ZIRCONIUM AND HAFNIUM

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Production of zirconium is from two ore minerals, zircon and baddeleyite. The principal economic source of zirconium is the zirconium silicate mineral zircon ($ZrSiO_4$). Only a relatively small quantity of baddeleyite, a natural form of zirconium oxide or zirconia (ZrO_2), was mined in 2003. Zircon, the principal ore material, was mined at many locations worldwide. Baddeleyite was produced from a single source at Kovdor, Russia.

Zircon is the primary source of all 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 of tin minerals. The major end uses of zircon, in descending order of quantity, are refractories, foundry sands (including investment casting), and ceramic opacification. Zircon is also marketed as a natural gemstone, and its oxide is processed to produce cubic zirconia, a diamond and colored-gemstone simulant. Zirconium metal is used in chemical piping, heat exchangers, nuclear fuel cladding, pumps and valves in corrosive environments, and various specialty alloys.

The principal uses of hafnium are in high-temperature ceramics, nickel-based superalloys, nozzles for plasma arc metal cutting, and nuclear control rods.

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 data.

Production

Data for zirconium and hafnium manufactured materials are developed by the U.S. Geological Survey (USGS) from a voluntary survey of domestic operations. Of the 45 operations surveyed, 28 responded. Data for nonrespondents were estimated on the basis of prior-year levels. Data for zircon concentrates are developed by a second voluntary survey of domestic mining operations. Of the two domestic zircon producers, which have three mining and processing operations, 100% responded. Data on domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data.

Domestic production of milled zircon decreased by 4.8%, and production of zirconium oxide increased by 15.5% from their 2002 levels (table 1). Domestic production of zircon concentrate in 2003 was essentially unchanged from the previous year's level.

In 2003, U.S. mine producers of zircon were E.I. du Pont de Nemours and Co. (DuPont) and Iluka Resources, Inc. (a subsidiary of the Australian company Iluka Resources Limited). DuPont produced zircon from its Maxville heavy-mineral sands deposit near Starke, FL, which it has operated since 1993 and Iluka produced zircon from its heavy-mineral sand operations at Green Cove Springs, FL, and Stony Creek, VA, and was developing a mine at Lulaton, GA.

Iluka's Green Cove Springs, FL, operations included a dry-mining mobile concentrator and a heavy-mineral sands processing plant, which will also process feed from the Georgia operations starting in 2004. Iluka reported lower production from its Green Cove Springs operations in 2003 resulting from depletion of the main ore body. The company shifted production at Green Cove Springs to satellite mining methods that use a mobile concentrator to recover ore from various smaller deposits that are adjacent or in close proximity to the mined-out main ore body (Folwell, 2004§[1]). Iluka planned to decommission its floating-dredge concentrator at Green Cove Springs in early 2004 and spent $3 million to relocate its mobile concentrator. An additional $4.2 million was spent to upgrade the mobile concentrator in 2003 (Iluka Resources Limited, 2004b§). The dry mill at Green Cove Springs continued to operate at a capacity of 45 metric tons per hour (t/hr) and will receive heavy-mineral feed from its mobile concentrators at its operations in Florida and Georgia.

In 2003, Iluka relocated its principal mining operations to its new site in Lulaton in southern Georgia. The new mine under development in Brantley County, GA, was expected to be completed in the first quarter of 2004 (Folwell, 2004§). The operation had a planned capacity of 1,000 t/hr that would feed a matching-capacity mobile heavy-mineral sands concentrator (Iluka Resources Limited, 2004b§). The new 1,000-t/hr concentrator and mining unit at the Lulaton deposit was expected to commence operation in early 2004. Iluka completed the $36.8 million development of its operations in Georgia in 2003 (Iluka Resources Limited, 2004b§). The Lulaton deposit will ultimately replace the heavy-mineral sands production from the Green Cove Springs deposit at the completion of the satellite mining project.

Iluka operated two dry mines in Virginia, the Old Hickory and Concord, and a heavy-mineral sands processing plant. Production from the Old Hickory Mine at Stony Creek, VA, increased substantially as the company completed its $32.4 million heavy-mineral sands expansion project. The expansion project at the Old Hickory Mine included a new mine site (Concord Mine), mining unit, concentrator, zircon finishing plant, and an increase in heavy-mineral sands separation capacity (Iluka Resources Limited, 2004a).

