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A semi-permeable interface model for the genesis of subseafloor replacement-type volcanogenic massive sulfide (VMS) deposits

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Manitoba Geological Survey

Winnipeg Geological Society

Winnipeg Section of the Geological Association of Canada

Abstract:

Subseafloor replacement-style volcanogenic massive sulfide (VMS) deposits are a subset of VMS deposits where sulfides have replaced unconsolidated volcanic, volcanosedimentary, and sedimentary material. These deposits are anomalously large and are important global sources of metals. They have distinct textures at the sulfide-ore interface including bed-by-bed replacement of sedimentary layers, and typically fill void space between unconsolidated volcaniclastic detritus or fractures in flows or intrusions. At the microscale, metal-bearing sulfides have partially to fully replaced framboidal (bacteriogenic) sulfides, or the framboidal sulfides have acted as nuclei for additional metalliferous massive sulfide to deposit upon. This presentation will provide geological and mineralogical information from the three, exceptionally well preserved deposits: the Duck Pond and Boundary deposits in the Newfoundland Appalachians, and the Wolverine deposit, Yukon. The geology, geochemistry, and macro- to nanoscale textures preserved in these deposits provide unequivocal evidence for replacement and provide critical insight into the replacement process. The textures are reconciled within a semi-permeable interface model for replacement. In this model unconsolidated sediment, volcaniclastic rocks, or fractured coherent volcanic rocks provide a permeable to semi-permeable interface that allowed ingress of cold seawater into the pore spaces of the stratigraphic sequence prior to and during lulls in hydrothermal activity. Seawater sulfate in the porewater is partially reduced by bacteria to provide reduced sulfur (H2S) as well as framboidal pyrite in the host sequence(s). The reduced sulfur and framboidal pyrite, as well as the cool porewater, provided a thermal, redox, and chemical gradient for upwelling hydrothermal fluids to interact with. In such an environment rising hydrothermal fluids mix with cold water not only at the seawater interface leading to exhalative sulfide deposition, but also in the subseafloor leading to sulfide precipitation via replacement. The upwelling hydrothermal fluids can also interact with bacterial H2S in the pore spaces of the unconsolidated material resulting in additional subseafloor precipitation of metal sulfides. The fluids also result in replacement of framboidal pyrite nuclei via pseudomorphing and replacement of the original framboidal masses. This semi-permeable interface also favors enhanced zone refining, assuming the hydrothermal system is sufficiently long lived, leading to upgrading of the tenor of the sulfides with well developed metal zoning, as observed in many ancient replacement-type deposits. Furthermore, the precipitation of a significant subseafloor sulfide mineralization results in greater trapping of metals from upwelling fluids and larger tonnage deposits with greater contained metal. This model may also be applicable to other replacement-type deposits in broadly similar geological and hydrothermal environments (e.g., sediment-hosted and Irish-type Zn-Pb deposits). Further, critical tests are required to validate and refute the model and potential tests will be presented.