Geological, geochemical, isotopic and fluid inclusion studies at the Gays River Zn-Pb deposit: carbonate-hosted base metal mineralization in the basal Windsor Group of Nova Scotia

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The Gays River Zn-Pb deposit (2.4 MT 8.63% Zn, 6.33% Pb) is one of several mineralized (Zn, Pb, Ba, F) centres hosted by Viséan age (ca. 330 Ma) carbonates of the Windsor Group which form part of the large Maritimes Basin of Eastern Canada. The Gays River deposit is generally considered to represent Mississippi Valley Type (MVT) mineralization and ore formation is estimated at ca. 300 Ma. The local stratigraphy includes basement rocks of the Meguma Group (psammites, pelites), an apron of breccia (Meguma Group clasts in limestone matrix) and an overlying reef complex (buildup) with onlapping evaporites; the entire area is overlain by glacial debris and a sediment-filled trench of Cretaceous age incises along the evaporite-limestone contact. The limestones have been pervasively dolomitized via constant volume replacement. Mineralization (Fe-poor sphalerite, Ag-poor galena) consists of massive replacement ore (MRO) and disseminated ore (DO) that forms a quasi-continuous, corrugated sheet of ca. 4 km strike length (E-W to NE-SW) with a 60 to 80 m vertical dimension. The MRO is confined to the forereef along the dolostone-evaporite contact; geochemical (REE) and textural data favour constant volume replacement of the dolostone as its origin. The DO occurs both as infilling of primary porosity and also replacement of dolostone; it forms the footwall to the MRO and gradually pinches out up dip and along the width of the reef. The Pb:Zn ratio of the ore increases down dip (i.e., basinwards towards the fluid source). $\delta^{34}S$ for galena and sphalerite (MRO and DO) are similar at +9 to +14‰ and reflect a sulfur source within the Windsor Group stratigraphy (i.e., $\delta^{34}S_{evaporites}$ = +13 to +16‰). $\delta^{13}C_{PDB}$ and $\delta^{18}O_{SMOW}$ data for calcites define a continuum with limiting values of -5‰, +25‰ and +3‰, +13‰, respectively, and indicate at least two reservoirs are involved. $^{87}Sr/^{86}Sr$ (Sr_i) for calcite ranges from 0.70817 to 0.71202 with the most radiogenic values from MRO samples. In $\delta^{18}O$-Sr_i space the Gays River trend sensibly overlaps that for the regional basin. REE data (bulk and laser ablation ICP-MS analyses) indicate large inter- and intra-sample ranges for ΣREE and $(La/Lu)_N$ for sparry calcites, but limited variation for calcite in the basal breccia and MRO. Fluid inclusion (calcite, fluorite, sphalerite) types are generally two phase (L+V) aqueous types ±halite; GC analyses indicate minor (<1 mole %) carbonic species are present. Thermometric measurements indicate T_H = 70 to >250°C, T_E = -70 to -50°C, and salinities = 23 to 35 wt. % equivalent NaCl. Thus, the above data indicate that while the carbonate bank experienced the same physio-chemical evolution as the regional Carboniferous basin (e.g., Shubenacadie), something unique must have occurred at Gays River to generate the deposit. Potential solutions are currently being addressed and will be discussed.