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, metasiltstones, 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°C and −40°C, and final melting of ice ranging from −23°C 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 δ34S CDT values in a narrow range between −2.2‰ and +1.9‰, while chalcopyrite δ34S 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 δ34S 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°C 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 δ34S CDT values of E1 North chalcopyrite. Higher δ34S 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.