ZIRCONIUM AND HAFNIUM

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In 2004, there was a shortfall in the supply of zirconium minerals. Prices increased for standard and premium grades of zircon concentrates. The cause of the shortage was the result of several factors including increased demand, the closure of several zircon-producing mines, reduced zircon grades at a few mines, and the transfer of mining equipment from mined-out sites to new mining locations.

The principal economic source of zirconium is the zirconium silicate mineral zircon. A relatively small quantity of the zirconium is derived from the mineral baddeleyite, a natural form of zirconium oxide or zirconia (ZrO_2). In 2004, zircon, the principal ore material, was mined at many locations worldwide, principally Australia, South Africa, and the United States. 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 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 nuclear fuel cladding, chemical piping, pumps, and valves in corrosive environments, heat exchangers, and various specialty alloys.

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

World production of zirconium mineral concentrates in 2004, excluding U.S. production, was estimated to be essentially the same as that of 2003. Data on U.S. production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data. Domestic production of zircon increased by nearly 20% from that of 2003. In 2004, production of milled zircon decreased, and that of zirconium oxide increased when compared with those of 2003. According to U.S. Census Bureau trade statistics, the United States was a net exporter of zirconium ore and concentrates. In 2004, U.S. imports of zirconium ore and concentrates decreased by 5%, and domestic exports of zirconium ore and concentrate decreased by almost 4%. Increased domestic demand for zircon in 2004 caused a decrease in U.S. exports as U.S. demand consumed essentially all the available supply, including the additional zircon produced during the year.

With the exception of prices and referenced data, all survey data in this report have been rounded to no more than three significant digits. Totals and percentages were calculated from unrounded numbers.

Production

Data for zirconium and hafnium manufactured materials are developed by the U.S. Geological Survey (USGS) from a voluntary survey of domestic operations. Twenty-four of the 48 operations surveyed 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 four 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 10.8%, and production of zirconium oxide increased by 4.4% from their 2003 levels (table 1). Domestic production of zircon concentrate in 2004 was nearly 20% higher than the previous year's level.

Zircon is normally produced as a byproduct of the mining and processing of heavy-mineral sands containing the titanium minerals ilmenite and rutile. In 2004, U.S. mine producers of zircon were Dupont Titanium Technologies [a subsidiary of 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. Iluka produced zircon from its heavy-mineral sand operations at Green Cove Springs, FL; Stony Creek, VA; and from its new mine in Lulaton, GA. Iluka's Florida operations included a dry mining mobile concentrator and a heavy-mineral sands processing plant, which began processing heavy-minerals concentrate from the Georgia operations in 2004. The Lulaton Mine feeds a 1,000-metric-ton-per-hour (t/hr) mobile heavy-mineral sands concentrator (wet mill) (Iluka Resources Limited, 2004b§[1]). Heavy-mineral concentrate from the Lulaton Mine was trucked from Georgia to the dry mill site at Green Cove Springs, FL.

In Florida, Iluka reported higher production from its Green Cove Springs dry mill operations in 2004 resulting from the startup of its new Lulaton Mine in Georgia along with supplemental production from satellite mining at Green Cove Springs, FL (Iluka Resources Limited, 2005§).

In Virginia, Iluka operated two dry mines, the Old Hickory and the Concord, and a heavy-mineral sands processing plant (dry mill) near Stony Creek, VA.

Zircon production from the Old Hickory Mine, which had increased substantially in 2003 as a result of an expansion

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

project, was increased further in 2004 by the additional production from the new Concord Mine (Iluka Resources Limited, 2004a§). Iluka's expansion at Stony Creek included a new mine site (Concord Mine), mining unit, concentrator, and zircon finishing plant and additional heavy-minerals sands separation capacity (Mineral Sands Report, 2004a).

Development of the Lulaton deposit in Georgia was expected to replace heavy-mineral sands production from the Green Cove Springs Mine. In 2004, Iluka decommissioned its floating dredge concentrator at Green Cove Springs and upgraded its mobile concentrator, which supported its shift to satellite mining methods in the areas of Green Cove Springs that were not minable by dredging methods (Iluka Resources Limited, 2004b§). The dry mill at Green Cove Springs continued to operate at a capacity of 45 t/hr and will receive heavy-mineral sands feed from the Florida and Georgia mobile concentrators.

