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KEYNOTE SPEAKER

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Mineral zonation and ore formation in IOCG deposits: new insights from the integration of mineralogy, geochemistry and petrophysics

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The Ernest Henry breccia pipe and the Starra shear zone-hosted Cu-Au deposits are two major iron oxide- copper-gold (IOCG) systems in the Cloncurry District of Queensland, Australia. Systematically collected SEM-based modal mineralogy combined with data of anisotropy of magnetic susceptibility, geochemical, and petrophysical analyses, as well as high-resolution X-ray computed tomography images from both deposits enable a consistent model for IOCG deposit formation in which hydrolytic alteration plays an essential role in Cu-Au mineralization. The modal mineralogy data, associated replacement textures, and the deposit-scale distribution of key mineral assemblages indicate that hydrothermal alteration produced a mappable zonation of mineral assemblages and petrophysical properties within and around the ore bodies. Characteristic mineral halos of feldspars, micas, and chlorites, as well as individual minerals such as pyrite and apatite envelope the ore body and extend up to hundreds of metres into the barren host rocks. Although the mineral zonation around the two deposits differ in size and in specific mineral assemblages, they both resulted from a sequence of iron oxide-alkali-calcic alteration, shearing, brecciation, and previously unrecognized hydrolytic alteration, which was coincident with the high-grade Cu-Au mineralization. Hydrolytic alteration reactions increased the rock-porosity via fluid-rock interactions resulting in increased permeability, for example by the partial to near-complete replacement of magnetite by hematite according to: $Fe_3O_4 + 2H^+ = Fe_2O_3 + Fe^{2+} + H_2O$ with ΔV = -32 %.

In contrast, hydrothermal replacement of feldspars and biotite by chlorite at the breccia margins and in bounding shear zones reduced porosity and likely permeability. In both deposits, these and similar mineral replacements resulted in rims of alteration minerals sealing the zone of Cu-Au mineralization, which led to fluid-focusing and the formation high-grade Cu and Au ore bodies with characteristic internal zonation of Cu-bearing minerals. Aspects of the mineral and metal zonation observed at the Ernest Henry and the Starra deposits are also observed in other Australian IOCG deposits including the Prominent Hill deposit in the Gawler Craton. This highlights the significance of hydrolytic alteration in IOCG deposit formation and the importance for mineral exploration to systematically recognize its effects on host rocks when evaluating IOCG drill targets.

Tobias Schlegel

Tobias holds a PhD of ETH Zurich, Switzerland, and joined CSIRO Mineral Resources as a research scientist in 2019 coming from RWTH Aachen University in Germany, where he did his post-doc. He previously worked as a project geologist in foundation ground reconnaissance, hydrogeological consulting, and 10 years as a chemical laboratory technician in pharmaceutical drug discovery. His research activities over the past decade are focused at understanding the formation of iron oxide-copper-gold deposits including the Prominent Hill, Ernest Henry, and the Starra deposits. Together with colleagues at CSIRO Mineral Resources and partners in the mineral industry and geological surveys, he conducts applied science projects investigating the role of different crustal fluids and their interaction with host rocks leading to Fe, Cu and Au mineralisation. He uses alteration geochemistry, SEM-based mineral mapping, mineral chemistry, stable isotopes, and petrophysical properties of rocks to develop tools that allow mineral exploration to navigate toward high metal grades during their evaluation of drill targets.