The Voisey's Bay footprint – tracking the geochemical signal of magmatic Ni-Cu-Co sulphide mineralization in northern Labrador

Derek H.C. Wilton[1], Gary Thompson[2], James Conliffe[3], Praise Nyade[4], and Paul J. Sylvester[4]

1. Department of Earth Sciences, Memorial University, St. John's, Newfoundland A1B 3X5, Canada ¶ 2. Brownfield Exploration, Vale Newfoundland and Labrador Limited, Suite W200, Bally Rou Place, 280 Torbay Rd., St. John's, Newfoundland A1A 3W8, Canada ¶ 3. Mineral Deposits Section, Geological Survey of Newfoundland and Labrador, PO Box 8700, St. John's, Newfoundland A1B 4J6, Canada ¶ 4. Department of Earth Sciences, Memorial University, St. John's, Newfoundland A1B 3X5, Canada

The Voisey's Bay (VB) deposits constitute a significant new (discovered 1993) style of orthomagmatic Ni-Cu-Co sulphide mineralization. The sulphides are hosted by the Voisey's Bay Troctolites (VBT) in a feeder and magma chamber system which constitutes only a minute component of the aerially extensive (19,000 km^2) Nain Plutonic Suite (NPS); the VBT is one of the oldest assemblages (ca. 1330 Ma) in the NPS and is essentially swamped by younger anorthosite and granite suites. The VBT is intrusive into Archean Nain Province orthogneiss and Paleoproterozoic Churchill Province enderbite and paragneiss. Notwithstanding intensive exploration of the NPS and host gneisses, no other examples of this type of mineralization have been found.

We report the preliminary results of three research projects funded by the Research and Development Corporation (RDC), Government of Newfoundland and Labrador, through the GeoExplore program to detect and track geochemical footprints of the VB mineralization. Project 1 is examining the massive-sulphide mineralization from two perspectives, viz.; (1) mechanisms of sulphide-mineral breakdown due to oxidation by the atmosphere and ground waters, and the nature of mineral residues in till cover, and (2) conversely, explaining why upper surfaces of the Ovoid deposit were not oxidized. Variably oxidized sulphide minerals (pyrrhotite, chalcopyrite, and pentlandite) have been identified in till surrounding the Ovoid deposit. In pyrrhotite, oxidation appears to develop first along troilite-exsolution lamellae. The surface of the Ovoid massive-sulphide mineralization exhibits glacial straie and thus was essentially sealed from oxidation; the "seal" was determined to be a calcite-cemented clay layer. Project 2 is investigating three temporally distinct geochemical haloes that might be associated with the VB mineralization, viz.; (1) an Emplacement Halo in the contact aureole of the gneissic country rock associated with the VBT intrusion, (2) a Late Aqueous-Emplacement Halo formed as the VB sulphides were cooling, and (3) a Post-Emplacement Halo in younger NPS granitoids. Early analyses of primary fluid inclusions in quartz veins, seemingly derived during the late cooling of sulphides, suggest the presence of two-phase (liquid + vapour), low salinity (< 7 eq. wt% NaCl) H_2O + NaCl inclusions with a wide range of homogenization temperatures and phase ratios that precipitated from a boiling fluid at relatively low temperatures (<250 °C) and depths (< 300 m). Project 3 is evaluating whether a biogeochemical halo is present in black spruce trees and Labrador Tea shrubs surrounding the VB deposits. Preliminary results indicate Ni concentrations of up to ca. 40 ppm Ni in spruce bark from south of the Ovoid deposit compared with levels below detection limits in tree bark from control areas near Voisey's Bay and Anaktalak Bay. Factor analyses of the data indicate a sulphide loaded with Ni, Cu, Co, and Ag.

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