U.S. producers of zirconium and hafnium metal were Wah Chang (an Allegheny Technologies, Inc. company), Albany, OR, and Western Zirconium (a subsidiary of Westinghouse Electric Co.), Ogden, UT. Primary zirconium chemicals, those produced directly from zircon, were produced by Wah Chang and Magnesium Elektron Inc., Flemington, NJ. Secondary zirconium chemicals, produced from intermediate 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

Approximately 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.

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 high-temperature, high-strength structural ceramics, heat- and break-resistant shirt buttons, golf shoe spikes, golf putters, fiber optic connector components, coatings for the hot sections of jet engines, and cubic zirconia, a gemstone simulant for diamonds and colored gemstones. YSZ is increasingly used in dental applications as inlays, crowns, and bridges as 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§).

Ammonium- and potassium-zirconium carbonate are used as paper and board coatings or insolubilizers for high-quality print performance. Zirconium chemicals are also used in inks to promote adhesion to metals and plastics and as crosslinkers in polymers and printing inks.

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal is used as cladding for nuclear fuel rods. Commercial-grade zirconium, unlike nuclear grade, 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 2004, increased demand for zircon concentrates resulted in increased prices. The average value of imported ore and concentrates increased by 20.5% to $477 per metric ton in 2004 from $396 per ton in 2003. The average value of zircon ore and concentrates exports increased by 24.3% to $661 per ton in 2004 from $532 per ton in 2003. Domestic list prices of standard- and premium-grade zircon were higher as a result of a tightening of the domestic supply and an increase in global demand. The greatest demand was from foreign markets for ceramics, especially those in China and Europe.

Published prices for bulk grades of zircon, free on board, increased for ceramic, refractory, and foundry grades (Industrial Minerals, 2004). Ceramic-grade Australian zircon prices increased to between $490 and $600 per ton at yearend 2004 from between $395 and $420 per ton at yearend 2003. U.S. prices also increased for premium-grade zircon to between $460 and $550 per ton from between $395 and $420 per ton the previous year. Australian zircon, foundry-grade, increased in price to between $450 and $550 per ton at yearend 2004 from between $370 to $400 per ton at yearend 2003. U.S. prices for standard-grade zircon concentrate increased to $455 per ton in 2004 from $370 per ton in 2003 (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 2004. U.S. exports of zirconium ore and concentrates were 68,800 metric tons (t), a 2.6% decrease from those of 2003 (table 3). The United States was a net exporter of zirconium and hafnium metal in 2004. U.S. zirconium metal exports are classified under Harmonized Tariff Schedule of the United States (HTS) tariff numbers 8109.20.0000, "Unwrought zirconium powder," and 8109.30.0000, "Zirconium waste and scrap." In 2004, U.S. exports of unwrought zirconium (powder) were 138 t, and exports of zirconium waste and scrap were 96 t. U.S. exports classified as HTS 8109.90.0000, "Other zirconium metal, waste and scrap," were 1,470 t, a 0.8% decrease in quantity from the 2003 level.

U.S. imports of zirconium ore and concentrates were 35,200 t, a decrease of 6% from the 37,400 t imported in 2003 (table 4). Australia and South Africa supplied 92% of the imports

of ores and concentrates. Imports for the category HTS 8109.20.0000, "Unwrought zirconium powder," were 74.4 t in 2004, and the leading sources, in descending of quantity, were China, Germany, and Japan. Imports for the trade category HTS 8109.30.0000, "Zirconium waste and scrap," were 14.2 t in 2004, and the leading sources, in descending order of quantity, were Japan and Canada. Domestic imports of ferrozirconium alloys were 165 t in 2004, a 7% increase from the 154 t imported in 2003. In 2004, in order of decreasing quantity, ferrozirconium imports originated primarily from Brazil, Norway, and the United Kingdom. U.S. imports of "Unwrought hafnium, including powder," which were imported under a recently established trade category HTS 8112.92.2000, were 4.02 t in 2004.

World Review

Excluding U.S. production, world production of zirconium mineral concentrates was estimated to be 849,000 t, essentially the same as that of 2003 (table 5). An Australian publication estimated that world zirconium mineral production increased to 1.15 million metric tons (Mt) in 2004 from 1.08 Mt in 2003, which included the additional production estimated for the United States (Mineral Sands Report, 2005d, p. 12). Australia and South Africa supplied about 85% of all production outside the United States. World reserves of zircon were estimated to be 41 Mt of ZrO_2, while identified world resources of zircon were about 75 Mt of ZrO_2. Zircon reserves increased based on the discovery and assessment of several heavy-mineral sands deposits in Australia and Kenya. During 2004, because of increased demand for zircon, the heavy-mineral sands 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 was the world's leading producer of zircon in 2004, with mines in Australia and the United States. Iluka Resources accounted for an estimated 34% of the world's production (Mineral Sands Report, 2005c). 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 of South Africa, Consolidated Rutile Ltd. (CRL) of Australia, Vilnohirsk State Mining & Metallurgical of Ukraine, Bemax Resources N.L. of Australia, and Millenium Inorgânica Chemicals do Brasil S/A of Brazil.