U.S. producers of zirconium and hafnium metal were Wah Chang (an Allegheny Technologies company), Albany, OR, and Western Zirconium (a subsidiary of Westinghouse Electric

[1]References that include a section mark (§) are found in the Internet References Cited section.

Company), Ogden, UT. Primary zirconium chemicals were produced by Wah Chang and Magnesium Elektron Inc., Flemington, NJ. Secondary zirconium chemicals were produced by about 10 companies, and zirconia was produced from zircon sand at plants in Alabama, New Hampshire, New York, Ohio, and Oregon.

Consumption

It is estimated that 95% of the consumption of zirconium is as zircon, zirconium oxide, or other zirconium chemicals. The remainder is consumed as zirconium metal and zirconium-containing alloys. Data on consumption of zircon concentrates are withheld to avoid disclosing company proprietary data. Zircon, used for facings on foundry molds, increases resistance to metal penetration and gives a uniform finish to castings. Milled or ground zircon is used in refractory paints for coating the surfaces of molds. Zircon in the form of refractory bricks and blocks is 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.

Stabilized 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) is used in the manufacture of oxygen sensors that control combustion in furnaces and automobile engines. YSZ is also used in the manufacture of a diverse array of products, including coatings for the hot sections of jet engines, cubic zirconia (a gemstone simulant for diamonds and colored gemstones), fiber optic connector components, golf putters, golf shoe cleats, heat- and break-resistant shirt buttons, and high-temperature, high-strength structural ceramics. YSZ is increasingly used in dental applications 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 (Ardlin, 2002; Aurum Ceramic Dental Laboratories, Inc., 2004§).

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal is used as cladding for nuclear fuel rods. Commercial-grade zirconium, unlike nuclear-grade zirconium, contains hafnium and is used in the chemical-process industries because of its excellent corrosion resistance.

Hafnium is used in nuclear control rods because of its high thermal neutron absorption cross section. However, the leading end use for hafnium metal is as an alloy addition in superalloys.

Prices

In 2003, increased demand for zircon concentrates generally resulted in higher domestic prices; however, prices for imports were essentially unchanged (table 4). The average value of imported ore and concentrates was $396 per metric ton in 2003 compared with $397 per ton in 2002. The average value of zircon ore and concentrates exports increased by 1.7% to $532 per ton from $523 per ton in 2002 (table 3). Domestic list prices of standard- and premium-grade zircon were higher as a result of a reduction in the domestic supply and an increase in global demand. The greatest demand for ceramic-grade zircon was from foreign markets, especially those in China and Europe.

Published prices for bulk grades of zircon, free on board, increased for ceramic-grade but were unchanged for refractory- and foundry-grade zircon (Industrial Minerals, 2003a). Ceramic-grade Australian zircon prices increased to between $395 and $420 per ton at yearend 2003 from between $360 and $390 per ton at yearend 2002 (table 2). United States prices also increased for ceramic-grade zircon to between $395 and $420 per ton. Australian zircon, foundry-grade, increased in price to between $370 and $400 per ton at yearend 2003 from between $320 to $370 per ton (table 2), while United States foundry sand remained unchanged at $350 to $390 per ton. Australian refractory-grade zircon was also unchanged at $350 to $390 per ton (table 2).

Foreign Trade

According to U.S. Census Bureau trade statistics, the United States was a net exporter of zirconium ore and concentrates in 2003. U.S. exports of zirconium ore and concentrates were 70,600 metric tons (t), a 50% increase from those of 2002 (table 3). The United States was a net exporter of zirconium and hafnium metal in 2003. U.S. zirconium metal exports are classified under two recently established Harmonized Tariff Schedule of the United States (HTS) tariff numbers—8109.20.0000, “Unwrought zirconium powder,” and 8109.30.0000, “Zirconium waste and scrap.” The previously used HTS tariff number 8109.10.0000, “Unwrought zirconium, waste and scrap,” was discontinued. In 2003, U.S. exports of unwrought zirconium (powder) were 101 t, and exports of zirconium waste and scrap were 104 t. U.S. exports classified as “Other zirconium metal, waste and scrap,” were 1,490 t, a 4% increase from the 2002 level.

