The Willett Cu-rich massive-sulphide deposit, Bathurst Mining Camp, New Brunswick: general geology, deposit characteristics, and felsic volcanic chemostratigraphy

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The Willett property is located in the Bathurst Mining Camp in northern New Brunswick. It is underlain by the volcano-sedimentary rocks of the Middle Ordovician California Lake Group, which hosts several other significant massive-sulphide deposits, in particular the Caribou, Orvan Brook, Wedge, and Nepisiguit deposits. Similar to the Tetagouche Group, this newly defined group has experienced variable degrees of hydrothermal alteration related to the genesis of massive-sulphide deposits, regional greenschist-grade metamorphism, and metasomatism-related polyphase deformation. This area, like many other massive-sulphide deposits in the Camp, is intimately related to felsic volcanism and coeval sedimentation.

The Willett massive-sulphide showing (< 50 000t grading up to 6.35% Cu, 8.50% Zn, 3.24% Pb, 246 g/t Ag, and 1.00 g/t Au) is hosted in intensely deformed argillaceous sedimentary rocks of the Boucher Brook Formation. Based on field observations and diamond drill core logging, the sulphides are interpreted to be boudinaged rafts in a tectonic melange that has been transported some unknown distance from its original stratigraphic location. Like the Wedge deposit, the Willett deposit is very Cu-rich indicative of an original proximal association to its stockwork system and host volcanic package. The occurrence of numerous, variably sized aphyric to feldspar-phyric rhyolitic blocks in the melange proximal to the massive sulphides suggests an intimate association with the

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Spruce Lake Formation felsic volcanic rocks that occur to the north and south of the showing and (possibly) the quartz-feldspar-phyric and quartz-phyric felsic pyroclastic rocks of the Shellalagh Hill Brook Member of the Spruce Lake Formation located to the south, preceding deformation. Therefore, it was important to ascertain which autochthonous Spruce Lake felsic package these volcanic rocks were most closely associated.

A lithogeochemical study of selected Spruce Lake felsic volcanic rock samples representing roughly a cross section through the northern unit in the Willett area suggests that there may be two distinct rhyodacitic volcanic packages in this unit. This interpretation is based on two separate Zr/TiO_2 populations; the lower ratios (Zr/TiO_2= 0.060-0.068) occur near the outer margins (to the north and the south) of the Spruce Lake felsic volcanic unit and higher ratios (Zr/TiO_2 = 0.086-0.089) occur predominantly in the inner portions or core of the unit; this is consistent with increasing fractionation of the package. Other chemical differences between the core (c) and margins (m) of the unit (based on 10 averaged sample analysis) include: K_2O (wt.%), 7.91(c) to 4.17(m); Ba (ppm), 805(c) to 418(m); Zr (ppm), 234(c) to 167(m); Y (ppm), 54(c) to 34(m) and Nb (ppm) 16(c) to 12(m). Zr/Y values of 3.5 to 4.7 (avg. 4.3) for both core and margin indicate that the Spruce Lake felsic volcanic rocks are transitional with tholeiitic affinities. A plot of Nb versus Y reveals that the samples straddle the volcanic-arc and within-plate fields with respect to tectonic setting. Considering the local synclinal fold geometry, the two separate Zr/TiO_2 populations may be indicative of vertical chemostratigraphic differences within the Spruce Lake felsic volcanic sequence. These geochemical attributes may be significant for both local chemostratigraphic correlation, as well as empirically identifying similar felsic volcanic packages hosting deposits elsewhere in the Spruce Lake Formation.