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Iron oxides: a versatile tool for geochemical fingerprinting and geochronology

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The common iron-oxides (magnetite and hematite) can incorporate >30 different trace elements into their crystal lattices at concentrations readily measurable by LA-ICP-MS. Coupled with their refractory character allowing preservation of primary signatures, this makes them attractive targets for systematic geochemical fingerprinting. The distinct trace element signatures in oxides of different provenance and age can be used to support development of genetic and space-time evolution models. South Australia (SA) hosts a broad variety of iron deposits (Archean to Neoproterozoic), including BIF-style and reworked, redeposited sub-types, in some instances overprinted during tectonothermal events. Iron oxides are also the dominant component of giant Mesoproterozoic iron oxide copper-gold (IOCG) systems such as Olympic Dam (OD). Anomalously high-concentrations of rare earth elements and Y (collectively, REY) and the elements U, W, Sn and Mo ('granitophile' elements), as well as distinct variation in chondrite-normalised REY-fractionation trends are measured in hematite from different parts of the OD orebody and immediately adjacent [1]. In combination with preliminary U-Pb dating of Fe-oxides, these trace element patterns help define space-time evolution of Fe-oxides, from deep (early; ~1.6 Ga) to shallow (late; ~1.4-1.2 Ga) parts of the OD breccia complex. Fe-oxide geochemistry also assists recognition of older (~1.8-1.75 Ga), inherited BIF-type protoliths on the margins of the deposit [2]. These older blocks are interpreted to have been encapsulated within the ~1.6 Ga Roxby Downs Granite, hosting OD mineralisation. Younger (~0.8 Ga) ages are obtained from dating accessory minerals in post-magmatic magnetite-apatite assemblages within mafic intrusions [3]. Data for BIF-style systems in SA show that Fe-oxides from different ore types have subtle differences in geochemical signatures in a given orefield and/or orebody (Keyser et al. this conference). In particular, an increase in Σ REY budget and changes in REY fractionation trends are associated with replacement processes between Fe-oxides or of Fe-oxides by Fe-hydroxides. Although hematite from some BIFs contains measurable U and W, hydrothermal Fe-oxides from IOCG systems show the highest content of 'granitophile' elements, e.g. hematite displaying oscillatory zonation where either U or W can reach concentrations up to few wt.% [1, 4].

High-U hematite from OD was used as a Pb-Pb geochronometer [4] to give ages of 1590±8 and 1577±5 Ma via LA-ICP-MS using GJ-1 zircon as a primary standard. An iron-oxide matrix-matched standard is required if the method is to be routinely applied to estimate the timing and duration of mineralising events. Such work is in progress and employs ID-TIMS analysis to measure absolute U/Pb isotopic values on homogeneous areas in grains pre-assessed by SHRIMP and extracted using a micro-drill. The reliability of Fe-oxides as a versatile tool for geochemical fingerprinting/ geochronology depends upon understanding the mechanisms of trace element incorporation/ release. Transmission Electron Microscopy (TEM) and scanning-TEM imaging using the ultra-high-resolution FEI Titan Themis TEM

(Adelaide Microscopy) to evaluate high-U and high-W hematites shows differences in their superstructure domains and nanoscale characteristics. This suggests W substitution into oxygen sites, which may be a more robust mechanism for trace element incorporation than direct metal-for-metal substitution previously proposed for high-U hematite [4].

References

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