Mineralogy and Composition of Vanadium-Bearing Shales at the Van Property, Mackenzie Mountains, Northwest Territories

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Vanadium is a vital component in new battery technologies related to energy storage and is hence listed as a critical metal by several countries. Shale-hosted V deposits are a type of V resource that is underexplored. To account for an increasing V demand, the mineralogy of V-bearing phases in and chemistry of V-hosted shales need to be better understood.

The Van property, in the Mackenzie Mountains, Northwest Territories, is a shale-hosted V prospect. Samples from the V-enriched Duo Lake Formation (OSD) and the younger Prevost Formation were collected for mineralogical and compositional analyses including lithogeochemistry, X-ray diffraction, and scanned electron microscopy.

The OSD has average $C_{graphite}$, C_{org}, and S concentrations of 4.0±2.1, 7.8±3.2, and 0.8±0.2 wt %, respectively. Vanadium, Zn, and Cu are enriched especially within the Lower Cherty Mudstone Member of the OSD, with maximum concentrations of several thousands of ppm. In contrast, samples from the Prevost Formation have lower $C_{graphite}$, C_{org}, and S concentrations, are depleted in V, Zn, and Cu, and can have elevated BaO concentration (1.2 wt %).

Vanadium-rich samples of the OSD are dominated by quartz with minor graphite-muscovite and trace sulfides, illite, and oxides. Vanadium does not form own its mineral phases but is hosted in Ti-bearing oxides that are spatially associated with clays but not with graphite.

The relatively flat REE pattern with a negative Ce anomaly and low Th/Sc ratio (<0.6) indicates a mafic sedimentary source and deposition along a passive margin, similar to other critical metal-enriched shales in the Selwyn Basin. The association of V with Ti-oxides indicates a moderately oxidized state (e.g., V^{4+}). However, it is unknown if the enrichment of V in the shales was a product of direct V scavenging from seawater, syngenetic or epigenetic hydrothermal activity, and if organic matter played a role.