Micron- to nanoscale insights into genesis of the Cu-Au-U-Ag Olympic Dam system, South Australia

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Olympic Dam is one of the largest Cu-U-Au deposits on Earth. U-Pb and Pb-Pb geochronology on preserved magmatic and hydrothermal minerals allows interpretation in terms of initial hydrothermal ore formation at ~1590 Ma associated with Gawler SLIP emplacement. Ore textures suggest multiple episodes of replacement, remobilization and recrystallization and are supported by (radio)isotope data yielding a range of younger ages. Micron- to nanoscale studies of feldspars and accessory phases within the alteration envelope, and of Fe-oxides, Cu-(Fe)-sulphides, U-minerals, and REE-bearing minerals within the deposit all point to common mechanisms involved in the forming the mineral assemblages, prevailing µm-scale mineral textures, and measured variations in mineral compositions observed today. Feldspars record the magmatic to hydrothermal transition and early (Fe-metasomatism) alteration from perthite to Ba-rich K-feldspar, releasing REE [1]. Evidence for coupled dissolution-precipitation reactions (CDRR) is widespread. Porosity is however transient and not networked. Uraninite and hematite are hydrothermal minerals and display preserved oscillatory zoning and incorporation of REE and other trace elements [2,3]. These primary features give way to fluid-assisted reworking and recrystallization. CDRR permits release of trace elements from the lattice to be trapped as nm- to µm-scale inclusions. Nanoscale textures indicating T≥400 ºC are preserved in Cu-(Fe)-sulfides and hint at a primary, vertical deposit-scale zoning [4]. Nonetheless, CDRR, replacement, phase transformation and local (µm- to tens m-wide) remobilization are evident. Fluid regimes were likely heterogeneous given texturally distinct generations of the same mineral observed at the sample scale. Redistribution of U and daughter isotopes between minerals and into pores and microfractures, at scales from nm upwards is documented from nanoSIMS and TEM studies of various minerals, with implications for interpretation of geochronological data.

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