

## Geochemistry and Paleotectonic Setting of Felsic Volcanic Rocks in the Finlayson Lake Volcanic-Hosted Massive Sulfide District, Yukon, Canada

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### Abstract

The Finlayson Lake volcanic-hosted massive sulfide (VHMS) district represents one of Canada's most recent VHMS discovery regions with ~34 million metric tons (Mt) of massive sulfide mineralization found since the mid 1990s. Felsic volcanic rocks are associated with three units: the Fire Lake unit, the Kudz Ze Kayah unit, and the Wolverine succession. Significant accumulations of polymetallic felsic VHMS deposits (Kudz Ze Kayah, GP4F, and Wolverine) have only been discovered in the Kudz Ze Kayah unit and Wolverine succession to date. In the hanging wall of the Money Creek thrust, felsic volcanic and high-level intrusive rocks in the Fire Lake unit have calc-alkalic and tholeiitic affinities with low high field strength element (HFSE) contents and intermediate Zr/Sc (9.4–43.4) and Zr/TiO<sub>2</sub> (254–864) ratios. These rocks are interlayered with mafic rocks with arc geochemical signatures, to date devoid of significant VHMS mineralization, and represent bimodal magmatism within an evolving Devonian-Mississippian continental-arc system. The Kudz Ze Kayah unit in the footwall of the Money Creek thrust stratigraphically overlies the Fire Lake unit and consists of felsic volcanic rocks with high HFSE contents, within-plate (A-type) signatures, and high Zr/Sc (15.3–190.3) and Zr/TiO<sub>2</sub> (630–2,185) ratios. The Kudz Ze Kayah unit felsic rocks are crosscut and overlain by alkalic mafic rocks, are associated with abundant carbonaceous sedimentary rocks, and represent magmatism within a Devonian-Mississippian ensialic back-arc rift-basin environment. The Wolverine succession unconformably overlies the Kudz Ze Kayah unit. Felsic rocks below the Wolverine deposit have geochemical attributes similar to the Kudz Ze Kayah unit with high HFSE contents, within-plate (A-type) signatures, and high Zr/Sc (29.9–84.2) and Zr/TiO<sub>2</sub> (391–1,220) ratios. In contrast, aphyric rhyolite flows in the hanging wall of the deposit have much lower HFSE contents and the lowest Zr/Sc (3.5–27.7) and Zr/TiO<sub>2</sub> (181–591) ratios in the district. All the felsic rocks of the Wolverine succession are interlayered with abundant carbonaceous sedimentary rocks and are overlain by midocean ridge basalt (MORB)-like basaltic rocks. The Wolverine succession is interpreted to have formed within an Early Mississippian ensialic back-arc basin environment that eventually evolved to sea-floor spreading.

The variation in the HFSE budgets of the felsic rocks of the Finlayson Lake district likely reflects variations in the source and/or temperature of crustal melting. In particular, felsic rocks of the Fire Lake unit have higher Nb/Ta and lower Ti/Sc ratios than other volcanic rocks in the district, suggesting possible derivation from mafic crustal sources and/or lower crustal fusion temperatures. The Kudz Ze Kayah unit and footwall rocks to the Wolverine deposit are inferred to have formed from high-temperature partial melting of continental crust. The hanging-wall aphyric rhyolites from the Wolverine deposit may have formed from either lower temperature continental crustal melting or may have been derived from the mixing of HFSE-depleted N-MORB mafic magmas and evolved continental crust.

Polymetallic felsic volcanic-associated, VHMS deposits within the Finlayson Lake district are preferentially associated with HFSE-enriched felsic rocks with high Zr/Sc (15.3–190.3) and Zr/TiO<sub>2</sub> (391–2,105) ratios. The HFSE and rare earth element (REE) systematics of VHMS-associated felsic rocks of the Finlayson Lake district are different from prospective felsic rocks from Archean VHMS environments in

the Superior province and are displaced toward higher Zr/Y and La/Yb<sub>n</sub> ratios. Their HFSE and REE systematics are similar to many Phanerozoic VHMS environments, in particular those at least partially to fully underlain by evolved continental crust. The geochemical differences between the felsic rocks of the Finlayson Lake district and those from Archean VHMS environments most likely reflect differences in the substrates from which the felsic rocks were derived (e.g., evolved versus juvenile).