Widespread euxinic conditions are not a prerequisite for sedimentary exhalative mineralization in the Selwyn Basin, Canada*

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Euxinic conditions have previously been considered a fundamental component of the genetic model for sedimentary-exhalative (SEDEX) mineralization in the Selwyn Basin, Yukon, Canada. Previous work has proposed that co-precipitation of base metal sulfides and barite in a stratified water column produced Pb-Zn-Ba enrichment during episodes of mudstone deposition in the Cambrian, Silurian, and Late Devonian. This means the main control on metal precipitation is the availability of reduced sulfur, produced during near-quantitative bacterial reduction of seawater sulfate in the water column.

At Macmillan Pass, relatively un-deformed and un-metamorphosed Late Devonian mudstones host the Tom and Jason SEDEX deposits. To fully assess the ambient conditions in the basin, we have sampled two drill-holes from Tom, which intersect the mineralized horizon proximal and distal to the hydrothermal vent. Also, at both deposits, drill-core intersecting the hydrothermal vents and overlying stratabound mineralization has been extensively sampled. In the un-mineralized mudstone samples, we report Fe speciation data (n = 38) that enable interpretation of water column redox conditions leading up to, and following, hydrothermal activity. The paragenetic relationship between barite and base metal sulfides in the stratabound mineralization has been determined using transmitted and reflected light, and back-scatter electron imaging. Conventional sulfur isotope analysis of mineral separates from the vent, and in-situ isotopic microanalysis (secondary ion mass spectrometry; SIMS) of sulfur isotopes in barite, pyrite and galena in the stratabound mineralization has been carried out.

Iron speciation results from the distal hole indicate ambient conditions in the basin were dominantly anoxic and ferruginous (Fe$_{py}$/Fe$_{HR}$ = <0.8), and by corollary that the water column contained low concentrations of sulfate. A number of samples from the proximal drill-hole record euxinic conditions (Fe$_{py}$/Fe$_{HR}$ = >0.8), which may reflect a hydrothermal input of sulfur, either as H$_2$S or SO$_4^{2-}$, into the basin. In the absence of regional euxinia, an alternative source of reduced sulfur is, therefore, required to form the mineralization. The $\delta^{34}$S values of sulfides in the hydrothermal vent range from 4‰ to 24‰; this suggests that sulfur may have been leached from underlying strata and transported in the hydrothermal fluid. In the stratabound mineralization, barite is commonly replaced by sphalerite and galena, and it is possible that some sulfur is recycled in this process; we explore evidence for this using in-situ sulfur isotope analysis (SIMS) of these phases.
In summary, water column euxinia does not exert a fundamental control on the formation of the deposits at Tom and Jason. Instead, redox conditions in the basin were more likely governed by the interplay of fluxes of organic carbon (productivity), reactive iron (hydrothermal, detrital) and sulfur (riverine, hydrothermal). We suggest that euxinic conditions do not form a prerequisite for shale-hosted Pb-Zn deposits, and any syn-sedimentary mineralization represents a minor contribution to these hydrothermal systems.