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Zircon: Tiny Crystals with Long History and Big Uses

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ZIRCON: TINY CRYSTALS WITH LONG HISTORY AND BIG USES

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INTRODUCTION

Zircon is probably an unfamiliar name to most people. The reason is probably that zircon crystals are usually tiny and do not exist as single pieces like quartz or olivine does. Instead, zircon is commonly found as accessory minerals in igneous rocks, mixed in a matrix of a whole bunch of other minerals. The name zircon is believed to be derived from either the Arabic word *zarquan*, meaning vermilion, a type of red pigment, or the old Persian word *zargūn*, which means golden-colored. Both colors are relatively common for zircon (King, 2008). Zircon has a fairly long history; the earliest known written record about zircon dates back to around 1400. In the Middle Ages, people believed that wearing zircon jewelry could cure insomnia and protect them against many diseases (MacDonald, 2013). Nowadays, zircon is said to be among the most useful minerals in the world. In the field of geology, zircon is important especially because of its use in radiometric dating. Outside of science, zircon is also widely used in industry. More closely related to daily life, as zircon can occur in many different colors, it is used to make inexpensive gemstones.

Fig. 1 A rare 40 mm long zircon crystal with calcite (right) veining in granite (left) (King, 2008).

PHYSICAL PROPERTIES

Zircon is most commonly seen in reddish, grayish, and yellowish brown color with a subadamantine luster (Nesse, 2008). Its streak is white (Nesse, 2008). Zircon crystals are often euhedral and elongated, consisting of a tetragonal prism with a terminal tetragonal dipyramid. Zircon grains are often very small, generally shorter than 200μm (MacDonald, 2013). Regardless of its small size, zircon is in fact a relatively dense mineral with a specific gravity in the range of 4.6 to 4.7 g/cm^3 (King, 2008). Zircon is physically robust; it has an extremely high melting points at 2130 ºC (King, 2008) and a hardness of 7.5 on the Mohs scale (Nesse, 2012).

Fig. 2 (Above) A photo showing the small size of zircon, ruler scale in millimeter.

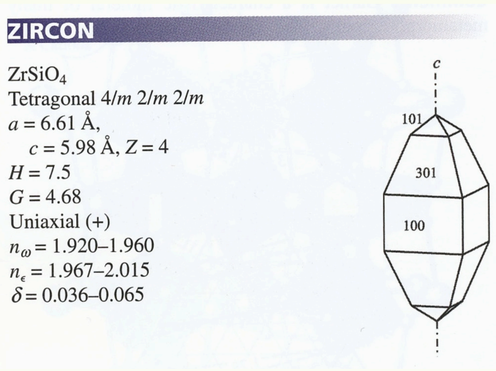


Fig. 3 (Right) Crystalography diagram of zircon and its physical and optical properties (Nesse, 2012).

CHEMICAL COMPOSITION AND STRUCTURE

Zircon is an orthosilicate with chemical composition of $ZrSiO_4$. Its structure is commonly seen in many minerals. The general formula for this structure is ATO_4, where T sites are isolated tetrahedra, and A sites are eightfold-coordinated sites in-between the tetrahedra (Finch & Hachar, 2003). In zircon’s case, T sites are silica tetrahedra, and zirconium cations fill in A sites. A zirconium atom and surrounding oxygen atoms form a distorted cube, as some of the silica tetrahedra share one oxygen atom with zirconium and some share two. Due to this common structure, zircon is capable of incorporating various trace elements (Finch & Hachar, 2003). Some hafnium is always present in zircon, sometimes at quite high concentration (Deer et al., 1966). Some hafnium is always present in zircon, sometimes at quite high concentration (Deer et al., 1966). Other than hafnium, Zircon can also incorporate many other elements, such as thorium (Th) and uranium (U), which are often caught from the parental magma (King, 2008).

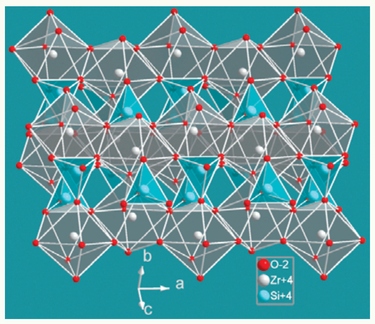


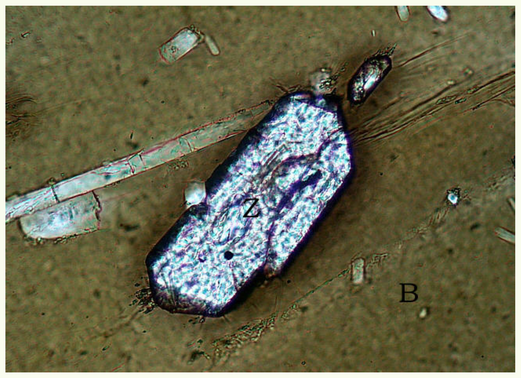
Fig. 4 Diagram showing the lattice structure of zircon (MacDonald, 2012)

OCCURRENCE

Zircon originally forms in felsic magmas (MacDonald, 2013), and therefore, it is commonly found in many plutonic felsic rocks, such as granite. It is also fairly common in metamorphic rocks as its physical resistibility allows it to survive high-grade metamorphism (King, 2008). Zircon is seldom affected by weathering and thus can stay unchanged in sedimentary rocks. Its high specific gravity leads to settlement to the bottom and therefore is common in river and beach sand deposits (Dietrich & Skinner, 1979).

