Sedimentary Hosted Statiform Copper Mineralization – Bonavista Peninsula, Newfoundland: Insights on Mineralizing Processes and Controls

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Abstract

The Bonavista Peninsula is located within the Avalon Zone of Eastern Newfoundland and is broadly divided into two Neoproterozoic (Ediacaran) sedimentary domains with differing depositional settings. The eastern domain consists of the Neoproterozoic Conception, St. John's and Signal Hill Groups. These rocks are interpreted to have been deposited in turbiditic, deep marine and fluvial environments, and locally contain spectacular Ediacaran fossils. The second domain is the focus of this investigation and is composed of Neoproterozoic sedimentary rocks of the Musgravetown Group, interpreted to have been deposited in shallow marine and fluvial depositional environments.

The Ediacaran Musgravetown Group on the Bonavista Peninsula contains copper mineralization in both the lower deltaic to shallow marine Rocky Harbour Formation and the overlying terrestrial, redbed dominated sequence of the Crown Hill Formation. The most significant deposits known to date are in the latter. Although dominated by redbed sedimentary rocks deposited in a continental terrestrial-fluvial and/or alluvial fan environment with progressive oxidization fronts, the Crown Hill Formation also contains localized, fine-grained grey reduced sedimentary rocks that are semi-concordant to concordant with bedding. These are interpreted to have formed in a lacustrine-type environment, rather than representing episodic marine transgressions. The Crown Hill Formation records periods of desiccation and also rapid burial and compaction, both of which are relevant to hydrothermal mineralizing processes as they provide increased fluid salinities (increased potential to mobilize metals) and increased cross-stratigraphic permeability, respectively.

Copper mineralization in the Crown Hill Formation is hosted by the grey reduced beds within the redbed-dominated sequence, and is spatially associated with fracture systems that intersect a synsedimentary framboidal pyrite-rich central core of the reduced unit. Textural relationships of mineralized veins suggest that copper sulphides were precipitated after partial cementation and lithification of the host sedimentary rocks. Oxidized, saline hydrothermal fluids are interpreted to have leached metals from a previously reddened and altered underlying sedimentary sequence, with copper sulphide precipitation resulting from redox reactions that occurred as fluids entered this sulphur-rich, reduced environment.

Copper sulphides are dominated by chalcocite with lesser amounts of bornite, chalcopyrite and covellite. Sulphides occur both as veinlets and as replacements of primary framboidal and diagenetic cubic pyrite. Mineralization appears to have been introduced synchronously with silica veining, and is associated with mild propylitic (epidote-chlorite-sericite-albite +/- carbonate) alteration. Metal zonation patterns show systematic stratigraphic trends suggesting early precipitation of V, followed by Cu, Co and Ag, and then Pb and Zn, from upward-percolating fluids. The presence and grade of copper mineralization within the reduced horizon appears to be controlled by a combination of fluid chemistry, availability of a reductant, fracture density, permeability and porosity. Early drilling results were favorable, locally defining a chalcocite bearing reduced unit containing 1.0% Cu and 12.1 g/t Ag over 14.25 meters with a higher grade zone containing up to 2% Cu and 23.1 g/t Ag over 6 meters; however, mineralization has proven difficult to trace laterally. The significant grade variations between adjacent drill holes that have otherwise identical rock types and stratigraphy imply that the interplay between the controlling factors on copper mineralization is complex.