Hydrothermal alteration and mineralisation at the Mt Carlton high-sulphidation Au-Ag-Cu epithermal deposit (NE Queensland, Australia)

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The Mt Carlton high-sulphidation Au-Ag-Cu deposit is located in the northern Bowen Basin, NE Queensland (Australia). High-grade mineralisation is confined to NE-trending, steeply dipping (75-90°) structures, and is hosted in a rhyodacitic unit of the Lizzie Creek Volcanic Group (Early Permian). The core of the hydrothermal system shows silicic alteration, with variable amounts of alunite (disseminated- and vein-type), anhydrite and pyrite. Outwards, the silicic zone progressively grades into an envelope of quartz-alunite-barite-pyrite → quartz-dickite-kaolinite-pyrite → illite-montmorillonite-pyrite alteration.

After the alteration, the majority of metals were deposited in an initial stage of high-sulphidation mineralisation, dominated by enargite-luzonite-pyrite. This stage is overprinted by two intermediate-sulphidation stages, one Zn-Pb-Au rich (sphalerite-galena-electrum) and one Cu-(Au) rich (tennantite), respectively. The known mineralisation along ~800 m strike length shows a distinct metal zonation from NE to SW of Cu-Au → Cu+Zn+Pb+Ag → Ag+Pb → Ag. This metal zonation is mainly linked to the mineralogy of the initial high-sulphidation ore stage.

Ar-Ar dating of alunite from the Mt Carlton lithocap gives an age of 284.3 ± 2.0 Ma. It is not distinguishable from U-Pb ages of the Lizzie Creek volcanic rocks (283-287 ± 2-4 Ma), indicating that the mineralisation occurred shortly after the formation of the host rocks.

Stable isotope analyses (S, O, H) of sulfates (alunite, anhydrite and barite) and coeval pyrite suggest that they formed from a SO_4^{2-}-dominated fluid with a mixed magmatic-meteoric signature. Thermometric calculations based on S isotope pairs indicate a temperature range of ~220-130 °C for the hydrothermal alteration stage (alunite-pyrite), and ~130-115 °C for late, intermediate-sulphidation ore (sphalerite-galena, sphalerite-pyrite).

The combined petrographic and isotopic evidence thus suggest that a cooling fluid that evolved from high- to intermediate-sulphidation states was involved in the genesis of the Mt Carlton deposit.