Formation scale variations in felsic volcanic host rock lithogeochemistry of VMS deposits: A case study of the Spruce Lake Formation in the Bathurst Mining Camp

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The Bathurst Mining Camp in northern New Brunswick is a world class Zn-Pb-Cu mining district, containing 46 known Volcanogenic Massive Sulfide (VMS) deposits. The camp is comprised of a Cambro-Ordovician poly-deformed sequence of bimodal volcanic and intercalated sedimentary rocks that were deposited in the Tetagouche-Exploits back arc basin. This study focuses on the northernmost California Lake Group, specifically the Spruce Lake Formation. This formation consists of a thick sequence of porphyritic dacitic to rhyodacitic volcanosedimentary rocks interpreted to have formed in a deep marine environment as stacked cryptodomes. Traditionally, formation scale exploration in felsic volcanosedimentary sequences is focused on textural interpretation to locate the proximal volcanic facies that tend to be most prospective for VMS deposits. Due to the pervasive alteration and polyphase deformation in the region, primary volcanic textures can be destroyed or highly cryptic. Felsic volcanic host rocks of the hanging- and foot-walls of seven VMS deposits in the Spruce Lake Formation were sampled from drill core and analysed using a lithium meta/tetraborate fusion followed by inductively coupled plasma mass-spectroscopy and optical emission-spectroscopy. The concentrations of Zr, Nb, Y, La, Eu, Yb, and Ti were used as immobile elements and normalized to Al to correct for mass balance effects associated with alteration. Compared to the average composition of felsic volcanic rocks in the Spruce Lake Formation, the VMS host rocks have significantly increased Zr, Ti, La, and Eu, and decreased Nb, Y, and Yb, with the footwalls having larger degrees of enrichment and depletion. By applying multivariate statistical analysis to the immobile elements and the individual deposit characteristics, it was found that the overall concentration of immobile elements tends to increase from west to east. Tonnage and grades of the deposits are positively correlated with Zr, Nb, and La, while being negatively correlated with Yb and Y. Copper grades, associated with higher temperatures, are positively correlated with Zr, Nb, Ti, and La; while Zn and Pb grades are positively correlated with Y and Yb. The enrichment of Zr, Ti, La and depletion of Nb, Y, and Yb is indicative of high temperature and shallow magmatism and is caused by primary magmatic fractionation processes; which is well documented in VMS mining districts around the world. Being able to apply these regional lithogeochemical systematics to a single volcanic sequence could be used as an exploration tool, in the future, for locating the most prospective areas.