U.S. imports of zirconium ore and concentrates were 37,400 t, an increase of 6% from the 35,300 t imported in 2002 (table 4). Australia and South Africa supplied 91% of the imports of ores and concentrates. Imports for the category HTS 8109.20.0000, “Unwrought zirconium powder,” were 52 t in 2003, and the leading source was Germany. Imports for the new trade category HTS 8109.30.0000, “Zirconium waste and scrap,” were 23 t in 2003, and the leading sources, in descending order of quantity, were the United Kingdom, Japan, and Mexico. The trade category HTS number 8109.10.6000, “Unwrought zirconium, waste and scrap, powders, other,” was discontinued. Domestic imports of ferrozirconium alloys were 154 t in 2003, an 8% decrease from the 167 t imported in 2002. Imports under trade category HTS number 8109.90.0000, “Other zirconium, waste and scrap,” were 468 t, a decrease from the 474 t imported in 2002. In 2003, in order of decreasing quantity, ferrozirconium imports originated from India, Brazil, and Japan. U.S. imports of “Unwrought hafnium, including powder,” which were imported under a recently established trade category HTS number 8112.92.2000, were 5 t in 2003, essentially unchanged from the 2002 level.

Higher worldwide demand for zircon in 2003 caused increases in U.S. imports and exports.

World Review

Excluding U.S. production, world production of zirconium mineral concentrates in 2003 was estimated to be 864,000 t, a 10% increase compared with that of 2002 (table 5). World zirconium mineral production was estimated to be 1.08 million metric tons (Mt), which included the additional production estimated for the United States (Mineral Sands Report, 2004a). Australia and South Africa accounted for about 88% of all production outside the United States. World reserves of zircon were estimated to be 38 Mt of ZrO_2, while identified world resources of zircon were about 72 Mt of ZrO_2. During 2003, the zirconium industry continued to be active in the exploration and development of mineral deposits on a global basis, particularly in Australia, Kenya, Mozambique, South Africa, and the United States. Iluka Resources Limited was the world's leading producer of zircon in 2003, with mines in Australia and the United States. Iluka accounted for an estimated 33% of the world's production (Mineral Sands Report, 2004b). Other major zircon producers, in order of decreasing production, were Richards Bay Minerals (RBM) of South Africa, Namakwa Sands (Pty.) Ltd. of South Africa, Tiwest Joint Venture of Australia, DuPont of the United States, Ticor South Africa Pty. Ltd. of South Africa, Vilnohirsk State Mining & Metallurgical of Ukraine, and Consolidated Rutile Ltd. (CRL) of Australia.

Australia.—Australia was the leading producing country of zircon concentrates in the world (table 5). In 2003, major producers of zircon concentrates, in order of estimated zircon production, in Australia were Iluka Resources, Tiwest, CRL, and RZM/Cable Sands Ltd. (CSL). Australian zircon production for 2003 was as follows: Iluka, 301,000 t; Tiwest, 80,000 t; CRL, 30,000 t; CSL, 24,000 t; and lesser amounts from Mineral Deposits Ltd. (MDL), Currumbin Minerals Pty Ltd., and Murray Basin Titanium Pty. Ltd., 8,000 t (Iluka Resources Limited, 2004, p. 13; Mineral Sands Report, 2004b). Total Australian production in 2003 was estimated to be 452,000 t, an 8% increase from the revised 2002 level of 417,000 t (Mineral Sands Report, 2004a). Australia's zircon production for 2003 was 462,000 t based on data from the Australian Bureau of Agricultural and Resource Economics (table 5). Differences in the production estimates are likely based on company data being compiled by the two sources on differing dates.

Worldwide production from Iluka was 406,000 t of zircon in 2003, an increase of about 12.5% from the 361,000 t in 2002 (Iluka Resources Limited, 2004, 2004a§). Iluka's production for 2003 included production from its CRL subsidiary. The company operated 10 mines worldwide, 8 of which were in Australia (6 on the west coast and 2 on the east coast), and 2, in the United States. Iluka's Australian subsidiary WA Titanium Minerals operated 6 mines and a zircon finishing plant (Narngulu) in Western Australia in 2003. Iluka's other mining operations were the North West Mine near Capel, the North Mine and the South Mine near Eneabba, and the Yoganup, Yoganup Extended, and Busselton Mines in the southwestern region. Mining of the Yoganup Extended Mine remnants were scheduled to begin in 2003.

Iluka's two east coast mines, the Yarraman Mine and the Ibis Mine, were operated by CRL on North Stradbroke Island, New South Wales. Production from the Yarraman Mine reportedly increased as a result of improvements to the tailings circuit in the last half of 2002; however, by yearend 2003, zircon production was lower as a result of dredge repairs at Yarraman and lower ore grades at both mines (Iluka Resources Limited, 2003a§; Folwell, 2004§). Dry mining commenced at the Yarraman Mine to offset the reduced production while the dredge was repaired. The dredge was repaired and recommissioned in July (Industrial Minerals, 2003b). CRL operated a dry separation plant at Pinkenba near Brisbane, Queensland.