Australia.—Australia was one of the leading countries in the production of zircon concentrates in the world (table 5). In 2004, major producers of zircon concentrates, in order of estimated zircon production, in Australia were as follows: Iluka Resources, 283,000 t (excluding its interest in CRL); Tiwest, 76,000 t; CRL, 43,000 t; and Bemax, 21,000 t; lesser amounts produced were from Doral Mineral Industries Ltd., 13,000 t, Currumbin Minerals Pty. Ltd., 3,000 t, and Murray Basin Titanium Pty. Ltd., 3,000 t (Mineral Sands Report, 2005a). Total Australian production in 2004 was estimated to be 442,000 t, a 2% decrease from the 2003 level of 452,000 t (Mineral Sands Report, 2005a). The USGS reported Australia's zircon production for 2004 to be 441,000 t based on data from the Australian Bureau of Agricultural and Resource Economics (table 5; Australian Mineral Statistics, 2005).

Worldwide production from Australian-based Iluka was 428,460 t of zircon in 2004, an increase of about 5.6% from the 405,685 t in 2003 (Iluka Resources Limited, 2005§). Iluka's production for 2004 includes production from its CRL subsidiary. Iluka continued to operate a zircon finishing plant at Narngulu in Western Australia in 2004. Development started at two of Iluka's new mines in Western Australia, the Yoganup West Mine and the Wagerup Mine.

Iluka's two east coast mines, the Yarraman and Ibis, were operated by CRL on North Stradbroke Island, New South Wales. Production from the Yarraman Mine in 2004 increased as the Yarraman dredge repairs were completed and dry-mining of higher grade areas adjacent to the dredge supplemented the feed. The Enterprise dredge was upgraded in 2004 and was scheduled to be moved from the Ibis to the new Enterprise mining area in 2005 (Iluka Resources Limited, 2005§). CRL operated a dry separation plant at Pinkenba, Brisbane, Queensland.

Iluka announced the startup of mining operations at its Douglas heavy-mineral sands project in the Murray Basin in southwestern Victoria. A wet concentrator plant was scheduled for completion in the second quarter of 2005. A $130 million dry heavy-mineral separation plant is planned for completion in Hamilton, Victoria, in fourth quarter of 2005 (Iluka Resources Limited, undated§). Iluka acquired the Douglas deposit from Basin Minerals Limited (BML) in 2002 (Iluka Resources Limited, 2003§). 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 1.62 Mt of zircon.

Iluka's announced the discovery of two heavy-mineral deposits in the Eucla Basin of South Australia, the Jacinth deposit and the Ambrosia prospect (Mineral Sands Report, 2005b). Air-core drilling on the Jacinth delineated an average heavy-mineral grade of 6% containing an economic heavy-mineral content of 55% zircon, 22% ilmenite, and 7% rutile. Inferred resources at the Jacinth are 108 Mt of ore containing 3.5 Mt of zircon. The Ambrosia prospect is located 2 kilometers (km) north of the Jacinth deposit. Initial drilling indicated a heavily mineralized zone with greater than 11% heavy minerals. The heavy-mineral mineral suite contained 66% zircon, 10% ilmenite, and 6% rutile (Mineral Sands Report, 2005b).

Iluka announced that it will start an environment effects statement for its Kulwin, Woornack, Rownack, Rainlover, and Pirro deposits (KWR project) in Ouyen, Victoria. Production from the KWR heavy-mineral project is scheduled for the second half of 2007 (Iluka Resources Limited, 2004).

In Western Australia, Bemax Resources' wholly owned subsidiary Cable Sands operated the Tutunup and Ludlow Mines and the Bunbury Mineral Separation Plant at North Shore (Bemax Resources N.L., 2005). In 2004, the Tutunup and Ludlow Mines produced 106,165 t of heavy-mineral concentrates that was processed into 14,590 t of zircon concentrate (the wet mill at Ludlow Mine started in December 2004). The Bunbury Mineral Separation Plant has a capacity of 750,000 metric tons per year (t/yr) of ore. Cable Sands continued to seek approvals to develop a new heavy-mineral sands deposit, the Gwindinup deposit, 30 km south of Bunbury.

