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Critical Minerals in the Metamorphosed Roots of Devonian Source Rocks, Keno Hill Ag-Pb-Zn District, Selwyn Basin, Yukon

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Summary

Upper Devonian organic-rich shales of the Western Canada Sedimentary Basin are characterized by widespread, active hard fluid overpressures in the subsurface, fueled by the regional-scale generation and mobilization of secondary methane, carbon dioxide and water at peak burial. These contribute to delamination of strata, as well as fracturing and pressure leak-off during uplift and denudation. The Western Canada Sedimentary Basin provides a well-documented analogue of active gaseous hydrothermal systems, giving insight into the possible history of exposed mineralized rocks in the Cordillera and Omineca Belt to the west, which have passed through the oil and gas windows prior to peak burial in the Cretaceous under metamorphic conditions.

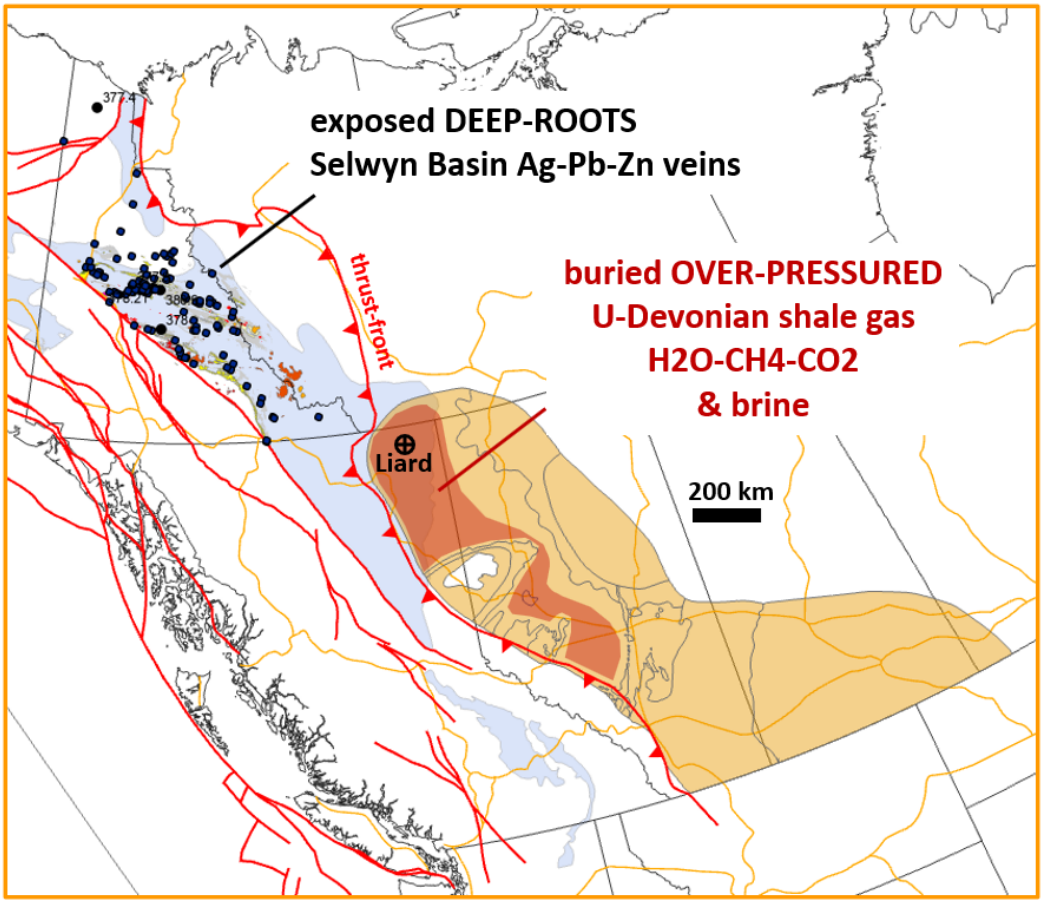


Figure 1. Exposed Ag-Pb-Zn veins of the Selwyn Basin, Yukon, hosted largely in Late Devonian to Mississippian strata, reflecting the deep roots of active shale-gas systems in the WCSB.

In the northern Selwyn Basin (Figure 1), along the 200 km length of the Keno Hill Quartzite and underlying organic-rich shales of the upper Devonian Earn Group (Frasnian, Figure 2), evidence of widespread overpressure-driven delamination is provided by the regionally persistent sill morphology of both Triassic (mafic Galena Suite) and Cretaceous (granitic Tombstone Suite) intrusive assemblages. Both magmatic systems are constrained to these units, and were drawn-into the stratigraphy during separate Triassic and Cretaceous uplift episodes, abetted by over-pressures in the sediments. Furthermore, circulating hydrothermal systems with open space Ag-Pb-Zn-Cu mineralization and veining also follow schistosity and bedding (Figure 3 and 4), as well as along steeper faults, with mineral zoning developing at a regional scale (Lynch, 1989).

