rutile Ltd.'s (CRL) mineral sands operations on North Stradbroke Island was temporarily interrupted when a 450-ton dredge sank.² CRL's other dredge on North Stradbroke Island was not affected, and the repaired dredge was put back into operation in May.

Hanwah Corp. purchased ICI Australia's zirconia plant at Rockingham, Western

Australia. Although the plant has been idle since 1992, the plant was designed to produce 450 tons per year of high-purity zirconia. Hanwah planned to recommission the plant in 1995.³

Canada.—Tiomina Resources Inc. completed a prefeasibility review of its Natashquan mineral sands project in Quebec. The review concluded the project was feasible, and the company was seeking joint-venture partners to develop the project.⁴

China.—CRL entered into a joint venture with the Wujin County Third Building Co. to produce micronized zircon at a new facility located Xiayi, Jiangsu Province. Construction of a new 3,000-ton-per-year plant began in June, and the plant was expected to be commissioned in March 1995.⁵

Russia.—Seamet Ltd. entered into a joint venture with a Russian partner for the development of the Tsentralnoye mineral sands deposit in southern Russia. The deposit is reported to contain proven reserves of 2.25 million tons of heavy minerals.⁶

South Africa.—Anglo-American Corp.'s subsidiary, Namakwa Sands Ltd., commissioned mining operations at Brand-se-Baai on the west coast of South Africa. When completed, the project was expected to produce 120,000 tons of zircon annually.

United Kingdom.—Titanium dioxide producer Tioxide PLC moved into the advanced ceramics market as a supplier of zirconia. Tioxide plans to market three grades of zirconia based on a gas-phase process that allows the formation of zirconia crystals in one step. The new operation was incorporated into Tioxide's Billingham facility.⁷

Outlook

Growth in demand for zircon materials is being led by its use as an opacifier in glazed ceramic tile manufacture. Zircon consumption has been forecast to reach more than 1 million tons by the year 2000. By the end of the century, consumption in the ceramics industry is forecast to be about 50% of total consumption. Although Australia is expected to continue as a major supplier of zircon, South Africa should overtake Australia as the leading producer of zircon concentrates.⁸

¹Industrial Minerals. Jangarup Enters Production. No. 322, July 1994, p. 74.

²Mining Journal. Cons. Rutile Dredger Sinks. Apr. 29, 1994, p. 311.

³Industrial Minerals. ICI Sells Zirconia Plant. No. 326, Nov. 1994, p. 8.

⁴———. Tiomin Minsands Project Advances. No. 322, Aug. 1995, p.11.

⁵———. CRL Zircon Opacifier JV. No. 327, Dec. 1994, p. 9.

⁶———. Australian Interest in Tambov Mineral Sands. No. 327, Dec. 1994, p. 11.

⁷———. Tioxide Develops Zirconia Business. No. 316, Feb. 1994, p. 19.

⁸———. Shifts in Zircon Supply and Demand. No. 322, Aug. 1994, p. 17.

OTHER SOURCES OF INFORMATION

American Metal Market, daily newspaper.

Chemical Engineering, biweekly.

Chemical Week, weekly.

Engineering and Mining Journal, monthly.

Industrial Minerals (London), monthly.

International Strategic Minerals Inventory. U.S.

Geological Survey, Circular 30-L.

Metal Bulletin (London), semiweekly.

Platt's Metals Week, weekly.

Mining Engineering, monthly.

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Roskill Information Services Ltd. (London).

The Economics of Zirconium, 7th edition, 1992.

TABLE 1
SALIENT U.S. ZIRCONIUM STATISTICS 1/

(Metric tons)

| | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---------|---------|------------|-----------|--------|
| Zircon: | | | | | |
| Production: | | | | | |
| Concentrates | 102,000 | 103,000 | 108,000 | W | W |
| Milled zircon | 43,900 | 44,400 | 45,100 | 46,700 | 53,300 |
| Exports | 30,200 | 31,300 | 27,900 | 35,900 | 32,000 |
| Imports for consumption 2/ | 26,800 | 35,700 | 37,400 | 70,000 | 82,000 |
| Consumption, apparent 2/ | 103,000 | 111,000 | 121,000 r/ | W | W |
| Stocks, Dec. 31: Dealers and consumers 3/ | 28,100 | 24,400 | 21,600 | 26,000 | 30,100 |
| Zirconium oxide: | | | | | |
| Production 4/ | 7,480 | 9,750 | 8,690 | 10,000 r/ | 12,100 |
| Exports 5/ | NA | NA | NA | 1,280 | 1,220 |
| Imports for consumption 5/ | NA | NA | NA | 1,990 | 2,400 |
| Consumption, apparent | NA | NA | NA | W | W |
| Stocks, Dec. 31: Producer 4/ | 737 | 872 | 719 | W | W |

r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes insignificant amounts of baddeleyite.

3/ Excludes foundries.

4/ Excludes intermediate oxides associated with metal production.