Southern Titanium N.L. changed its name to Australian Zircon NL (AZC) effective December 7, 2004 (deListed, undated§). AZC completed a bankable feasibility study on its Mindarie project and expected to obtain financing to develop the mine and processing plants in the first half of 2005 (Australian Zircon NL, 2005a§). The Mindarie deposit is located in the Murray Basin, a sedimentary basin of Cenozoic age. The Murray Basin is composed of lacustrine (a lake environment) and shallow marine sediments surrounded by igneous and metamorphic rock that weathered and washed into the basin. A series of beach and offshore sand strandlines were deposited in the Murray Basin from 5 million to 2 million years ago. The Pliocene ore is in the Loxton-Parilla sands at 8 to 30 meters (m) depth on an uplifted block of a former strand-plain, while the Tertiary ore is in multiple strand lines of a paleobeach placers (Eco-Minex International Co. Ltd., undated§). AZC upgraded its reserves for the Mindarie project to 60.4 Mt of ore at a grade of 4.21% heavy minerals (2.55 Mt of heavy minerals) (Australian Zircon NL, 2005).

AZC's joint-venture project with Austpac Resources NL, the WIM 150, is located near Horsham in western Victoria. Reserves for the project are 452 Mt of ore grading 5.9% heavy minerals. AZC will increase its participation in the project to an 80% share when a bankable feasibility study is completed. Testing was started on a 3.5-t sample of the fine-grained WIM 150 ore to determine the best method for separating the heavy minerals (Australian Zircon NL, 2005b§).

Alkane Exploration Ltd. announced that measured resources at its Dubbo zirconia project in New South Wales were 35.7 Mt of ore grading 1.96% zirconia, 0.04% hafnia, 0.14% yttria, 0.46% niobium pentoxide, 0.03% tantalum trioxide, and 0.75% rare-earth oxide (excluding yttria). Inferred resources were an additional 37.5 Mt. Planned capacity of the Dubbo operation was 200,000 t/yr of ore producing 3,000 t/yr of zirconia equivalent, 600 t/yr of niobium-tantalum concentrate, and 1,200 t/yr of rare-earth oxide (yttria and lanthanide oxides). A decision on development of the Dubbo zirconia project is possible by 2006 (Alkane Exploration Ltd., 2005§).

Brazil.—Two companies produced zircon in 2003—Millennium Inorgânica Chemicals do Brasil 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 in the State of Rio de Janeiro. Zircon resources in Brazil are unchanged from the previous year and are in the States of Amazonas, 1,657 t; Bahia, 92.4 Mt; Minas Gerais, 94.3 Mt; Paraiba, 210.4 Mt; Rio de Janeiro, 115.5 Mt; Rio Grande do Norte, 40 Mt; Sao Paolo, 9.3 Mt; and Espirito Santo, 5.7 Mt. Zircon reserves in Brazil were 2.226 Mt grading 3.3% contained zirconium oxide. Total Brazilian production of zircon in 2003, the latest year for which preliminary data were available, was 26,059 t, a decrease from the revised 29,342 t produced in 2002 (Fabricio da Silva, 2004, p. 121-122).

Canada.—A 5–t/hr pilot plant to recover heavy minerals from oil sand was opened by Titanium Corporation, Inc. in Saskatchewan. The operation plans to recover titanium minerals and zircon. Feed for the plant is recovered from tailings from Syncrude Canada Ltd.'s oil recovey plant in Alberta. Tailings from Syncrude contain greater than 30% heavy minerals (Mineral Sands Report, 2004b).

Tiomin Resources Inc. owns rights to a large heavy-mineral sands deposit in Natashquan in northern Quebec. The Natashquan deposit is a successive sequence that coarsens upward. The sedimentary facies can be subdivided into the following groups: predeltaic, prodeltaic and deltaic, shoreface progradation, and recent. These successive sequences can be grouped into the following major layers: a lower sequence (predeltaic, prodeltaic and deltaic sequence) and an upper sequence (shoreface progradation and recent). A 116-hole drilling program confirmed resources over a mean thickness of 22 m and a heavy minerals concentration of 9.9%. The proportion of magnetite, ilmenite/hematite, and zircon increases toward the bottom of the sequence, while garnet is more abundant in the upper sequence. The project is on hold until Tiomin's Kwale heavy-mineral sands deposit in Kenya is developed (Tiomin Resources Inc., undated§).