Iluka continued to explore and delineate resources in the Murray Basin area of New South Wales and Victoria. The company completed a prefeasibility study of the Douglas heavy-mineral-sands project that it acquired from Basin Minerals Limited (BML) in 2002 (Iluka Resources Limited, 2003b§). Iluka paid A$139 million for BML's extensive heavy-mineral sands interests, including the Culgoa and Douglas deposits. BML's major deposit includes the Douglas mineral sands project in southwestern Victoria. Iluka was creating plans to develop the Douglas deposit and construct a heavy-mineral sands separation plant near Horsham, Victoria, in 2005. The Douglas deposit covers an area of 5,860 square kilometers and has a resource of 22.4 Mt of heavy minerals. Five strandline deposits within the Douglas deposit contain 11.3 Mt of ilmenite (including leucoxene), 1.26 Mt of rutile, and 1.62 Mt of zircon (Mineral Sands Report, 2002).

BeMaX Resources N.L. and DuPont Titanium Technologies (DTT) announced an agreement granting DTT exclusive rights to purchase and sell its premium-grade zircon from the Gingko Mineral Sands Project (GMSP) (BeMaX Resources N.L., 2003). Located in the Murray Basin near Pooncarie, New South Wales, the GMSP contains reserves of 184 Mt of ore grading 3.2% heavy minerals. Ginkgo is reportedly the first heavy-mineral sands deposit in the fully permitted New South Wales part of the Murray Basin (DuPont Titanium Technologies, 2003). BeMaX has signed agreements and contracts for the sale of more than 90% of the heavy-mineral sand products from the deposit. Commissioning of the Ginkgo operation was planned for late 2004 with shipments entering the market in 2005 (BeMaX Resources N.L., 2003). At planned capacity, DTT could receive up to 32,000 metric tons per year (t/yr) of zircon.

In October, BeMaX, Sons of Gwalia Limited, and Nissho Iwai Corp. signed a merger agreement. The assets of the companies will be wholly owned by BeMaX and include the mining operations of RZM Cable Sands and the Murray Basin Titanium joint venture with combined production of 350,000 t/yr of heavy-mineral concentrates (Industrial Minerals, 2003a).

Southern Titanium NL completed development of a mine plan and will seek financing to develop its Mindarie deposit in the Murray Basin. Zircon was expected to provide 60% of the revenue from the project (Southern Titanium NL, 2003§). Mindarie reported reserves of 1.9 Mt of heavy minerals and expected to produce 43,700 t/yr of zircon and 9,600 t/yr of rutile. The heavy minerals are contained in paleoplacers of Pliocene and Tertiary age. The Pliocene ore is in the Loxton-Parilla sands at shallow depth on an uplifted block on a former strand plain, while the Tertiary ore is in multiple strand lines of paleobeach placers (Placer Stockfile, undated§).

In October, Alkane Exploration Ltd. signed a joint-venture agreement with Astron Limited to develop the Dubbo zirconia deposit in New South Wales. Astron will receive a 50% share in the project by funding all expenditures, including construction and development of a pilot plant. Astron is a major zirconia processor and has technology to separate heavy-mineral sands and produce zircon flour, fused zirconia, and zirconium chemicals. Astron's zirconia and zirconium chemical operations are in northeast China at Bayuchuan and Zibo (Alkane Exploration Limited, 2004§).

MDL ceased operation of its dredge at Fullerton, New South Wales, and began preparations to ship the dredge to Beach Mineral Company's (BMC's) Kuttam mineral sands deposit in India. MDL's Hawk Nest dry mill will reportedly continue operating and will receive part of its non magnetic heavy mineral feed from BMC's Indian mine. Mining at MDL's Viney Creek deposit in New South Wales ceased on January 30, 2003, and the dredge and a wet concentrator were put on a care-and-maintenance program while the company assessed local and worldwide mineral resources (Mineral Deposits Limited, 2003§).