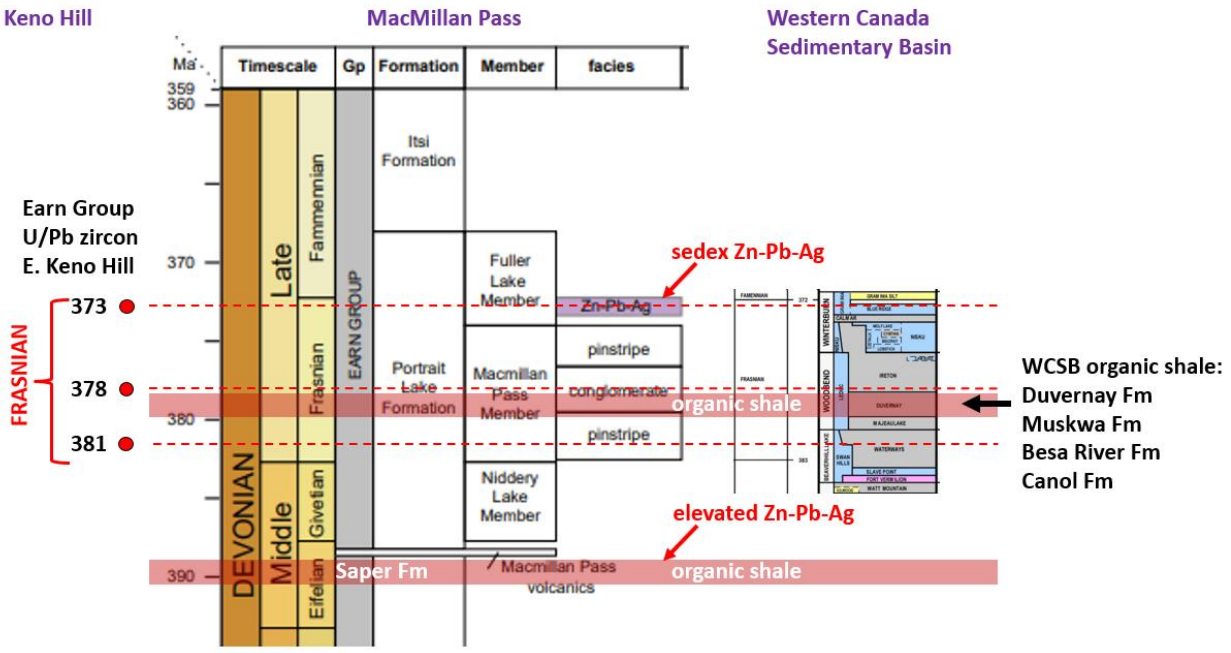


Figure 2. Tying Late Devonian (Frasnian) shales across the Selwyn Basin and into the WCSB.

Beyond the gas window, under Cordilleran metamorphic conditions, organic residue in the shales is comprised largely of graphite. However, graphite is a key ingredient to the mineralizing systems as it reacts readily with shale water producing carbon dioxide and methane, buffering the hydrothermal waters to reducing, acid, and pressurized conditions, prone to dynamic boiling during leak-off:

$$2C\ (\text{graphite}) + 2H_2O = CO_2 + CH_4\ (\text{Ohmoto and Kerrick, 1977})$$

In basin analysis terms, the nature of the “kitchen” is a key consideration in identifying appropriate material ingredients and pressure-temperature conditions for mineralization. The Keno Hill District is distinguished by (1) the presence of a fully mature kitchen on its eastern flank at peak Cretaceous burial, as defined by the presence of staurolite in the metamorphic halo of the large Roop Lakes Pluton; and (2) the organic-rich Devonian shales of the Earn Group, buffering the

system to hard overpressures, reducing conditions, and acidic low-pH waters. Peak kitchen conditions ensured the voluminous flux necessary for a world class high-grade Ag-Pb-Zn district. In East Keno, new discoveries feature conspicuous stacks of mineralized veins running parallel to the delaminated schistosity, according to the effects of the over-pressured fluid regime; these contrast structurally with the more typical steeper mineralized structures in the overlying quartzites. Drilling and mapping indicate that the deeper-seated delaminated pathways in the shales of the Earn Group comprise the feeder zone, and material source to the Ag-Pb-Zn veins in the overlying Keno Hill Quartzite.



