Sulfidation and desulfidation in a polymetallic orebody–Artemis prospect, NW Queensland, Australia

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Epigenetic sulfidation of carbonates is one of the dominant ore-forming processes. However, ore-stage sulfides may be affected by subsequent alteration driven by barren fluids leading to the precipitation of carbonates and silicates. One such example is the Artemis Cu-Au prospect which is located within the Eastern succession of the Mount Isa Inlier. It displays a complex association of sulfides and carbonates hosted in a vertical, 1–25 m wide marble lens adjacent to garnet-biotite schist, staurolite-muscovite schist and quartz-feldspathic psammite. The sulfide assemblage consists of massive pyrrhotite, sphalerite, chalcopyrite, galena, with minor arsenopyrite, cobaltite, costibite, Bi, cubanite ± Ag-sulfides, and Au; in decreasing order of abundance. Calcite is the dominant carbonate along with minor siderite.

Micro-XRF elemental maps of the garnet-bearing rock revealed sulfidation front where garnet and amphibole were replaced by chalcopyrite, pyrrhotite, Au, biotite, and muscovite. Microscopic analyses of the sulfidized marble show: (i) Ore-forming stage—dissolution of calcite-1 and precipitation of sulfides + calcite-2; (ii) Late alteration—replacement of calcite-2 by calcite-3 + siderite; On the other hand, the desulfidation processes affected galena, which shows embayed, lobate grain boundaries with calcite-3. In addition, Fe-Mn-Ca-garnet replaces the massive sulfides.

Pervasive replacement of early Co-rich arsenopyrite (7.4–9.7 wt.% Co) by relatively Co-poor arsenopyrite (3.3–6.9 wt.% Co) + galena constrains the temperature from 650±50 to 450±70 °C based on phase relation in the FeAsS-NiAsS-CoAsS system. Hexagonal pyrrhotite ($Fe_{(1-x)}S$, (x = 0.091–0.119)), sphalerite (7.0–10.3 wt.% Fe), and chalcopyrite are the dominant Fe-bearing sulfides.

The microscale investigations of (de)-sulfidation processes in the Artemis orebody document the impact of replacement reactions on metal sequestration in skarn, manto- and/or Mississippi Valley-type deposits and their subsequent mobilization. Microscale mineral replacement reactions can facilitate large-scale sulfidation. However, replacement processes bear potential to eradicate economic mineralization.