Brazil.—Two companies produced zircon in 2002—Millennium Inorgânica Chemicals do Brazil S/A from its heavy-mineral sands Mataraca Mine at Guaju, Paraiba State, and Indústrias Nucleares do Brasil S/A (INB) from its Buena mine and plant in the municipality of Sao Francisco de Itabapoana. Zircon resources in Brazil are in the States of Amazonas, 1.657 Mt; Bahia, 92,400 t; Minas Gerais, 94,300 t; Paraiba, 210,400 t; Rio de Janeiro, 115,500 t; Rio Grande do Norte, 40,000 t; Sao Paolo, 9,300 t, and Espirito Santo, 5,700 t. Zircon reserves in Brazil were 2,226 Mt. Total Brazilian production of zircon in 2002, the latest year for which preliminary data were available, was 20,000 t, a decrease from the 20,553 t produced in 2001 (Fabricio da Silva, 2004, p. 130-131).

Gambia, The.—Joint-venture partners Astron Limited and Carnegie Corporation announced the shipment of 12,000 t of zircon concentrate to Astron's processing facilities in China. Carnegie installed a 30-t/hr spiral concentrator which was commissioned in the Brufrut area in March. The three-month operation processed 50,000 t of tailings from the British-operated British Titan Products Co. Ltd. ilmenite operation, which operated in the 1950s. The joint-venture partners are reportedly in discussions about a future dredging operation to test recovery grades from the historic mineral sands areas (Industrial Minerals, 2003d).

India.—Indian Rare Earths Ltd. (IREL) produced heavy-mineral sands from its three mining divisions at Chavara, Manavalakurichi, and Orrisa. Ore at the Chavara deposit has heavy-mineral content as high as 40%. Zircon capacity of the operation, which employs both dry mining and dredging methods, is 14,000 t/yr. Two dredge and wet concentrators are in use at Chavara with capacities of 100 t/hr. The Chavara plant has grinding and sorting equipment to produce ground zircon at minus 45-micron (will pass through a 325-mesh screen) and 1- to 3-micron sizes. Capacity for the 45-micron product is 6,000 t/yr and for the 1-to-3-micron size is 500 t/yr (Indian Rare Earths Limited, 2004b§).

The Manavalakurichi operation, located 25 kilometers (km) north of Kanyakumari, near the southern tip of India, is supplied from heavy-mineral sand washings from fishermen from five local villages and a dredge. The zircon capacity of the plant is 10,000 t/yr. IREL's Manavalakurichi facilities include a chemical plant that produces zircon frit and zirconium-base chemicals (Indian Rare Earths Limited, 2004b§). Manavalakurichi was the first site of heavy-mineral sands production in India in 1910 with the construction of a plant to recover monazite for its thorium and rare-earths content for use in lamp mantles (Mukherjee, undated§).

At Chatrapur, the Orissa Sands Complex (OSCOM) is mined by dredging methods. The large-scale complex operates two dredges with capacities of 500 t/hr and 100 t/hr, respectively (Indian Rare Earths Limited, 2004a§). The OSCOM produces a full-range of heavy-minerals, including garnet, ilmenite, monazite, rutile, sillimanite, and zircon (Indian Rare Earths Limited, 2004b§).

On July 11, MDL announced the signing of a cooperative agreement with BMC to expand BMC's Kuttam Mine in southeast India. A drilling program indicated a heavy-mineral grade of about 20% within an extensive surface paleodunal system. The agreement provides for the transfer of MDL's 9-million-metric-ton-per-year dredge at Fullerton, New South Wales, Australia, to the Kuttam deposit. BMC will reportedly fund the cost of shipping, reconstructing, and installing the dredge in India. MDL will provide equipment and separation technology to add the production of rutile and zircon to the existing BMC products—ilmenite and garnet (Mineral Deposits Limited, 2003§).

Kenya.—Tiomin Resources Inc. of Toronto, Ontario, Canada, announced the completion of a pilot plant at its Kwale deposit and the production of 20 t of mixed heavy-mineral sands concentrate. Tiomin had leased 1,500 acres for the mine as of yearend 2003 and was in final negotiations with the Government of Kenya for an additional 550 acres (Tiomin Resources Inc., 2003).

Madagascar.—Iluka began a drilling program on its Farafangana heavy-mineral prospect on the southeast coast (Iluka Resources Limited, 2004a§). The initial air core drilling program was expected to be completed in the first half of 2004.

Ticor Limited announced it was studying the feasibility of mining the heavy-mineral sand holdings of Madagascar Resources NL on the west coast. Exploration of the deposits was planned, and initial samples indicated zircon and slag-quality ilmenite (Industrial Minerals, 2003f).