Gambia, The.—Carnegie Corporation Ltd. of Australia has exclusive prospecting licenses in The Gambia that included three mineral sands deposits; namely, Batukunku, Kartung, and Sanyang. Total measured, indicated, and inferred resources were estimated at 15.1 Mt containing about 1 Mt of heavy-mineral sands at a cutoff grade of 1%. The heavy-mineral assemblage for these deposits was estimated to contain 71% ilmenite, 15% zircon, 3% rutile, and 11% other (Carnegie Corporation Ltd., 2004, p. 7-11).

Joint-venture partners Astron Limited and Carnegie Corporation completed processing of 50,000 t of tailings from the British-operated Titan ilmenite operation from the 1950s. The venture recovered and shipped 12,000 t of zircon concentrate to Astron's processing facilities in China (Industrial Minerals, 2003).

India.—Indian Rare Earths Ltd. (IRE) produced heavy-mineral sands from its three mining divisions at Chavara, Manavalakurichi, and Orissa. Zircon capacity of the Chavara operation, which employs both dry mining and dredging methods, is 14,000 t/yr. Capacity for ground zircon is 6,000 t/yr for the -45-micron product and 500 t/yr for the 1- to 3-micron product (Indian Rare Earths Ltd., 2005§).

The Manavalakurichi operation, located 25 km north of Kanyakumari near the southern tip of India, was awarded the "Industrial Safety Award" by India's Atomic Energy Regulatory Board in 2004 for its production unit (Atomic Energy Regulatory Board India, 2004§). Zircon capacity of the plant is 10,000 t/yr. IRE's Manavalakurichi facilities include a chemical plant that produces zircon frit and zirconium-base chemicals (Indian Rare Earths Ltd., 2005§).

At Chatrapur, the Orissa Sands Complex (OSCOM) was awarded the "Green Site Award" by the Atomic Energy Regulatory Board in 2003 for its environmental improvements by planting trees (Atomic Energy Regulatory Board India, 2003§). The large scale complex operates two dredges with capacities of 500 t/hr and 100 t/hr, respectively (Indian Rare Earths Limited, 2004a§). OSCOM produces a full range of heavy minerals, including garnet, ilmenite, monazite, rutile, sillimanite, and zircon (Indian Rare Earths Ltd., 2004b§).

Kenya.—Tiomin Resources Inc. of Toronto, Ontario, Canada, announced that it had signed a 21-year agreement with the

Kenyan Government for exclusive mining rights to the Kwale heavy-minerals deposit. The deposit has reserves of 254 Mt of measured and indicated ore. Planned capacity of the plant was 37,000 t/yr of zircon concentrate (Tiomin Resources Inc., undated§). The Kwale deposit is one of four major heavy-mineral sand deposits that Tiomin has identified in the coastal region of Kenya. The Kilifi, Kwale, Mambrui, and Vipingo deposits are located from 6 to 12 km inland from the Indian Ocean with road access in place.

Mozambique.—Kenmare Resources plc began construction of the Moma Titanium Minerals (MTM) Mine. Estimated to cost $450 million, the company broke ground on the project on October 18, 2004 (Kenmare Resources plc, 2004). Kenmare expected production from the mine to begin in late 2006. Reserves at the MTM project are 407 Mt of ore grading 4.3% heavy minerals (Kenmare Resources plc, undated§). Measured and indicated reserves are 2.7 Mt of zircon in the Namalope/Tupuito mining zone. The MTM project comprises three coastal zones of economic heavy minerals, the Congolone, Mocambo, and Moma deposits.

Russia.—Kovdorsky GOK announced commercial production of apatite, baddeleyite, and iron ore in 2004 and was valued at 5.57 billion rubles, up by 10.1% from that of 2003. Baddeleyite shipments in 2004 were 6,470 t, up by 17.6% from the 2003 level of 5,500 t (Gateway to Russia, 2004§, undated§).

Senegal.—MDL continued to study its Grande Côte Zircon Project (GCZP) on the northwestern coast of Senegal, south of Saint Louis. Production was scheduled for late 2006 with an output of 7,000 t/yr of zircon and 12,000 t/yr of rutile and leucoxene. MDL was relocating one of its Australian dredges and a concentrator from its Viney Creek deposit and Hawks Nest dry mill to GCZP. MDL estimated dredgeable ore of 800 Mt grading 2.6% heavy minerals (Mineral Deposits Limited, undated§).

Sierra Leone.—Sierra Rutile Ltd. (SRL) announced that production from its mine will restart in 2005. After being destroyed in 1995 by rebel forces, SRL was scheduled to reopen its mining operations in April. The leading employer in Sierra Leone, the mine was expected to compose more than 50% of the country's export earnings.

