
Fluid inclusion evidence for an epithermal-porphyry link at the Mount Milligan porphyry Cu-Au system, Quesnel Terrane, British Columbia, Canada

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Based on detailed field studies, genetic links have been made between high sulfidation epithermal Au and porphyry Cu-Au systems but a connection between low sulfidation epithermal and porphyry systems is less clear, owing partly to the lack of preservation of fluid inclusions in the transitional environment between these two deposit styles. Recent studies have demonstrated that epithermal mineralization may be precipitated by the cooled, aqueous vapour phase that is produced by boiling of metal-rich intermediate density fluids in the porphyry environment.

At the Mount Milligan porphyry system of central British Columbia, Canada, mineralized andesitic and trachytic volcanic rocks occurring distally to the main Cu-Au porphyry zones contain abundant alteration veins that form narrow stockworks. The veins are comprised of quartz ± carbonate ± pyrite ± chlorite ± tourmaline and are younger than the porphyry stage mineralization based on cross-cutting relations. Bulk analyses of mineralized rock have yielded two distinct trends of mineralization.

Primary and pseudosecondary fluid inclusions in massive quartz and freestanding quartz crystals lining the walls of the alteration veins occurring in the volcanic host rocks to the porphyry system. The inclusions contain a two-phase aqueous fluid (L + V) at room temperature.

Microthermometric analysis of 60 inclusions from 6 different veins indicate fluid salinities ranging from 4.2–14.6 NaCl wt% eq (n = 60) and homogenization temperatures (to liquid) between 117 and 270 °C. Individual assemblages representing single veins show much narrower ranges in salinity and homogenization temperature. The homogenization temperatures in individual veins are consistent with the temperatures of chlorite crystallization in the veins determined by Al-in-chlorite compositional thermometry (by electron microprobe). Analyses of single inclusions from the veins by LA-ICPMS (ETH Zurich) show that the low to moderate salinity fluids contained extremely high dissolved concentrations of B, As, and Sb. Ratios of As/Sb in the inclusions overlap closely with bulk ratios in the associated epithermal mineralization in the volcanic rocks. However, the inclusions contain unusually low concentrations of metals expected to be mobile as chloride complexes in hydrothermal solutions (e.g., Pb, Zn, Fe, and Ag) compared to saline fluids documented in other Cu-Au

porphyry systems. The inclusions may represent a condensed vapour phase resulting from early boiling since boiling is a viable mechanism to fractionate chloride-complexed metals (into brine) from bisulfide-complexed metals (into vapour).

Fluid inclusion assemblages in alteration veins at the Mount Milligan porphyry system preserve evidence of the transport of a low- to moderate-salinity, aqueous fluid with chemical characteristics consistent with a contracted magmatic vapour phase that may have mixed at a shallow level with meteoric water causing the precipitation of pyrite-rich low sulfidation epithermal veins. Considering the distinct metal concentrations in the fluid inclusions, the tourmaline and anomalous As and Sb contents in bulk rocks, or elevated B, As, and Sb in fluid inclusions in apparently barren alteration veins in prospective volcanic terranes in the Canadian Cordillera may indicate proximity to alkalic porphyry-style mineralization or associated epithermal systems.