Sulfur isotopic studies of polymetallic sulfides hosted within hydrothermal mudstones associated with the Cambrian Lemarchant volcanogenic massive sulfide deposit, Newfoundland, Canada*

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Hydrothermal mudstones associated with the Cambrian precious metal-bearing Lemarchant Pb-Zn-Cu VMS deposit precipitated prior to, during, and after massive sulfide formation and therefore allow for monitoring the sulfur isotope evolution of the fringes of the deposit throughout its entire history. The metalliferous sediments cap massive sulfide mineralization, but also occur laterally along strike, or as interflow mudstones within the hanging wall basaltic rocks. These mudstones formed from black smoker plume fallout particles after mixing of hot, reduced, metal-rich vent fluids with cold, oxidized, sulfate-rich ambient seawater. In-situ sulfur isotope analyses of various sulfides within the Lemarchant mudstones (euhedral and framboidal pyrite, anhedral chalcopyrite, pyrrhotite, galena and euhedral arsenopyrite) by secondary ion mass spectroscopy had δ$^{34}$S values ranging from -38‰ to +12‰. The majority of samples have δ$^{34}$S values ranging from -38 to -8‰, indicating that the sulfur is predominantly biogenic-diagenetic in origin; hence, derived from bacterial sulfate reduction of seawater sulfate under open system conditions (i.e., oxygenated bottom waters). A smaller group of analyses displays heavier δ$^{34}$S values - ranging from -2‰ to +12‰ - that suggest possible inputs from mixed sulfur sources. These can be derived from either reduced sulfur thermochemical sulfate reduction of seawater sulfate represented by values from +5‰ to +12‰, and/or sulfur from magmatic fluids (and possibly by leaching of igneous wall rock) characterized by values from -2‰ to +5‰. The coincidence of lighter δ$^{34}$S values (-2‰ to +5‰) in the mudstones with minerals and textures indicative of epithermal deposition (e.g., electrum ± Hg ± Sb, bornite, sulfosalts, and bladed barite and calcite) further supports a process whereby the lighter δ$^{34}$S may be due to sulfur disproportionation during magmatic fluid boiling. The heavier δ$^{34}$S values (+5‰ to +12‰) are more indicative of conventional VMS fluids. The potential for epithermal inputs (and fluid boiling) in the Lemarchant mudstones suggests that the Lemarchant hydrothermal system likely have formed in intermediate water depths, likely between 1,000 and 1,500 meters, and therefore was situated in shallower water than most ancient VMS deposits.