Mozambique.—Kenmare Resources PLC received permits from the Government of Mozambique to commence construction of the Moma heavy-mineral sands project in 2002 and received funding guarantees from the Multilateral Investment Guarantee Agency (a member of the World Bank) in 2003. Development of the project was expected to take 2 years with production scheduled to begin in 2005 (Industrial Minerals, 2003e).

Russia.—Development of the Algaminsky zirconium deposit in the Russian Far East was started. A 300-t sample of zirconium-baddeleyite concentrates was obtained in a pilot-plant project. The deposit was estimated to have more than 1 Mt of ore containing 64,000 t of zirconium and baddeleyite (Invest 2 Russia, undated§).

Kovdorsky GOK announced gross output increased by 20.3% in 2003 compared with 2002. The production of apatite and baddeleyite also increased. Concurrent with the increased production, technical improvements in the Kovdorsky operations were instituted (Semenova, 2003).

South Africa.—RBM was the second leading producer of zircon in the world with 235,000 t in 2003, a decrease from 260,000 t produced in 2002 (Mineral Sands Report, 2004b).

Ticor South Africa [a mining venture between Kumba Resources Ltd. of South Africa (60%) and Ticor Limited (40%)] produced about 50,000 t of zircon in 2003 (Mineral Sands Report, 2004b). Anglo American plc increased its shareholdings in Kumba Resources Ltd. to more than 35% from 20.1% by purchasing shares on the open market (Industrial Minerals, 2003f). Namakwa Sands Pty. Ltd. (a wholly owned subsidiary of Anglo American) was ranked by Mineral Sands Report as the third leading producer of zircon in the world in 2003 from its mine at Brand-se-Baai. Zircon production was 85,000 t in 2003 (Mineral Sands Report, 2004b). A portion of the dry mill at Koekenaap was destroyed by fire in October and reportedly will affect production of ilmenite, rutile, and zircon (Industrial Minerals, 2003c). Zircon capacity at Namakwa was 133,000 t/yr with a remaining mine life of about 32 years.

In September, Mineral Commodities Limited (MRC) of Australia announced that its permit for the Xolobeni mineral sands deposit in Eastern Cape Province, South Africa, was not within the boundaries of the proposed Pondoland wildlife park. MRC's permit covers an area between the Mtentu and Mzamba Rivers about 200 km south of Durban on the Natal coast. The company stated that Xolobeni resources were about 310 Mt of ore (Mineral Commodities Limited, 2003a§). The ore is contained in a series of inland paleodunes of well-sorted, medium-grained sands that are rounded to subrounded. The four areas of the deposit (two measured, one indicated, and one inferred) total about 310 Mt of ore grading 5.4% heavy-minerals with a cutoff grade of 1.5%. An early prefeasibility study proposed zircon output of 15,000 t/yr during a 17-year minelife (Mineral Commodities Limited, 2003b§).

Ukraine.—Heavy-mineral sands producer Vilnohirsk State Mining & Metallurgical Plant (VSMMP) was ranked as the world's seventh leading zircon producer in 2003 (Mineral Sands Report, 2004b). Producing about 3% of the world's total at 35,000 t, VSMMP mined the Mayshev mineral sand deposit at Vilnohirsk, Dnipropetrovsk Oblast, in central Ukraine.

Outlook

The global demand for zirconium materials increased in 2003. Growth was expected to increase by 3% to 5% per year during the next few years, and new deposits are expected to come online. Prices were forecast to rise in the near term in response to higher energy costs and the increase in demand. The shortfall in supply is expected to continue through at least mid-2005. The increased demand relative to the available supply will contribute to continued price increases in the short term, especially in the spot market. During the next few years, however, zircon supply and demand are expected to be in closer balance as new deposits and plant expansions come online, especially in Australia and the United States. Expansions in supply are expected in Mozambique and South Africa, and further exploration and development efforts are underway in Australia, Canada, India, Kenya, South Africa, Ukraine, and the United States. Production of zircon in the United States is expected to increase by about 10% during the next 5 to 10 years.

