Tracing Cu-Au Ore-Forming Processes in the Proterozoic Elaine Dorothy Skarn Deposit, Mount Isa (Queensland, Australia), Using In-Situ Sulphide Mineral Compositions

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Copper-gold-bearing sulfide minerals form under diverse hydrothermal conditions across various geological settings, contributing to economically significant ore deposits. Trace elements incorporated within their crystal lattices provide critical insights into ore-fluid composition, source, and fluid evolution during protracted hydrothermal activity or subsequent remobilization. Skarn deposits form at temperatures between 300°C and 800°C, with sulfides precipitating during the later stages of hydrothermal activity (~250°C–400°C). These sulfide minerals are critical for interpreting the primary ore-fluid composition, offering insights into the chemical evolution, temperature, and metal content during the cooling phase of skarn formation. However, in ancient deposits, tracing ore processes based on sulphide geochemistry remain challenging since multiple complex deformations and hydrothermal activity affect the system.

This study focuses on the Elaine Dorothy Cu-Au-REE skarn, hosted within calcareous metasediments (garnet-diopside skarn) ascribed to the Paleoproterozoic Corella Formation (1750–1742 Ma). Early deformation and associated hydrothermal activities are linked to the calc-alkaline Burstall Granite, the Lunch Creek Gabbro and coeval felsic dikes, all emplaced at ca. 1740 Ma. The timing of this event contradicts previous constraints on the timing of mineralisation in the Mt Isa inlier (~1530 Ma Isan Orogeny). We combine field observations, petrographic studies, and in-situ trace element geochemistry (LA-ICP-MS) of pyrrhotite, pyrite, and chalcopyrite to investigate the paragenetic sequence, metal distribution, and hydrothermal alteration history of Eliane Dorothy. We show that sulphide minerals formed during both prograde to peak (garnet-diopside-wollastonite) and subsequent retrograde metamorphism (amphibole-phlogopite-chlorite). Based on textural evidence, distinct paragenetic sequences are distinguished. Importantly, we find that sulphide minerals are enriched in Ni and Co, suggesting a mafic magmatic fluid origin or contribution.

Future integration of the timing of deformation events with geochronological analysis of mafic rock generations in the vicinity of Elaine Dorothy deposit will potentially refine the understanding of the Mt Isa region's tectonic evolution.