Geology and fluid genesis of the Neoproterozoic Niblack Cu-Au-Zn-Ag volcanic-hosted massive sulfide camp, southeast Alaska, USA*

Corresponding author: Brian McNulty, University of British Columbia - Mineral Deposit Research Unit, bmcnulty@eos.ubc.ca

Co-authors:
Melissa J. Gregory, University of British Columbia - Mineral Deposit Research Unit, mgregory@eos.ubc.ca
Jim Oliver, Oliver Geoscience, olivergeoscience@gmail.com
Keith Roberts, Hunter Dickinson Inc., KeithRoberts@hdimining.com

The Niblack polymetallic volcanic-hosted massive sulfide (VHMS) camp is located on Prince of Wales Island, southeast Alaska, ~50 km southwest of Ketchikan. Multiple sulfide deposits occur at different stratigraphic levels in 565±0.4 Ma Alexander Terrane, Wales Group felsic volcanic strata that is preserved and exposed at surface by two property-scale thrust faults. This structural corridor is a geologic window to Late Neoproterozoic VHMS ore forming processes in a region of southeast Alaska dominated by Ordovician through Early Silurian Moira Sound unit stratigraphy. New lithogeochemical data combined with detailed volcanic lithofacies suggest the host stratigraphy was deposited in a juvenile oceanic back-arc basin tectonic setting.

The camp is host to at least six separate VHMS deposits, notably the Lookout deposit, Trio zone, and the historic Niblack Mine. The estimated resource of Lookout is 5,638,000 tonnes of indicated resource at 0.95% Cu, 1.75 g/t Au, 1.73% Zn, and 29.52 g/t Ag; and 1,023,000 tonnes of inferred resource at 0.73% Cu, 1.42 g/t Au, 1.17% Zn and 21.63 g/t Ag. Trio has an inferred resource of 2,370,000 tonnes at 1.00% Cu, 1.11 g/t Au, 1.56% Zn, and 16.56 g/t Ag. The historic Niblack Mine operated from 1902 to 1909 and produced ~205,000 tons of ore grading 3.2% Cu, 0.4 oz/ton Au, and 0.7 oz/ton Ag; zinc was not reported.

New geologic observations from detailed geologic logs indicate two styles of base and precious metal sulfide mineralization: (1) sub-seafloor sulfide and (2) seafloor exhalative sulfide. Sub-seafloor mineralization (Lookout, Trio) consists of 15-75% sulfide with disseminated to net-textured to semi-massive sulfide textures. These ores precipitated in unconsolidated, water-laden, vent-proximal felsic volcanic stratigraphy. Seafloor exhalative mineralization (Niblack Mine) is comprised of massive (>90%), poorly-banded sulfide. This style of sulfide mineralization precipitated on the paleo-seafloor in, or above, less-permeable vent-distal felsic ash tuff stratigraphy.

Sulfide mineralization styles, hydrothermal alteration assemblages, and variations in metal ratios represent hydrothermal fluid flow and cooling through the host stratigraphy. Temperature estimates from chlorite microprobe data indicate sub-seafloor (1:1 Cu:Zn and 1:10 Au:Ag), chlorite-rich alteration (Lookout) formed at 321±19°C and seafloor exhalative (3:1 Cu:Zn and 1:10 Au:Ag), magnesium-rich chlorite alteration (Niblack Mine) formed at 307±16°C.

Sulfur, oxygen, deuterium, and carbon stable isotope results are used to identify the origin of hydrothermal fluids. Sulfide mineral separates from the Niblack Camp have δ34S values of +6.6 to +10.5%, indicating sulfur was likely derived from leached igneous sulfide and minor seawater
sulfate reduction. Calculated fluid compositions of chlorite and sericite samples have values of +2.3 to +5.9‰ $\delta^{18}O_{\text{water}}$ and -24.9 to -77.1‰ $\delta D_{\text{water}}$ suggesting evolved Neoproterozoic seawater and magmatic hydrothermal fluid sources. The Lookout deposit is the largest in the camp and has a significant magmatic hydrothermal fluid component. Seafloor exhalative sulfide mineralization (Niblack Mine) formed from an evolved Neoproterozoic seawater-dominant hydrothermal fluid. This suggests magmatic fluids contributed additional metals and sulfur to the hydrothermal system, which enhanced the size and grade of the Lookout deposit.