South Africa.—RBM was the second ranked company in the production of zircon in the world with 200,000 t in 2004, a decrease from 235,000 t produced in 2003 (Mineral Sands Report, 2005c).

Ticor South Africa [a mining venture between Kumba Resources Ltd. of South Africa (60%) and Ticor Limited (40%)] produced about 49,000 t of zircon in 2004 (Mineral Sands Report, 2005c). Zircon production was from Ticor's Hillendale Mine near Richards Bay in KwaZulu-Natal Province. Ticor continued to develop its nearby Fairbreeze deposit and initiated detailed site engineering for the project in July with completion scheduled for mid-2005 (Kumba Resources Ltd., 2005§). Concentrate from the site will be treated at Ticor's existing dry mill separation plant at Empangeni. Production was scheduled for 2007.

Namakwa Sands Pty. Ltd. (a wholly owned subsidiary of Anglo American plc) was the third ranked zircon-producing company in the world in 2004 from its mine at Brand se Baai. Zircon production was 110,000 t in 2004 (Minerals Sands Report, 2005c). Zircon capacity at Namakwa was 133,000 t/yr with a remaining mine life of about 31 years.

Mineral Commodities Ltd. of Australia announced in September that it would initiate the three-stage mining right application for its Xolobeni mineral sands deposit in Eastern Cape Province, South Africa. Mineral Commodities' application will encompass the preparation of a scoping report, an environmental impact assessment (EIA) and draft environmental plan, and finally a premine monitoring program at the site (Mineral Commodities Ltd., 2004). Xolobeni resource estimates are 313 Mt of heavy-mineral sands ore (Mineral Commodities Ltd., 2003§).

Mineral Commodities also announced that it had applied for a prospecting permit in August for its Tormin mineral sands project. The company planned to prepare a limited scoping study and an EIA by November for the Tormin project (Mineral Commodities Ltd., 2004). A bench test of the deposit using a four-stage spiral concentrator produced a 98% heavy-mineral concentrate containing 65% ilmenite, 16% nonmagnetics (includes rutile and zircon), 17% garnet, and 2% nonheavy minerals.

Ukraine.—Heavy-mineral sands producer Vilnohirsk State Mining & Metallurgical (VSMMP) was the world's eighth ranked zircon producer in 2004 (Mineral Sands Report, 2005c). 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 consumption for zirconium materials increased in 2004. Growth of consumption of 3% to 5% per year through the next decade was expected, and new deposits are expected to come online in 2005 and 2006 to improve the supply. Prices were expected to rise in the near term in response to higher energy costs and the increase in demand. Production shortfalls are expected to continue through at least 2006. The increased consumption relative to the available supply will contribute to continued pressure for increases in the short term, especially in the spot market. During the next few years, the zircon supply and demand is expected to be in closer balance as new deposits and plant expansions come online, especially in the United States and Australia. Expansions in supply also 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 remain at current levels during the next 5 to 10 years.

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

(Metric tons)

	2000	2001	2002	2003	2004
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon	56,200	59,100	37,000	35,200	31,400
Exports	72,900	66,900	47,100	74,300 r	71,400
Imports for consumption[2]	65,200	60,600	36,000	38,100 r	36,200
Consumption, apparent[2, 3]	W	W	W	W	W
Stocks, December 31, dealers and consumers[4]	25,100	37,700	21,600	27,900	16,700
Zirconium oxide:					
Production[5]	22,900	21,500	17,600	20,400	21,300
Exports[6]	2,220	2,400	1,950	1,520	1,600
Imports for consumption[6]	3,950	2,950	2,900	2,350	3,960
Consumption, apparent[3]	24,600	22,200	18,300	20,700	23,700
Stocks, December 31, producers[5]	2,560 r	2,730 r	2,490 r	2,030	2,070

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Includes insignificant amounts of baddeleyite.
[3]Defined as production + imports for consumption - exports plus or minus government shipments plus or minus stock changes.
[4]Excludes foundries.
[5]Excludes intermediate oxides associated with metal production.
[6]Includes germanium oxides and zirconium dioxides.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM AND HAFNIUM MATERIALS

