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Investigating Shale-Hosted Vanadium Enrichment in the Selwyn Basin, NWT/YT

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Sedimentary basins commonly host critical mineral-rich black shales, including Zn-bearing sediment-hosted massive sulfide (SHMS) deposits. These deposits are characterized by laminated stratiform sulfides and were traditionally interpreted to form via precipitation from hydrothermal brines venting into a euxinic water column. Many deposits are now recognized as diagenetic precipitates or replacements from hydrothermal fluids circulating through permeable, sulfidic, and organic-rich strata. The genetic links of stratabound critical mineral deposits and their potential relationship to Zn-SHMS deposits remain poorly constrained.

Along the NWT-YT border within the Selwyn Basin, the Howard's Pass District (HPD) hosts 15 SHMS Zn-Pb deposits, stratabound within the Active Member of the Ordovician-Silurian Duo Lake Formation (DLF), with vanadium enrichment reaching up to 2890 ppm occurring in intervals. ~80km southeast of HPD, the Van Property hosts vanadium up to 6000 ppm occurring at a similar stratigraphic position in the DLF. The primary distinction between the two localities is that vanadium at HPD is not hosted in rutile, suggesting the enrichment may represent either a less evolved form of mineralization or a distal extension of the Van Property system. Although multiple genetic models have been proposed to explain the metal accumulation in SHMS deposits, the sources of metals (especially V) and their transport pathways remain underexplored in the HPD.

This research focuses on the Zn- and V- rich mineralization within the DLF at HPD and applies a suite of geochemical proxies to infer the paleo-depositional conditions during metal enrichment. Iron speciation indicates deposition under euxinic to ferruginous bottom water conditions, while 34/32S shows increasingly isotopically light sulfur with increasing stratigraphic depth, consistent with microbial sulfate reduction in an increasingly open system. 98/95Mo isotope data indicate partial euxinia, whereas lower concentrations of redox-sensitive elements reflect weakly sulfidic conditions. Elemental covariations suggest anoxic bottom waters with episodic sulfide availability in a sediment-starved restricted basin. Collectively, these geochemical signatures indicate metal enrichment occurring in a dynamically fluctuating redox setting. The results highlight the role of redox fluctuations in controlling metal concentration and preservation in sediments, potentially having broader implications for the understanding of sediment-hosted ore deposits.