

**The Evolution and Potential Sources of Mineralizing Fluids of the E1 Group of IOCG Deposits,
Cloncurry District, Northwest Queensland, Australia:
Implications from Fluid Inclusion and SHRIMP S Isotope Analyses**

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The E1 Group of Proterozoic iron oxide-Cu-Au deposits—E1 North, East, and South—is located 6 km east of the Ernest Henry IOCG deposit, in the far northeast of the polymetallic Cloncurry district of northwest Queensland, and hosts a total resource of 48 Mt of 0.72% Cu and 0.21 g/t Au. The mineralizing fluids of the E1 Group have not been studied in great detail and offer additional insight into the complex evolution of Cloncurry district iron oxide-associated Cu-Au deposits. We present a fluid evolution of the E1 Group hydrothermal system based on fluid inclusion microthermometrics of pre-ore, syn-early ore, and syn-late ore mineral assemblages, and ore formation temperatures calculated from in situ SHRIMP-measured sulfur isotopes in cogenetic late ore barite and chalcopyrite.

The E1 Group is hosted in variably porphyritic intermediate-mafic metavolcanic rocks, marbles, metasilstones, and carbonaceous pelites of the ~1740 Ma Corella Formation and Mount Fort Constantine Volcanics, and mineralization is characterized by layer- and matrix-controlled magnetite-carbonate-chalcopyrite ± barite ± fluorite replacement and veining of strongly sheared metasediments and metavolcanic breccias. The paragenetic sequence is characterized by four major stages: (1) early regional Na-Ca, composed mainly of albite and actinolite, (2) pre-ore K-Fe in magnetite, biotite K-feldspar, and minor quartz, (3) early Mg-Fe-carbonate-quartz-magnetite-associated mineralization, and (4) late Fe-Mn carbonate-barite-fluorite-associated mineralization. Stage 2 quartz, associated with the main phase of magnetite input, contains heterogeneously trapped, liquid-vapor ± halite, primary fluid inclusions which melt at -14°C. Stage 3 quartz, hosted in carbonate-quartz-chalcopyrite veins, is characterized by heterogeneously trapped primary, halite-saturated, hypersaline liquid-multisolid-vapor inclusions. Both stages 3 and 4 fluid inclusions homogenize above 450°C. Barite and calcite from stage 4 contain metastable liquid ± vapor inclusions with initial melting between -50° and -40°C, and final melting of ice ranging from -23° to -13°C, indicating the presence of NaCl-CaCl₂-rich brine. Homogenization into the liquid phase in most inclusions occurs at temperatures >150°C, though some homogenize at ~95°C.

Stage 4 chalcopyrite from E1 North, the largest of the three orebodies, shows $\delta^{34}\text{S}_{\text{CDT}}$ values in a narrow range between -2.2‰ and +1.9‰, while chalcopyrite $\delta^{34}\text{S}_{\text{CDT}}$ from E1 South are characterized by higher values ranging from 6.8‰ to 14.1‰. Sulfur in barite coeval with the chalcopyrite exhibits similar trends, with E1 North $\delta^{34}\text{S}_{\text{CDT}}$ of barite ranging from 16.4‰ to 21.2‰ CDT, and E1 South varying between 18.2‰ and 27.7‰. The formation temperature of stage 4 barite-chalcopyrite, calculated from sulfur isotope pairs, is constrained to 300° to 420°C in both orebodies. The transition in fluid inclusion composition from stage 3 (halite rich) to stage 4 (NaCl-CaCl₂ rich), along with the decrease in minimum formation temperature (>450°C to as low as 320°C), is interpreted to represent the dilution of an early, relatively hot, sulfate-rich, and hypersaline fluid with a separate Ca-Ba-rich fluid, which was synchronous with cooling. This early fluid was likely magmatic, based on the low $\delta^{34}\text{S}_{\text{CDT}}$ values of E1 North chalcopyrite. Higher $\delta^{34}\text{S}_{\text{CDT}}$ values at E1 South may be explained by fractionation from the E1 North hydrothermal center, though the influence of primary sulfide-bearing graphitic pelites found at E1 South cannot be excluded.