Magmatic-meteoric water interaction during hydrothermal ore deposition

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Hydrothermal convection of ambient fluids can induce significant cooling of as well as mixing with magmatic fluids in the upper crust, both being potentially efficient mechanisms driving ore deposition. Fluid inclusion evidence from the tin-mineralized Yankee Lode (Mole Granite, Australia) deposit suggests that meteoric water incursion into the evolving mineralizing magmatic-hydrothermal system triggered cassiterite precepitaion. To trace meteoric water interaction in the Yankee Lode, we carried out high resolution, in situ oxygen isotope measurements (SIMS analyses) in combination with scanning electron microscope cathodo-luminescence (SEM-CL) imaging on a previously well-studied quartz crystall. Growth temperatures are provided from texturally controlled fluid inclusion studies by Audétat et al. (1998) [1]. Calculated $\delta^{18}O$ values of the fluid over successive quartz generations decrease from magmatic isotopic composition with $\delta^{18}O$ values of ~10 ‰ to very light $\delta^{18}O$ values of about -15 ‰. The main cassiterite formation event agrees with a progressive drop in the fluid's $\delta^{18}O$ value demonstrating that tin precipitated from a hot saline magmatic fluid upon gradual inmixing of cooler meteoric water.

In contrast, porphyry copper ore formation has been linked to entirely magmatic fluids and meteoric water incursion has generally been attributed to peripheral parts of the system or post-ore stages. However, recent numerical simulations imply a significant role of meteoric water for the copper enrichment processes. After validation of the methodology with the Yankee Lode sample, we will also apply it to hydrothermal quartz samples from two significant porphyry copper deposits (Bingham Canyon, USA and Elatsite, Bulgaria) to investigate a potential role of meteoric water incursion in porphyry copper ore precipitation.

[1] Audétat, Günther & Heinrich (1998), Science 279, 2091-2094.