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

(Metric tons)

	1999	2000	2001	2002	2003
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon	55,600	56,200	59,100	37,000	35,200
Exports	69,500	72,900	66,900	47,100	70,600
Imports for consumption[2]	57,600	65,200	60,600	36,000 r	38,100
Consumption, apparent[2]	W	W	W	W	W
Stocks, December 31, dealers and consumers[3]	24,700	25,100	37,700	21,600	27,900
Zirconium oxide:					
Production[4]	17,100	22,900	21,500	17,600	20,400
Exports[5]	1,680	2,220	2,400	1,950	1,520
Imports for consumption[5]	3,140	3,950	2,950	2,900	2,350
Consumption, apparent	W	W	W	W	W
Stocks, December 31, producers[4]	W	818	2,150	1,530	2,030

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] 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		2002	2003
Zircon:			
Domestic, standard-grade, bulk[1]	dollars per short ton	350.00	370.00
Domestic, premium-grade zircon[1]	do.	410.00	440.00
Imported sand, ceramic-grade, free on board, bulk[2]	dollars per metric ton	360.00-390.00 r	395.00-420.00
Imported sand, refractory-grade, free on board[2]	do.	350.00-390.00	350.00-390.00
Imported sand, foundry sand-grade, free on board, bulk[2]	do.	320.00-370.00 r	370.00-400.00
Baddeleyite, contract price, cost, insurance, and freight main European port:[3]			
Refractories/abrasive grade	dollars per metric ton	2,000-2,400 r	2,000-2,400
Ceramic grade (98% zirconium oxide and hafnium oxide)	do.	2,600-3,800	2,600-3,000
Zirconium oxide:[4]			
Electronic, same basis	dollars per pound	3.66-7.50	4.00-7.00
Insulating, stabilized, 325° F, same basis	do.	4.00	3.00-5.00
Insulating, unstabilized, 325° F, same basis	do.	4.00	NA
Dense, stabilized, 300° F, same basis	do.	4.20	NA

[r]Revised. NA Not available.
[1]Domestic average price.
[2]Source: Industrial Minerals, no. 423, December 2002, p. 71; no. 435, December 2003, p. 75.
[3]Source: Mineral Price Watch, issue 97, January 2003, p. 11; Industrial Minerals, no. 435, December 2003, p. 74.
[4]Sources: Chemical Market Reporter, v. 262, no. 22, December 16-30, 2002, p. 26; v. 264, no. 22, December 22-29, 2003, p. 23.

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

		2002		2003	
Class and country	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ore and concentrates:	2615.10.0000				
Argentina		811	$500	1,480	$1,060
Australia		45	26	22	28
Belgium		805	449	1,190	681
Brazil		2,270	1,090	1,320	665
Canada		4,780	3,270	4,060	2,470
China		832	473	707	641
Colombia		2,680	1,600	5,360	3,070
Dominican Republic		264	173	135	90
Ecuador		464	269	360	232
France		586	438	359	275
Georgia		17	11	--	--
Germany		6,040	2,870	11,100	4,680
Guatemala		59	45	--	--
Guyana		1	3	2	5
Hong Kong		22	11	--	--
Hungary		19	42	--	--
Indonesia		7	8	--	--
Ireland		128	147	139	167
Israel		128	214	292	368
Italy		14,600	5,750	22,600	8,540
Japan		1,210	1,320	937	1,350
Korea, Republic of		113	367	586	775
Mexico		3,080	1,170	6,410	3,120
Netherlands		5,000	1,980	7,020	2,850
Pakistan		1,030	608	836	531
Peru		113	73	45	30
Philippines		58	34	--	--
Portugal		73	88	--	--
South Africa		3	15	708	519
Sweden		52	34	52	34
Taiwan		116	387	105	93

See footnotes at end of table.