Specification of material		2003	2004
Zircon:			
Domestic, standard-grade, bulk[1]	dollars per short ton	370.00	455.00
Domestic, premium-grade zircon[1]	do.	440.00	596.00
Imported sand, ceramic-grade, free on board, bulk[2]	dollars per metric ton	395.00-420.00	460.00-550.00
Imported sand, refractory-grade, free on board[2]	do.	350.00-390.00	450.00-550.00
Imported sand, foundry sand-grade, free on board, bulk[2]	do.	370.00-400.00	450.00-550.00
Baddeleyite, contract price, cost, insurance, and freight main European port:[3]			
Refractories/abrasive grade	dollars per metric ton	2,000-2,400	2,000-2,400
Ceramic grade (98% zirconium oxide and hafnium oxide)	do.	2,600-3,000	2,600-3,000
Zirconium oxide:[4]			
100 kg:[5]			
Calcia stabilized zirconia	dollars per kilogram	NA	20.70
Magnesia stabilized zirconia	do.	NA	21.00
Yttria (3 mol%) stabilized zirconia	do.	NA	22.40
Yttria (8 mol%) fully stabilized zirconia	do.	NA	24.10
1,000 kg:[5]			
Calcia stabilized zirconia	dollars per kilogram	NA	18.10
Magnesia stabilized zirconia	do.	NA	19.40
Yttria (3 mol%) stabilized zirconia	do.	NA	18.80
Yttria (8 mol%) fully stabilized zirconia	do.	NA	20.10

NA Not available.
[1]Domestic average price.
[2]Source: Industrial Minerals, no. 435, December 2003, p. 75; no. 446, December 2004, p. 73.
[3]Source: Industrial Minerals, no. 435, December 2003, p. 74; no. 446, December 2004, p. 72.
[4]Source: Stanford Materials Corp. at URL http://www.stanfordmaterials.com/zr.html.
[5]Prices are for bulk quantities; nominal, free on board California.

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

Class and country	HTS[2]	2003 Quantity (metric tons)	2003 Value (thousands)	2004 Quantity (metric tons)	2004 Value (thousands)
Ore and concentrates:	2615.10.0000				
Argentina		1,480	$1,060	563	$495
Australia		22	28	--	--
Belgium		1,190	681	2,540	1,290
Brazil		1,320	665	1,190	1,060
Canada		4,060	2,470	7,750	4,320
China		707	641	1,380	1,930
Colombia		5,360	3,070	2,470	2,320
Dominican Republic		135	90	207	191
Ecuador		360	232	202	184
France		359	275	560	437
Georgia		--	--	11	10
Germany		11,100	4,680	3,850	2,270
Guyana		2	5	--	--
Hong Kong		--	--	6	3
India		11	8	294	391
Indonesia		--	--	14	19
Ireland		139	167	36	52
Israel		292	368	256	330
Italy		22,600	8,540	17,700	7,790
Japan		937	1,350	2,580	2,800
Korea, Republic of		586	775	1,480	2,500
Mexico		6,410	3,120	11,800	6,620
Netherlands		7,020	2,850	10,100	4,280
Pakistan		836	531	428	351
Peru		45	30	--	--
Portugal		--	--	9	4
South Africa		708	519	10	21
Sweden		52	34	69	51
Taiwan		105	93	30	115
United Kingdom		4,360	4,930	2,880	5,220
Venezuela		249	165	394	349
Vietnam		244	160	126	109
Other		33	81	7	6
Total		70,600	37,600	68,800	45,500
Ferrozirconium:	7202.99.1000				
Canada		8	14	7	13
China		--	--	18	64
Germany		3	3	8	8
Japan		(3)	3	--	--
Korea, Republic of		--	--	(3)	7
Mexico		1,920	2,010	881	1,210
Total		1,930	2,030	913	1,310
Unwrought zirconium, powders:	8109.20.0000				
Brazil		(3)	8	(3)	10
Canada		3	97	2	65
China		15	622	--	--
France		3	135	11	357
Germany		2	55	2	89
Italy		2	75	1	34
Japan		2	166	23	565
Korea, Republic of		(3)	43	1	13
Mexico		1	11	2	52
Norway		2	69	1	33
Romania		(3)	7	--	--
Taiwan		(3)	10	--	--
United Kingdom		71	1,090	90	1,250
Other		(3)	13	4	132
Total		101	2,400	138	2,600

See footnotes at end of table.

