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*FLUID INCLUSION AND ISOTOPE EVIDENCE FOR THE ORIGIN OF THE UPTON Ba-Zn-Pb DEPOSIT, QUEBEC APPALACHIANS, CANADA**

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Abstract

The Upton Ba-Zn-Pb deposit is hosted by the Early Ordovician crinoidal limestone of the Upton Group in the southern Quebec Appalachians. Mineralization consists of barite and minor amounts of sphalerite, pyrite, galena, and chalcopyrite. The paragenesis includes (1) development of secondary porosity and precipitation of subhedral barite, bladed barite, and barite rosettes; (2) precipitation of fracture-filling barite; (3) filling of fractures and remaining voids in the limestone by a sparry calcite; and (4) precipitation of sulfides, quartz, organic matter, and bitumen in the fractures and along the stylolites. Fluid inclusions were studied in pre-barite syntaxial calcite overgrowths, in subhedral and bladed barite, and in post-barite calcite, sphalerite, and quartz. The homogenization temperatures and salinities of the fluid inclusions are greater than 50°C (single-phase liquid inclusions) and 3.9 to 6.9 wt percent NaCl equiv for syntaxial calcite cement, 42.1° to 96.9°C and 4.7 to 8.1 wt percent NaCl equiv for subhedral and bladed barite, 101.4° to 142°C and 5.1 to 7.5 wt percent NaCl equiv for fracture-filling barite, 82.4° to 132.2°C and 18.3 to 19.7 wt percent NaCl equiv for sphalerite, and 121.8° to 164.2°C and 1.7 to 4.2 wt percent NaCl equiv for quartz. Bitumen is present throughout the paragenesis, but primary CH_4 inclusions only occur in quartz. H_2S- and CH_4-enriched gases were detected in barite and calcite by quadrupole mass spectrometry (QMS) analysis, occurring as secondary fluid inclusions. The $^{87}Sr/^{86}Sr$ ratios of the barite range from 0.70654 to 0.70781, lower than Early Ordovician seawater. Based on these results and previous C-O-S isotope data, we propose that the Upton Ba-Zn-Pb deposit was formed by mixing of two fluids, a marine water-dominated, SO_4^{2-}-rich fluid, and an ^{18}O-enriched and ^{87}Sr-depleted basinal brine, which carried Ba, Zn, and Pb. The reduced sulfur required for the precipitation of sulfides was derived from the thermochemical reduction of sulfate by hydrocarbons. The late precipitation of sulfides after barite may be related to the sluggishness of the sulfate reduction. The mineralization occurred during the Middle to Late Ordovician Taconian orogeny, and tectonic burial and compression is thought to have initiated the circulation of fluids, which would have been channeled through the sedimentary pile along thrust faults and vertical fractures and migrated into the confined crinoidal limestone.

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