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Cryptic Alteration Haloes in Sediment-Hosted Ore Deposits: New Tools, New Exploration Vectors, New Genetic Models

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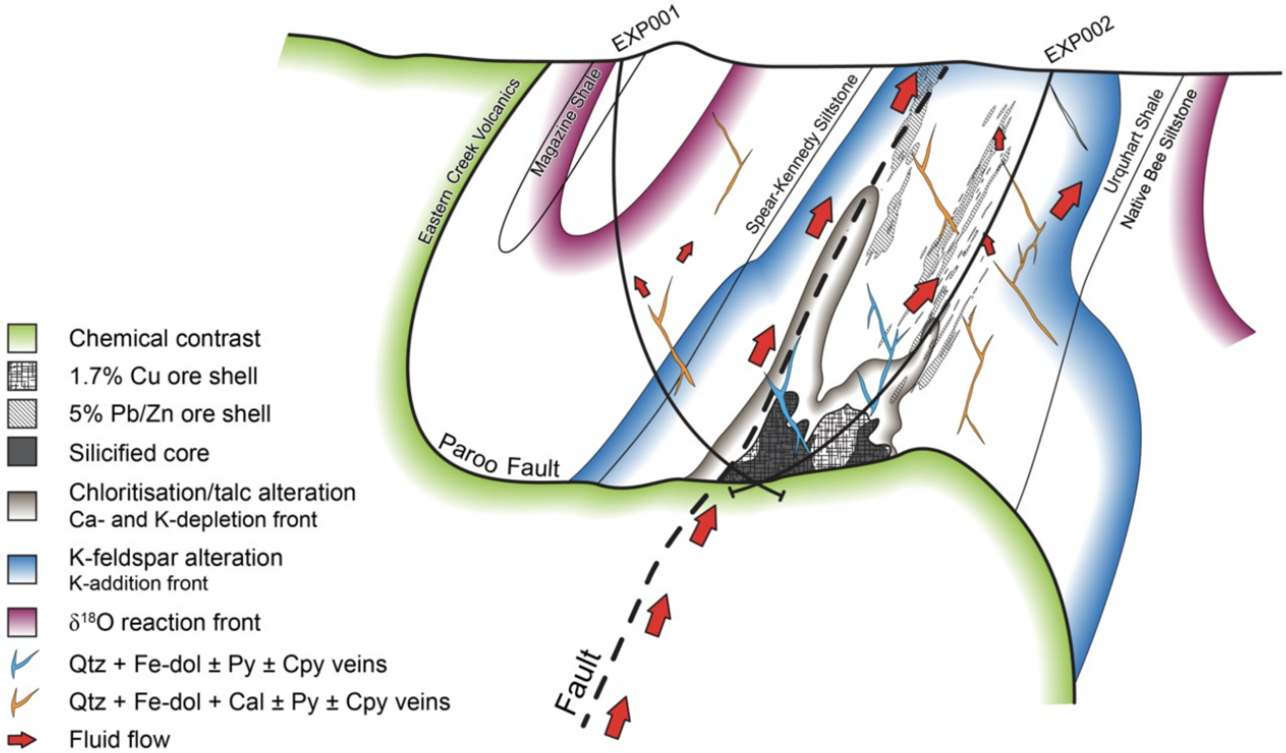
Sediment-hosted ore deposits of various types often have "cryptic" alteration haloes—that is, visible alteration is difficult to recognise and use to vector towards mineralization. Over the last 15 years, a series of new analytical tools and approaches have made recognising and quantifying alteration in sediment-hosted deposits possible. This includes the routine use of 4-acid ICPMS geochemistry (e.g., Halley et al., 2016), automated mineralogy using scanning electron microscopy, the use of shortwave infrared (SWIR) and longwave infrared (LWIR) core imaging (Barker et al., 2021), and routine, inexpensive stable isotope analyses (Barker et al., 2011; Beinlich et al., 2017). Collectively, these methods can be utilised to recognise and quantify alteration footprints at varying distances from mineral deposits. In the the case of stable isotopes, the isotopic footprint can extend 5-10 kilometres around mineralization. For whole-rock lithogeochemistry, haloes can extend hundreds of metres to kilometres around mineralization, while mineralogical alteration can be tracked tens of metres to more than a kilometre from ore bodies. In this presentation, we will overview the development and use of these methods. Then we will show two case studies, from the Four Mile Carlin-type gold deposit in Nevada and the Mount Isa Copper deposit in Australia, to demonstrate how these tools can be integrated to define mineralogical, geochemical, and isotopic alteration haloes which provide vectors towards mineralization and ultimately inform genetic models.

At Mount Isa, newly acquired petrographic and geochemical data collected across a range of scales identified an extensive zoned alteration system that manifests as a series of interpreted reaction fronts, which extends at least 1500 m beyond mineralisation. Copper mineralisation is contained within a zone of visible mineral alteration, hydrothermal brecciation, and veining, locally known as the "silica-dolomite." The silica-dolomite is characterised by silicification and brecciation of shales, recrystallisation of dolomite, and intense ^{18}O-depletion, from $\delta^{18}O \approx 22‰$ VSMOW in the least altered rocks to $\delta^{18}O \approx 10‰$ in the most altered zone. A cryptic halo of K- and Ca-depletion extends from the inferred fluid input zones to include the region outboard of the visible mineral alteration envelope. Beyond the region of Ca-depletion and K-depletion, a large halo of cryptic potassic alteration is identified by whole-rock geochemical analysis. Potassium responsible for this alteration is interpreted to have been remobilised from zones of silicification and K-depletion at the core of the hydrothermal system. The change from dolomite- to calcite-dominated vein cement within individual veins is interpreted to be driven by increases in the relative activity of calcium during the evolution of the hydrothermal fluid. Consequently, ore-stage veins with mixed dolomite-calcite vein cement potentially represent a distal expression of silicification and decalcification within the core of the mineralising system. The alteration haloes described above, both visible and cryptic, are all contained with the broad zone of ^{18}O-depletion, representing the most spatially extensive alteration halo to copper mineralisation at Mount Isa (Andrew, 2021).



EXP001
EXP002
Eastern Creek Volcanics
Magazine Shale
Spear-Kennedy Siltstone
Urquhart Shale
Native Bee Siltstone
Paroo Fault
Fault
Chemical contrast
1.7% Cu ore shell
5% Pb/Zn ore shell
Silicified core
Chloritisation/talc alteration
Ca- and K-depletion front
K-feldspar alteration
K-addition front
δ^{18}O reaction front
Qtz + Fe-dol ± Py ± Cpy veins
Qtz + Fe-dol + Cal ± Py ± Cpy veins
Fluid flow