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Combined Micron-Scale EBSD Study and LA-ICP-MS Analysis Reveals the Evolution of Pyrite and Cu-Fe-Sulphides in the Olympic Dam Cu-U-Au-Ag Deposit, South Australia

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The breccia-hosted Olympic Dam IOCG-type deposit, South Australia, displays a systematic inwards and upwards zonation of Cu-Fe-sulphides from pyrite-chalcopyrite, bornite-chalcopyrite, to bornite-chalcocite assemblages, interpreted as a preserved primary feature. This includes lower-grade pyrite-chalcopyrite disseminations (outer shell) enclosing the resource. Superimposed tectonothermal events have modified deposit mineralogy and ore textures since mineralisation at ~1.6 Ga but remain imperfectly constrained. To better understand both syn- and post-formational deformation, we combine electron backscatter diffraction (EBSD) with laser ablation-inductively coupled-plasma mass spectrometry (LA-ICP-MS) element mapping of pyrite and chalcopyrite to reveal microstructures and associated trace element (re)distribution.

Pyrite grains from representative outer shell assemblages either preserve marginal dislocation glide or dislocations formed by dislocation creep, both indicative of ductile deformation >260°C. Two stages of ductile deformation are inferred from such microfabrics, separated by intermittent fracturing. Dislocations display characteristic enrichment in Ag-Au-Pb-Bi-Te and are shown to disrupt an earlier As-Co-Ni compositional zoning.

Chalcopyrite from pyrite-chalcopyrite and chalcopyrite-bornite assemblages is revealed as fine aggregates despite its homogenous appearance. Silver, Bi, Pb, and Sb are present along the aggregate grain boundaries and, to a lesser extent, along twin planes. Chalcopyrite also preserves (220) and (001) crystallographic preferred orientations, {110} and {112} twinning, grain boundary migration recrystallization, and foam textures, which can be correlated to P-T conditions.

Coupled EBSD-LA-ICP-MS analysis provides valuable new insights into ore genesis and superimposed events. Our findings represent the first evidence for ductile deformation in pyrite from a brecciated IOCG deposit. Novel application of EBSD to chalcopyrite shows its suitability for unravelling low-medium–temperature stages of ore evolution, complementing data from coexisting pyrite, a mineral routinely used to depict higher-temperature deformation. Grain-scale elemental distributions confirm the key role played by microstructures in Cu-Fe-sulphides as traps for critical/precious metals (Ag, Bi, Sb, Au, Te), and deleterious Pb.

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