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Constraints on the Pre-Eruptive Metal and Volatile Content of Magmas Associated with Archean Volcanogenic Massive Sulfide Deposits from Zircon-Hosted Melt Inclusions

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Archean VMS systems in the Abitibi Subprovince of Canada differ greatly in metal tenor, particularly in Au endowment. In this first study of silicate melt inclusions (SMI) in such environments, primary melt inclusions in zircon hosted in pre-, syn-, and post-VMS ore felsic volcanic lithologies will provide compositional constraints on the initial metal and volatile chemistry of the magma before eruption, allowing a comparison of the precursor metal budgets of magmas that actively degassed and/or were passively leached to supply metals to the deposits. Primary methodologies conducted in this study include (i) SMI petrography (inclusion and host zircon origin, preservation, accidentally trapped phases, etc.); (ii) SEM-EDS for determination of bulk inclusion compositions on exposed SMIs; and (iii) LA-ICP-MS to quantify major/trace element composition of SMIs and host zircon chemistry.

Magmatic zircons from volcanic rocks hosting the LaRonde-Penna VMS deposit in the Abitibi Subprovince contain accidentally trapped mineral inclusions (e.g., apatite, quartz, biotite, oxides; 50% of all inclusions), SMIs (40%), and sulfide (melt and/or mineral) inclusions (~10%). SMIs (up to 35 μm diameter) occur as microcrystalline (recrystallized) and monomineralic to polymineralic. They are composed of quartz, alkali-feldspars, albite, epidote, and apatite daughter phases in varying proportions. Sulfide inclusions (1.5-15 μm) are composed of galena and/or chalcopyrite, and in some lithologies, zircon-hosted inclusions contain sulfide melt co-entrapped with silicate melt, indicating sulfide saturation.

LA-ICP-MS data of SMIs show a wide range of compositions ranging from sub-alkaline rhyolite to alkaline intermediate melts (trachyte to trachyandesite); notably, this is prevalent within single lithologies indicating that zircons preserve melt aliquots along a variety of possible evolutionary pathways involving fractionation, contamination, and/or magma mixing. Metal contents of SMIs generally increase from Lower Bousquet units to Upper Bousquet units, and low metal values in the Footwall unit are possibly due to magmatic degassing prior to ore formation.