# Zirconium and Hafnium

*Joseph Gambogi, the zirconium and hafnium commodity specialist for the U.S. Geological Survey, has prepared the following information on the two elements.*

Zirconium and hafnium are corrosion-resistant metals that are grouped in the same family as titanium on the periodic table. The two elements commonly occur in oxide and silicate minerals and have significant economic importance in everything from ink, ceramics and golf shoes to nuclear fuel rods.

Zirconium and hafnium are found primarily in the zirconium-silicate mineral zircon, typically in a zirconium to hafnium ratio of about 50-to-1. Zircon itself is produced as a byproduct of the mining and processing of heavy-mineral sands containing the titanium minerals ilmenite and rutile.

Zircon ceramics, opacifiers, refractories and foundry applications are the leading end uses for zircon. Other end uses include abrasives, chemicals and welding rod coatings. The leading markets for hafnium metal are in superalloys, nuclear control rods and high-temperature ceramics. Additionally, superalloys can operate in temperatures as high as 1,100 degrees Celsius and are used in the hot sections of aircraft and industrial gas-turbine engines.

Zircon increases resistance to metal penetration and gives a uniform finish to castings, so milled or ground zircon is often 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.

The zirconium-oxide mineral baddeleyite is used principally in the manufacture of alumina-zirconia abrasives 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 is used in the manufacture of oxygen sensors that control combustion in furnaces and automobile engines. It is also used to make 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 replica for diamonds and colored gemstones. Yttria-stabilized zirconia is also increasingly used in dental applications as inlays, crowns and bridges because it has higher fracture resistance than similar alumina products.

Ammonium- and potassium-zirconium carbonates are used as paper and board coatings. Zirconium chemicals are also used in inks to promote adhesion to metals and plastics and as links in polymers and printing inks.

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal is used as a shield 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.

In 2006, world production of zircon was 870,000 metric tons; there are no available statistics on world production of zirconium and hafnium metal. World reserves of zircon are estimated to be 38 million tons of zirconium oxide. Identified world resources of zircon exceed 60 million tons, of which

the United States has about 14 million tons. Leading producers include the United States, Australia and South Africa. World resources of hafnium are associated with those of zircon and baddeleyite and exceed 1 million tons, of which the United States holds about 130,000 tons.

Because of increased demand for zircon by ceramics and chemicals industries, the heavy-mineral sands industry continues to be active in the global exploration and development of mineral deposits, particularly in Australia, Kenya, Mozambique, South Africa and the United States.

Originally published as *Geotimes* Mineral Resource of the Month, March 2007
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Sample of zirconium powder.  Images from *Minerals in Your World*.

Sample of hafnium ore, penny for scale.  Images from *Minerals in Your World*.