OPTICAL PROPERTIES

Zircon is a uniaxial mineral with a tetragonal symmetry in the 4/m 2/m 2/m point group. It usually does not exhibit any twining or have good cleavages that are readily observable. Under the petrographic microscope, zircon has very high positive relief, standing out from everything else in the thin section. It has very weak pleochroism that usually cannot be seen. Under cross-polarized light, zircon displays parallel extinction. Zircon’s birefringence is in the range of 0.042 to 0.053; therefore, it yields interference colors in the third order. When the grain is oriented with its long axis in the NW-SE direction, zircon’s interference color decreases as the accessory plate is pushed in, indicating that it is a length slow mineral. In zircon, the index of refraction of ordinary ray is 1.924, and that of the extraordinary ray is 1.984. Hence, zircon is optically positive.



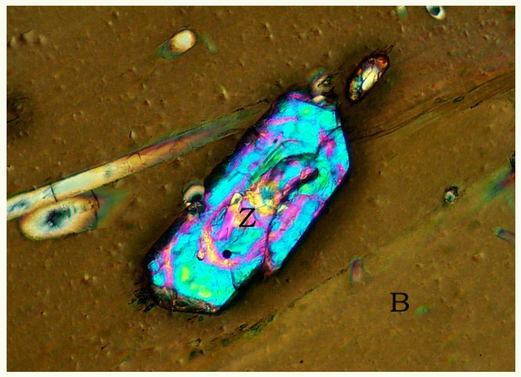


Fig. 5 (Left) Zircon enclosed in biotite under plane-polarized light, 200x. The high relief makes zircon looks more “3-dimensional” than its surroundings (after Hollocher, n.d.).
Fig. 6 (Right) Zircon enclosed in biotite under cross-polarized light, 200x. The mineral exhibits third order interference colors (after Hollocher, n.d.).

USES OF ZIRCON

Radioactive uranium isotopes that are almost always included in zircons allow this mineral to be widely used for radiometric dating (MacDonald, 2013). Uranium, through multiple intermediate states, eventually decays to lead, and therefore the dating technique is called uranium-lead (U-Pb) dating. The often-present titanium also enables zircon to retain chemical record of high-temperature geological events (MacDonald, 2013). Zircon has substantially long physical and chemical durability and thus is present in many of the oldest known rocks on Earth (Finch & Hachar, 2003). Hence, zircon is often used to date extremely old rocks and examine the early Earth environment. For example, Marty and Yokochi (2006) used the dating data as well as early Earth temperature and water-rock interaction records obtained from zircon grains to reconstruct the environment on early Earth and concluded that water must have been present in on Hadean Earth and the temperature on Earth surface may have been milder than people used to believe. Other than geochronology, zircon is also used in other fields. In industry, zircon’s ability to refract light, its high melting point, and its low thermal expansion make it great for high-temperature industrial processes (MacDonald, 2013). For example, it is used as refractory bricks in glass production. Zircon’s hardness also makes it an excellent abrading agent (MacDonald, 2013). In addition, zircon is also used as a gemstone, as it can be in many other brilliant colors, such as a deep blue color, which is loved by jewelry makers (King, 2008). Zircon is also a source for zirconium, which is also widely used in industry (King, 2008).

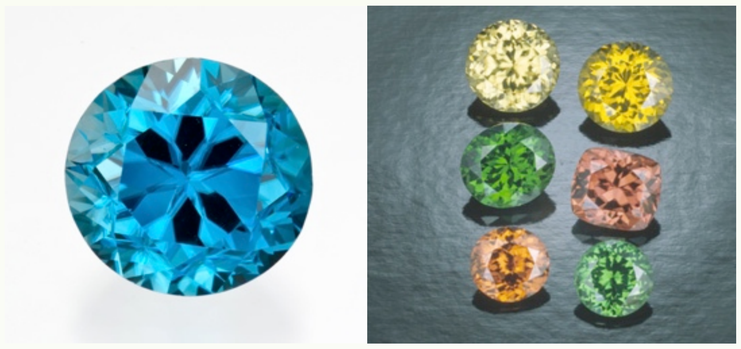


Fig. 7 Photos of gemstone zircon, left one showing the the famous zircon blue color, and right one showing various other colors zircon can have (GIA, n.d.).

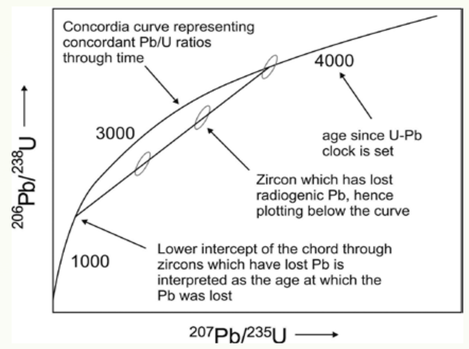


Fig. 8 An example diagram of the curve as a result of U-Pb dating (MacDonald, 2013).

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