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Economic Geology, v. 101, pp. 1547–1567

A Geochemical Process Model for the Mount Isa Copper Orebodies

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Abstract

In this paper we present new data and review existing data on the distribution, lithochemistry and paragenesis of copper ore at Mount Isa and provide the first description of a body of anhydrite, dolomite, barite, and hematite recently intersected at the northern end of the copper system. It has been previously proposed that the extraordinary spatial coincidence of giant copper and lead-zinc deposits at Mount Isa is due to the emplacement of copper into host rocks made chemically favorable for copper mineralization by enrichment in dolomite and/or pyrite and mechanically favorable by the presence of preexisting layers of ductile lead and zinc sulfide ore. Several recent studies, however, suggest that copper and much if not all of the lead and zinc were deposited contemporaneously.

We provide evidence that high-grade (>2.5%) copper is associated with fractured and silicified rocks. Early breccia-cementing quartz is commonly euhedral and contains numerous growth zones defined by disordered carbon and brine inclusions containing CH_4. This quartz is inferred to have been deposited from a cooling brine ("basement brine") that equilibrated with rocks beneath the level of the deposit. Consistent with earlier studies, we have noted that there is often late dolomite (dolomite II) infilling of vuggy porosity defined by this euhedral quartz. Chalcopyrite, however, postdates both phases and there is textural evidence of both dolomite and quartz dissolution during chalcopyrite formation.

The nature of the copper-bearing fluid ("basinal brine") was deduced from the intimate association of chalcopyrite and anhydrite and from previous fluid inclusion studies. This brine was oxidized and sulfur rich but undersaturated in quartz, consistent with this fluid being introduced from above as proposed in several previous studies. New reaction path modeling suggests that reduction of the oxidized brine by the carbonaceous and Urquhart Shale was the most likely depositional process. Many other rock types in the region also had the capacity to reduce oxidized ore-forming brines, thus ore can be anticipated in these other units, provided that sufficient porosity and permeability existed during ore formation. The modeling further suggests that the presence of dolomite is not a prerequisite to economic copper grades, although carbonate dissolution possibly contributed (with fracturing) to enhanced porosity and permeability. Furthermore, sulfide-rich rocks were no more effective at precipitating copper than sulfide-absent rocks, consistent with several lines of evidence demonstrating that pyrite or other sulfide minerals were not consumed during ore formation. Mixing of the basinal and basement brines could also have caused precipitation of copper, but the predicted gangue assemblages differ from those observed in nature.

Various radiometric ages are consistent with formation of the Mount Isa copper deposits after initiation of the unconformable South Nicholson basin, although we recognize that more precise and accurate dating of the ore and fluid-flow events are required. Basal red-bed sediments of the South Nicholson basin would have provided suitable aquifers for the oxidized, copper-rich basinal brines. We speculate that the driving force for brine flow was the development of topography to the east of Mount Isa.

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