The importance of magmatism in the genesis of the Wolverine volcanogenic massive sulphide (VMS) deposit, Yukon, Canada: constraints from lithogeochemical, Nd-Hf isotope, and in situ U-Pb-Hf isotope data

Stephen J. Piercey

Department of Earth Sciences, Memorial University, 9 Artic Ave, St. John's, Newfoundland and Labrador A1B 3X5, Canada

<spiercey@mun.ca>

The Wolverine volcanogenic massive sulphide (VMS) deposit, Yukon, is a unique natural laboratory to study the interrelationships of magma evolution and tectonics in the genesis of VMS deposits in volcanic- and sedimentrich extensional basins. The deposit is spatially and stratigraphically associated with high-level rhyolite porphyritic intrusions. Pre-VMS (~352 Ma) quartz-feldspar porphyries (QFP) have continental crust-like Nb/Ta ~12, εNd_t = -7.1 to -11.5 (average = -10.6), and εHf_t = -12.2 to -20.8 (average = -16.5). The syn-VMS (~347 Ma) feldspar porphyries have higher high field strength element (HFSE) and rare earth element (REE) concentration, and higher Nb/Ta (~17), εNd_t = -7.8 to -8.1 (average = -8.0), and εHf_t = -13.6 to -18.0 (average = -14.8). Both suites have Proterozoic (to Archean) depleted mantle model ages (1.59–2.58 Ga). In situ U-Pb on zircons illustrate that while some ages are close to previously reported concordant TIMS ages, most samples have evidence of inheritance with ages ranging from 348–381.7 Ma for the QFP suite and 368.9–370.5 Ma for the FP suite. In situ εHf_t values for the zircons range from -11.5 to -21.0 (average -15.3) and -11.6 to -26.0 (average = -18.7) for the QFP and FP, respectively. The chemical and isotopic shifts from the QFP to younger FP suite reflects the varying contributions from evolved continental crust versus juvenile basaltic melts, and can be accommodated within an evolving continental back-arc basin in which there was a progressive increase in mantle input as a result of upwelling of juvenile basaltic material beneath the back-arc basin as it opened. Notably, the upwelling of mafic magmatism and greater mantle components in the syn-VMS FP suite also coincided with higher temperature felsic magmatism and VMS deposit genesis.

The presence of high temperature magmatism and extensional geodynamics, coupled with a H_2S-rich shaledominated near-vent environment were critical for generating the Wolverine hydrothermal system and the resultant deposition of mineralization. Identification of similar tectonic environments with similar geological and geochemical features is critical for finding new resources along evolving continental margins.

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