Bingham: A mesothermal Cu-Au deposit dominated by vapor transport of metals?

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Bingham (Utah) is one of the largest and richest porphyry Cu-Mo-Au deposits, formed in intimate association with stockwork veining and potassic alteration centered on a quartz monzonite porphyry stock. Geological mapping, cathodoluminescence (CL) petrography and fluid inclusion study including LA-ICPMS analyses of metal ratios in successively trapped inclusion assemblages have led to somewhat surprising results (Redmond et al., 2004; Landtwing et al., 2005).

While the conditions of quartz deposition in the veins span the large range of pressures and temperatures (>550°C/600bar to 200°C/150bar) observed in many other porphyry systems, the precipitation of bornite and chalcopyrite occurs in a narrow P-T interval, at relatively low temperatures between 425°C and 350°C. CL-textural evidence for vein reactivation and quartz dissolution indicates that Cu-Fe-sulfides precipitate where copper solubility decreases with cooling (Hezarkhani et al., 1999), while silica solubility is reverse (Fournier, 1999).

Even though Cu-depletion with falling temperature is best recorded by inclusions of hypersaline liquid, a coexisting lowsalinity vapor must have been the dominant metal-introducing phase at Bingham. This fluid is trapped by numerous lowerdensity inclusions, whose Cu/Na ratio is even higher than that of the brine inclusion and varies over a similar range. Retrograde quartz solubility is confined to a small P-T-X(NaCl) window on the low-salinity vapor side of the salt – water fluid-phase stability field, at temperatures just above the critical point of water. Precise mass-balance estimation of the phase proportion of liquid/vapor is difficult, because of the poorly defined chloride concentration in the low- to intermediate-density inclusions, but the vapor probably predominated over the hypersaline liquid by a factor of at least five by mass (or fifty by volume).

References

Fournier R.O., Econ. Geol. 94, 1193-1211 (1999);

- Hezarkhani A. et al., Mineralium Deposita 34, 770-738 (1999);
- Landtwing M.L. et al., Earth. Planet. Sci. Lett. (2005, in press).

Coupled heat and salt transport around cooling magmatic intrusions

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We present the results of numerical simulations of coupled heat and salt transport around a cooling magmatic intrusion exsolvinging a saline fluid. The 800°C magma chamber is emplaced 5 kilometers below the surface at litohstatic pressure conditions. For the crust, we consider both uniform and depthdependend permeability distributions and allow the permeability to change transiently as a function of pressure and temperature.

Using a new equation of state for the NaCl-H₂O system, we investigate the impact of a model magmatic fluid that is geologically more realistic than pure H₂O. In particular, we study the effects of phase separation of a saline single-phase fluid into a high-density, high-salinity brine and low-density, low-salinity vapor phase well above the critical pressure and temperature of pure H₂O. This allows us to identify transient flow patterns of vapor and brine and their likely effects on the formation of porphyry-style Cu-Mo-Au deposits.

At lithostatic conditions, the magmatic fluid is initially exsolved as a single-phase fluid. It separates into a vapor and brine phase at the transition from lithostatic to hydrostatic conditions, which is accompanied by a steep drop in temperature from magmatic (\sim 800°C) to hydrothermal (\sim 400°C) conditions.

The vapor rises quickly in the crust and recondenses at shallow depths into meteoric waters. The brine is largely immobile because its volume fraction is very low. The brine contains the majority of the magmatic salt and is progressively diluted by entrained meteoric water. Low permeabilities around the magma chamber cause slower cooling of the intrusion and less movement and dilution of the exsolved magmatic fluid. Fluid pressures are close to lithostatic and can be above lithostatic, leading to hydrofracturing. High permeabilities around the magma chamber, however, cause convection dominated fluid flow, faster dilution of the magmatic fluid and rapid diffusion of the lithostatic fluid pressure in the vicinity of the magma chamber, but are probably less favorable for the formation of economic porphyry-style ore deposits.

Redmond P.B. et al., Geology 32, 217-220 (2004).