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

Class and country	HTS[2]	2003 Quantity (metric tons)	2003 Value (thousands)	2004 Quantity (metric tons)	2004 Value (thousands)
Zirconium waste and scrap:	8109.30.0000				
Australia		(3)	8	--	--
Belgium		18	100	--	--
Brazil		6	56	--	--
Canada		11	450	21	937
China		3	26	4	41
France		3	39	7	81
Hungary		--	--	(3)	4
Italy		14	130	14	117
Japan		34	480	48	537
Korea, Republic of		--	--	(3)	3
Netherlands		8	37	--	--
Singapore		(3)	16	(3)	12
Taiwan		--	--	(3)	6
United Kingdom		7	140	2	54
Total		104	1,480	96	1,790
Other zirconium waste and scrap:	8109.90.0000				
Argentina		38	2,200	32	1,870
Belgium		--	--	4	435
Brazil		24	983	6	806
Canada		333	15,800	379	19,400
China		120	7,240	175	11,100
Finland		9	767	1	124
France		114	5,810	34	2,440
Germany		125	7,890	62	3,830
Indonesia		18	67	--	--
Italy		53	2,570	4	255
Japan		258	15,500	238	14,800
Korea, Republic of		172	16,400	150	16,000
Malaysia		--	--	4	48
Mexico		3	265	28	782
Portugal		3	152	--	--
Spain		43	7,190	54	8,040
Sweden		4	322	7	637
Taiwan		23	2,540	29	2,030
United Kingdom		122	5,740	99	6,040
Other		26	1,180	160	1,950
Total		1,490	92,500	1,470	90,600

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States.
[3]Less than ½ unit.

Source: U.S. Census Bureau.

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

Class and country	HTS[2]	2003 Quantity (metric tons)	2003 Value (thousands)	2004 Quantity (metric tons)	2004 Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		25,000	$7,940	23,600	$9,450
Canada		1,130	582	1,310	718
China		1,720	2,500	1,050	1,770
Germany		27	56	28	45
India		5	34	12	67
Italy		--	--	39	24
Japan		8	54	3	21
Russia		270	644	422	985
South Africa		9,180	2,860	8,700	3,690
United Kingdom		60	131	--	--
Other		4	13	20	16
Total		37,400	14,800	35,200	16,800
Ferrozirconium:	7202.99.1000				
Brazil		69	125	124	234
China		--	--	(3)	3
India		79	77	--	--
Japan		6	43	--	--
Norway		--	--	37	34
United Kingdom		--	--	4	47
Total		154	245	165	318
Unwrought zirconium, powder:	8109.20.0000				
Canada		(3)	7	--	--
China		3	33	41	388
Germany		37	2,140	19	1,650
Other		10	85	14	284
Total		50	2,260	74	2,320
Zirconium waste and scrap:	8109.30.0000				
Japan		6	43	14	64
United Kingdom		15	21	--	--
Other		1	13	1	6
Total		22	77	15	70
Other zirconium, waste and scrap:	8109.90.0000				
Canada		29	4,700	35	4,460
China		1	133	7	201
Denmark		(3)	37	(3)	31
France		402	36,100	423	36,400
Germany		4	842	16	3,200
Japan		(3)	16	3	196
United Kingdom		20	54	200	205
Other		12	230	23	845
Total		468	42,100	707	45,600
Unwrought hafnium including powders:	8112.92.2000				
Canada		1	14	1	173
China		(3)	4	--	--
France		4	883	2	670
Germany		(3)	10	(3)	37
Other		--	--	(3)	16
Total		5	911	4	895

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States.
[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
ZIRCONIUM MINERAL CONCENTRATES: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country	2000	2001	2002	2003[e]	2004[e]
Australia	374,000	393,000	412,000	462,000 [4]	441,000 [4]
Brazil[5]	29,805	17,031 [r]	29,342 [r]	26,059 [r, 4]	26,000
China[e]	15,000	15,000	15,000	15,000	17,000
India[e]	19,000	19,000	19,000	20,000	20,000
Indonesia[e]	250	250	250	250	200
Malaysia	3,642	3,768	5,293	3,456 [r, 4]	3,500
Russia[e, 6]	6,500	6,500	6,500	6,500	6,500
South Africa[e, 7]	253,000 [4]	262,000	274,000	280,000 [r]	300,000
Thailand	--	100	--	--	--
Ukraine[e]	30,000	33,600	34,300	35,000	35,000
United States	W	W	W	W	W
Total[8]	731,000	750,000 [r]	796,000 [r]	848,000 [r]	849,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in total. -- Zero.
[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes data available through May 9, 2005.
[3]Malawi was also reported to produce zirconium concentrates but information is not sufficient 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, until 2002, 15,000 to 20,000 metric tons per year of baddeleyite from Palabora Mining Co. Ltd.
[8]Does not include U.S. data which have been withheld to avoid disclosing company proprietary data.