5/ Includes germanium oxides and zirconium dioxides.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM AND HAFNIUM MATERIALS

| Specification of material | 1993 | 1994 |
|--|-------------------|-------------------|
| Zircon: | | |
| Domestic, standard-grade, f.o.b. Starke, FL, bulk, per short ton 1/ | \$265.00 | \$278.00 |
| Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, FL, bulk, per short ton 1/ | 242.00 | 254.00 |
| Domestic, premium grade zircon, Starke, FL, bulk, per short ton 1/ | 294.00 | 309.00 |
| Imported sand, ceramic application, f.o.b., bulk, per metric ton 2/ | \$210.00 - 220.00 | \$230.00 - 240.00 |
| Imported sand, refractory application, f.o.b., bulk, per metric ton 2/ | 210.00 - 220.00 | 230.00 - 240.00 |
| Imported sand, foundry sand application, f.o.b., bulk, per metric ton 2/ | 190.00 - 210.00 | 210.00 - 230.00 |
| Baddeleyite, imported concentrate: 3/ | | |
| 98% to 99% ZrO ₂ , minus 100-mesh, c.i.f. Atlantic ports, per pound | .75 - .85 | .82 - .88 |
| 99%+ ZrO ₂ , minus 325-mesh, c.i.f. Atlantic ports, per pound | 1.07 r/ | 1.13 |
| Zirconium oxide: 4/ | | |
| Powder, commercial grade, drums, 2,000-pound minimum, per pound | 3.00 - 6.60 | 3.00 - 6.60 |
| Electronic, same basis, per pound | 3.50 - 8.00 | 3.50 - 8.00 |
| Insulating, stabilized, 325° F, same basis, per pound | 3.35 - 4.00 | 3.35 - 4.00 |
| Insulating, unstabilized, 325° F, same basis, per pound | 3.35 - 4.00 | 3.35 - 4.00 |
| Dense, stabilized, 300° F, same basis, per pound | 3.60 | 3.60 |
| Zirconium: 5/ | | |
| Powder, per pound | 75.00 - 150.00 | 75.00 - 150.00 |
| Sponge, per pound | 9.00 - 12.00 | 9.00 - 12.00 |
| Sheets, strip, bars, per pound | 20.00 - 50.00 | 20.00 - 50.00 |
| Hafnium: Sponge, per pound 5/ | 75.00 - 95.00 | 75.00 - 95.00 |

r/ Revised.

1/ E. I. du Pont de Nemours & Co. Inc. price list, July 1, 1993 and July 1, 1994, respectively.

2/ Industrial Minerals (London). No. 316, Jan. 1994, p.71; and No. 327, Dec. 1994, p. 63.

3/ The Applegate Group and American Vermiculite Corp. baddeleyite price lists.

4/ Chemical Marketing Reporter. V. 244, No. 26, Dec. 27, 1993; v. 247, No. 1, Jan. 2, 1995.

5/ American Metal Market. V. 101, No. 233, Dec. 3, 1993, p. 7; and v. 102, No. 232, Dec. 2, 1994, p. 6.

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

| Class and country | 1993 | | 1994 | |
|---|---------------------------|----------------------|---------------------------|----------------------|
| | Quantity (metric tons) | Value (thousands) | Quantity (metric tons) | Value (thousands) |
| Ore and concentrates: | | | | |
| Argentina | 567 | \$312 | 277 | \$155 |
| Brazil | 672 | 167 | 1,210 | 290 |
| Canada | 2,750 | 2,020 | 3,860 | 2,190 |
| China | 135 | 152 | 565 | 404 |
| Colombia | 1,710 | 1,230 | 2,350 | 1,580 |
| Dominican Republic | 175 | 173 | -- | -- |
| Ecuador | 195 | 59 | 153 | 92 |
| France | 462 | 228 | 660 | 291 |
| Germany | 15,300 | 3,390 | 5,940 | 1,930 |
| Hong Kong | 310 | 249 | -- | -- |
| Indonesia | 309 | 201 | 175 | 114 |
| Japan | 232 | 129 | 223 | 239 |
| Korea, Republic of | 112 | 43 | 113 | 600 |
| Malaysia | 253 | 167 | 175 | 123 |
| Mexico | 8,460 | 2,110 | 9,300 | 2,790 |
| Netherlands | 176 | 83 | 2,320 | 580 |
| Pakistan | 199 | 123 | 176 | 122 |
| Singapore | 526 | 320 | 488 | 314 |
| Taiwan | 577 | 420 | 576 | 382 |
| United Kingdom | 896 | 418 | 630 | 323 |
| Venezuela | 1,560 | 922 | 1,390 | 926 |
| Other | 385 r/ | 261 r/ | 1,450 | 466 |
| Total | 35,900 | 13,200 | 32,000 | 13,900 |
| Unwrought zirconium and waste and scrap: | | | | |
| Japan | 123 | 3,570 | 119 | 4,630 |
| Other | 125 r/ | 2,580 r/ | 104 | 1,940 |
| Total | 248 | 6,150 | 223 | 6,570 |

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

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

| Class and country | 1993 | | 1994 | |
|--|---------------------------|----------------------|---------------------------|----------------------|
| | Quantity (metric tons) | Value (thousands) | Quantity (metric tons) | Value (thousands) |
| Zirconium ore and concentrates: 2/ | | | | |
| Australia | 37,000 | \$5,220 | 45,500 | \$6,960 |
| South Africa, Republic of | 32,200 | 3,580 | 35,800 | 6,850 |
| Other | 815 r/ | 528 r/ | 714 | 1,070 |
| Total | 70,000 | 9,320 | 82,000 | 14,900 |
| Zirconium, unwrought and waste and scrap: | | | | |
| Canada | -- | -- | 57 | 58 |
| France | 33 | 233 | 28 | 198 |
| Germany | 16 | 338 | 49 | 637 |
| Japan | 64 | 447 | 29 | 42 |
| Other | 8 | 147 | 25 | 175 |
| Total | 121 | 1,170 r/ | 188 | 1,110 |
| Hafnium, unwrought and waste and scrap: | | | | |
| Canada | (3/) | 2 | -- | -- |
| France | 3 | 556 | 4 | 783 |
| Germany | (3/) | 104 | (3/) | 86 |
| United Kingdom | (3/) | 7 | (3/) | 2 |
| Total | 3 | 669 | 5 | 871 |

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Australia and the Republic of South Africa are believed to be point of origin; other countries are point of shipment.