The Potential of Iron Oxide U-Pb Geochronology—Examples from the Olympic Dam IOCG Deposit, South Australia

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The discovery of lattice-bound U and Pb in hematite from Olympic Dam and successful utilization of hematite as a geochronometer hint at potential broader application of U-Pb Fe oxide geochronology to directly date Fe oxide-bearing mineralization in various settings and constrain the lifespan of single deposits.

At Olympic Dam, the variety of hematite textures reflects cycles of brecciation and crystallization. Fe oxides and sulfides are intimately associated throughout the lateral and vertical extent of the orebody at Olympic Dam. The 2013 study reported ^{207}Pb-^{206}Pb ages (1590 ± 8 and 1577 ± 5 Ma) for oscillatory- and sectorial-zoned hematite from two underground bornite-bearing samples, but where the younger age is from acicular, second-generation hematite within high-grade ore. U-concentrations in brighter zones on the BSE images were in the 600 to 25,000 ppm range. Patterns are defined not only by zones with high U and Pb but also W and Mo.

Here, we report data for Fe oxides from different locations in the Olympic Dam breccia complex. Oscillatory-zoned hematite from deep (~1,600 m) mineralization in the SE lobe of the orebody gives ~1.6 Ga ages similar to the aforementioned samples, but, in this case, oscillatory zonation is defined by higher W (thousands of ppm) and lower U (mean <100 ppm); Sn and Mo (hundreds of ppm) are also part of the zoning. Such signatures, hereafter termed “granitophile,” are attributable to a granitic source.

Younger ages (~1.4–1.2 Ga) were obtained from two hematite generations within chalcopyrite-bearing hematite metasedimentary rock crosscut by barite veins from the upper part of the deposit core. Although zoned, like in the deep samples, this hematite features variable grain rounding. Uranium concentrations are comparable, but the granitophile signature is much weaker. The hematite here also differs in terms of much higher ΣREY, As, and Cr.

Magnetite from one drill hole intersecting the NE edge of the breccia complex gives the oldest age (1769 ± 58 Ma). This magnetite is part of Fe oxide ± siderite intervals within granite with variable intensity of alteration. The dated magnetite features strong zonation (Si and Al up to a few wt %), high ΣREY, variable U (hundreds to thousands of ppm), and coarsest (~200–500 µm) size. Such characteristics, particularly zonation patterns and association with siderite, contrast markedly with magnetite from deeper levels at Olympic Dam. Such magnetite may represent BIF-style mineralization engulfed by Roxby Downs Granite, host to mineralized Olympic Dam breccia. The age is broadly coincident with the Wallaroo Group, inferred to host BIF-style mineralization elsewhere in the Gawler craton.

Oscillatory zonation in hematite with granitophile signatures is not restricted to Olympic Dam hematite, but occurs in other deposits/prospects across the Gawler craton. Meaningful ages were also obtained from low-U hematite.

These preliminary results further support a model of ore evolution at Olympic Dam that strays from the current paradigm of formation during a single event at ~1.6 Ga. Significantly, this represents the first textural-geochemical-geochronological evidence for involvement of preexisting Fe oxide-rich lithologies at Olympic Dam. The younger ages are less easily matched to known geological events; they may relate to (1250–1200 Ma) Musgravian orogenesis.