Fluid chemistry and hydrological regime of a fossil geothermal system in the Antigonish Highlands, Nova Scotia

Tracy Cail
Department of Geology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 1C0, Canada

A series of hydrothermal veins, which can be traced intermittently over 10 km of coastal exposure in the northern Antigonish Highlands, Nova Scotia, were studied in order to identify the hydrologic controls and physico-chemical conditions of vein formation. The veins of interest consist mainly of calcite and minor amounts of euhedral quartz, sulphides and zeolites. In general, they occur within steeply dipping dextral faults that are parallel to the adjacent northeast trending Hollow fault.

The conditions of vein formation and the composition of the hydrothermal fluid were constrained using data obtained from hydrothermal minerals, alteration assemblages and fluid inclusion microthermometry. Microthermometric measurements of fluid inclusions in minerals from the vein and alteration assemblage were performed with a Linkham THMSG 600 heating and freezing stage. Petrographic and mineralogical analyses were done by transmitted and reflected light microscopy and powder X-ray diffraction techniques. Calcite crystals from open spaces within the veins contain two phase aqueous fluid inclusions of primary or psuedosecondary origin. Recorded eutectic temperatures indicate that the fluid inclusions can be modeled in the system H_2O-$CaCl_2$-$NaCl$. Freezing point depression yields bulk salinities between 25 and 30 wt. % NaCl equivalency. CO_2 clathrate was not observed in the freezing measurements, however crushing techniques revealed small amounts of condensed gases, most probably CO_2. Estimated trapping temperature for the inclusions range between 125 and 165°C. These temperatures are consistent with the presence of analcite in the veins, and with propylitic alteration associated with an earlier vein set.

Analysis suggest that the veins are the product of a geothermal system formed by infiltration, heating and circulation of meteoric waters within an extensive permeable zone produced by the Hollow fault. The system was driven by heat supplied by deep circulation of fluids within the faults or by tectonic uplift of hot basement rocks. Interaction of fluids with evaporites and possibly connate brines within the early Carboniferous Windsor group sedimentary rock may account for the high salinity of the fluids. The absence of vapour-rich inclusions suggests that heating of the fluid, rather than phase separation, was largely responsible for precipitation of calcite. However, local concentrations of quartz and sulphides indicate that boiling occurred sporadically due to fluctuations in pressure or fluid salinity. A modern analogue of the studied system is the Salton Sea geothermal field, California.