TABLE 3--Continued

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

Class and country	HTS[2]	2002 Quantity (metric tons)	2002 Value (thousands)	2003 Quantity (metric tons)	2003 Value (thousands)
Ore and concentrates--Continued:	2615.10.0000				
Thailand		19	$21	--	--
United Kingdom		1,100	702	4,360	$4,930
Venezuela		351	256	249	165
Vietnam		234	158	244	160
Other		21	45	44	89
Total		47,100	24,600	70,600	37,600
Unwrought zirconium, powders:	8109.20.0000				
Brazil		1	17	(3)	8
Canada		8	214	3	97
China		2	77	15	622
France		(3)	15	3	135
Germany		2	62	2	55
Italy		--	--	2	75
Japan		12	313	2	166
Korea, Republic of		1	40	(3)	43
Mexico		--	--	1	11
Norway		3	87	2	69
Romania		--	--	(3)	7
Taiwan		(3)	3	(3)	10
United Kingdom		75	1,170	71	1,090
Other		5	293	(3)	13
Total		109	2,290	101	2,400
Zirconium waste and scrap:	8109.30.0000				
Australia		--	--	(3)	8
Belgium		40	200	18	100
Brazil		6	146	6	56
Canada		10	360	11	450
China		3	26	3	26
France		2	18	3	39
Hungary		(3)	6	--	--
Italy		12	108	14	130
Japan		15	210	34	480
Korea, Republic of		7	139	--	--
Netherlands		--	--	8	37
Singapore		(3)	3	(3)	16
United Kingdom		4	94	7	140
Total		99	1,310	104	1,480
Other zirconium waste and scrap:	8109.90.0000				
Argentina		32	1,320	38	2,200
Belgium		8	398	--	--
Brazil		15	380	24	983
Canada		295	15,300	333	15,800
China		29	1,250	120	7,240
Finland		6	459	9	767
France		92	3,880	114	5,810
Germany		261	14,100	125	7,890
Indonesia		(3)	9	18	67
Italy		3	189	53	2,570
Japan		297	16,100	258	15,500
Korea, Republic of		153	14,600	172	16,400
Malaysia		4	341	--	--
Mexico		2	155	3	265
Portugal		(3)	11	3	152
Spain		62	12,300	43	7,190
Sweden		7	402	4	322
Taiwan		33	2,880	23	2,540
United Kingdom		84	2,810	122	5,740
Other		44	879	26	1,180
Total		1,430	87,800	1,490	92,500

See footnotes at end of table.

TABLE 3--Continued

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

-- 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 1/2 unit.

Source: U.S. Census Bureau.

TABLE 4

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

		2002		2003	
Class and country	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		14,500	$4,850	25,000	$7,940
Canada		884	456	1,130	582
China		1,360	2,000	1,720	2,500
Germany		147	142	27	56
India		10	72	5	34
Italy		207	135	--	--
Japan		9	93	8	54
Mexico		181	125	--	--
Russia		298	698	270	644
South Africa		17,700	5,330	9,180	2,860
United Kingdom		40	94	60	131
Other		1	5	4	13
Total		35,300	14,000	37,400	14,800
Ferrozirconium:	7202.99.1000				
Brazil		167	295	69	125
India		--	--	79	77
Japan		--	--	6	43
Total		167	295	154	245
Unwrought zirconium, powder:	8109.20.0000				
Argentina		3	39	--	--
Canada		21	21	(3)	7
China		(3)	11	3	33
Germany		20	1,630	37	2,140
Other		4	146	10	85
Total		48	1,850	52	2,260
Zirconium waste and scrap:	8109.30.0000				
Japan		29	130	6	43
United Kingdom		2	12	15	21
Other		3	154	1	13
Total		34	296	23	77
Other zirconium, waste and scrap:	8109.90.0000				
Canada		23	3,160	29	4,700
China		2	149	1	133
Denmark		(3)	41	(3)	37
France		395	30,200	402	36,100
Germany		12	2,220	4	842
Japan		2	28	(3)	16
Other		40	996	32	284
Total		474	36,800	468	42,100
Unwrought hafnium including powders:	8112.92.2000				
Canada		2	296	1	14
China		1	65	(3)	4
France		1	296	4	883
Germany		--	--	(3)	10
Japan		1	10	--	--
Total		5	668	5	911

See footnotes at end of table.

TABLE 4--Continued

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

-- 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 1/2 unit.

Source: U.S. Census Bureau.

TABLE 5

ZIRCONIUM MINERAL CONCENTRATES: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country	1999	2000	2001	2002	2003[e]
Australia	359,000	374,000 [r]	393,000 [r]	412,000 [r]	462,000 [4]
Brazil[5]	27,160	29,805	20,553 [4]	20,500	21,000
China[e]	15,000	15,000	15,000	15,000	15,000
India[e]	19,000	19,000	19,000	19,000	20,000
Indonesia[e]	250	250	250	250	250
Malaysia	1,763	3,642	3,768 [r]	5,293 [r]	3,800
Russia[e, 6]	6,800 [4]	6,500	6,500	6,500	6,500
South Africa[7]	219,000	253,000	262,000 [e]	274,000 [r, e]	300,000
Thailand	--	--	100	--	--
Ukraine[e]	25,000	30,000	33,600	34,300	35,000
United States	W	W	W	W	W
Total[8]	673,000	731,000 [r]	754,000 [r]	787,000 [r]	864,000

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

[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 9, 2004.

[3]Malawi was also reported to produce zirconium concentrates but information is not sufficent 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 and 15,000 to 20,000 metric tons per year of baddeleyite from Palabora Mining Co. Ltd.

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