Figure 3. Delamination bedding-parallel open-space vuggy Ag-Pb-Zn sulfide veins and breccia, hosted in black shales and pin-striped shales of the of the Late Devonian Earn Group, central Selwyn Basin, Yukon.

In the Keno Hill District late epithermal mineralization overprinting the Ag-Pb-Zn veins is now recognized as a widespread phenomenon, characterized by sulfosalts, native silver, and fine quartz veinlet stockworks. For the epithermal stage (<2-3 km), overpressures in the system were no longer maintained, allowing for the backwash of meteoric waters; it is estimated that the age of this late stage is on the order of tens of millions of years younger the initial Ag-Pb-Zn veins.

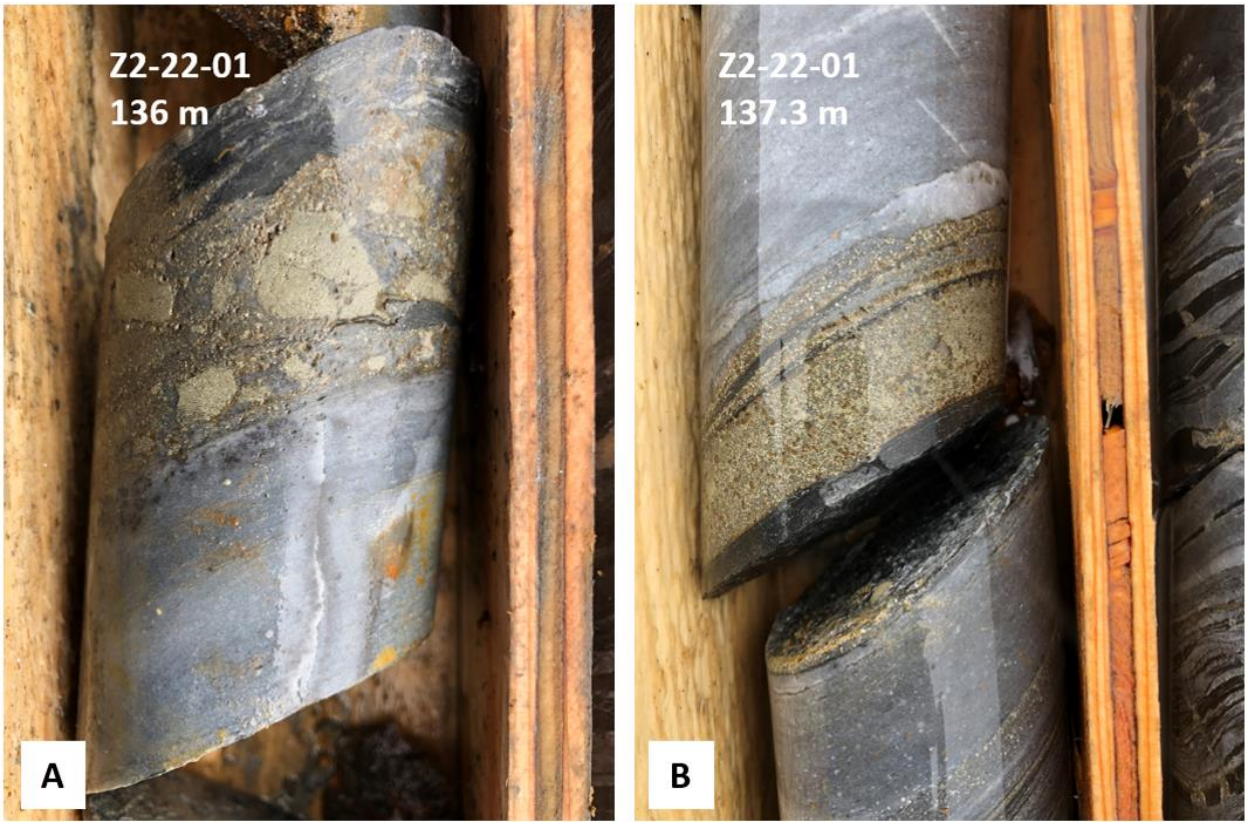


Figure 4. Delamination bedding-parallel Ag-Pb-Zn sulfide veins and breccia, hosted in Mississippian Keno Hill Quartzite above Devonian Earn Group, central Selwyn Basin, Yukon

Acknowledgements

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References

Lynch, J.V.G., 1989. Large-scale hydrothermal zoning reflected in the tetrahedrite-freibergite solid solution, Keno Hill Ag-Pb-Zn district, Yukon. The Canadian Mineralogist, v. 27, p. 383-400.

Ohmoto, H., and Kerrick, D., 1977. Devolatilization equilibria in graphitic systems. American Journal of Science, v. 277, 1013–1044.