

Stable Isotope Characterization of the Thermal Profile and Subsurface Biological Activity during Oxidation of the Great Australia Deposit, Cloncurry, Queensland, Australia

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Abstract

The application of stable isotope thermometry and phase relations was used to examine the thermal evolution of oxidation and secondary mineralization at the Great Australia Cu-Au-Co deposit, Cloncurry, Queensland, Australia. Results show that early secondary mineralization consisted of djurleite crystallization at temperatures $<93^{\circ}\text{C}$, followed by calcite mineralization at 66° to 75°C . The secondary mineralization paragenesis continued with azurite that formed at about 51°C , followed by malachite crystallization at 41° to 38°C , and malachite after azurite at 34°C . The final stage of secondary mineralization consists of calcite that formed at 25° to 30°C , followed by goethite. The general trend observed is for early oxidation and supergene enrichment at apparent temperatures less than 93°C and between 66° and 75°C , cooling to ambient surface temperatures late in the period of mineralization. A correlation is observed between decreasing isotope thermometry temperatures and increasing $\delta^{13}\text{C}$ values as oxidation and supergene enrichment progressed. This is interpreted to result from exothermic sulfide oxidation and associated subsurface thermophilic bacterial oxidation within the oxidation front. Over the period of oxidation and supergene enrichment, temperatures decreased and $\delta^{13}\text{C}$ values increased, recording in the secondary minerals the passing of the oxidation front and a diminishing subsurface bacterial carbon source.