Fluid inclusion studies of carbonate-hosted mineral deposits in the basal Windsor Group of Nova Scotia: generation of high-temperature, high-salinity fluids as a consequence of an anomalous geothermal gradient or dewatering of a sedimentary basin

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The basal part of the marine Windsor Group of the Maritimes Basin is host to Pb-Zn-Ba-Cu-Ag mineralization which replaces the carbonate rocks or infills primary and secondary porosity. The regionally extensive basal Windsor Group of Visean age (Macumber and Gays River formations), the local host, overlies either terrestial clastics of the late Devonian Horton Group (conformably) or metaturbidites of the Cambro-Ordovician Meguma Group (unconformably) and is overlain by evaporites of the Carrolls Corner Formation. Three of the most significant mineral deposits from separate Carboniferous sub-basins in Nova Scotia have been studied in detail and herein we report results of fluid inclusion studies and interpret the data in the context of additional geological and geochemical information. The Gays River deposit (Musquodoboit-Shubenacadie sub-basin; 2.4 Mt 8.6% Zn and 6.3% Pb) is located within a dolomitized carbonate bank, whereas at the Jubilee deposit (River Denys sub-basin; 0.9 Mt 5.2% Zn and 1.4% Pb) mineralized zones are hosted by brecciated calc-mylonite, and at Walton (Kennetcook sub-basin; former producer Ba-Pb-Zn-Cu-Ag) mineralized zones replace sideritized limestone. At Gays River and Jubilee, galena and Fe-poor sphalerite dominate with traces of other sulphides and calcite as the major gangue, whereas at Walton a greater variety of sulphides occur, including Fe-poor sphalerite, along with arsenides and Ag-bearing phases and abundant barite.

Fluid inclusions have been studied in pre-ore (dolomite, calcite, quartz (?); Gays River and Jubilee), syn-ore (sphalerite, calcite, barite; all deposits) and post-ore (calcite, barite, fluorite; all deposits) phases. Inclusion types include: (1) aqueous L-V ± Halite; (2) CH_4; (3) H_2O-CO_2 (Gays River); and (4) petroleum. Aqueous-type inclusions dominate, but petroleum types are abundant at Jubilee (pre-, syn- and post-ore) and Walton (syn- and post-ore). Homogenization temperatures (T_H) of aqueous inclusions for the three deposits range from <100°C to 300°C, with pre-ore phases having T_H of <160° at Gays River and <100°C at Jubilee. Salinities (eq. wt. % NaCl) of aqueous inclusions for all deposits range from 10 to 30 wt. % with most in the 20 to 25 wt. % range; low first-melting temperatures indicate H_2O-NaCl-$CaCl_2$ fluid composition and ice-hydrohalite melting suggests variable $CaCl_2$/NaCl ratios. At Walton and Gays River, low-salinity inclusions (0-5 wt. %) are commonly associated with high-salinity types. Type 2 inclusions (CH_4) homogenize to the vapor phase at -85° to -74°C. Petroleum inclusions homogenize to the liquid phase with T_H = 90-280°C at Walton and 30-200°C at Jubilee. Analyses (GC) of gases liberated from inclusions hosted by sphalerite and calcite at Gays River confirm the presence of CO_2, CH_4 and hydrocarbons.

The high temperatures of T_H for syn-mineralization phases contrast with the relatively lower temperatures of pre-ore phases and temperatures generally associated with MVT-style mineralization. Results from examination of clay mineralogy and organic maturation at Gays River also suggest a high-temperature anomaly compared to the local sub-basin. Thus, collectively the data indicate that the regional, saline brines generated within the basins either mixed with or were flushed out by higher-temperature fluids, perhaps focused along structural zones, to produce mineralization. A third fluid, which postdates mineralization, is suggested by mixing trends in T_H-salinity plots and by the presence of low-salinity inclusions. Generation of petroleum is related to local cracking of organic matter (Horton or Windsor group rocks) within the fluid pathway; rapid transport and trapping of the petroleum is essential to its preservation.