Towards a numerical reconstruction of the Bingham Canyon magmatic-hydrothermal ore system

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Porphyry-type ore deposits develop within much larger magmatic-hydrothermal systems. Dissolved metals are transported in both vapour and liquid phases and precipitated in response to steep temperature and pressure gradients. The driving force for fluid flow in such systems are density variations caused by the thermal energy released by a magmatic intrusion. The amount of thermal energy is given by the intrusion's volume and temperature. From the initial temperature and pressure distribution in a given geometry and from additional constraints on magmatic fluid contributions, numerical simulation can be used to develop reconstructions of the spatial and temporal evolution of the magmatic-hydrothermal system.

At Bingham Canyon, petrography and fluid inclusion data from the mine area indicate that ore precipitation took place from a vapour-dominated magmatic fluid plume in a temperature interval from 350 to 425°C and at pressures of 14 to 21 MPa [1, 2]. First generic models [3] predict steep temperature-pressure gradients along with a spatial and temporal fluid evolution that closely resembles the fluid inclusion results. In an ongoing project to apply this hydrological simulation technique to an actual case study, we are compiling 3D geological, geomagnetic and structural data to construct a geological model of Bingham Canyon.

A suite of scenarios varying in deep subsurface geometry and large-scale permeability structure will be tested with these simulations, to match observational constraints of the timing sequence of intrusion and veining, the zoned distribution of Cu, Au and Mo ore grades, and the chemical and density characteristics of fluid inclusions.

[1] Redmond *et al*. (2004) *Geology* **32** 217-220. [2] Landwing *et al*. (2005) *Planetary Science Letters* **235**, 229-243. [3] Driesner & Geiger (2007). *Reviews in Mineralogy* **65**, 187-212.

Precambrian seawater Fe and Si stable isotope signature in BIFs revealed by UV femtosecond laser ablation

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Seawater stable Fe and Si isotope compositions from the late Archean and Early Proterozoic presents much sought-after paleo-proxy information given the sensitivity to redox conditions and changes in ocean input fluxes. BIFs are suitable archives, provided that alteration of a potentially primary isotope composition by diagenesis can be identified. Then the bulk composition yields the composition of Fe and Si sources for a ocean basin at steady state, while the composition of primary minerals plus known fluid-mineral fractionation factors reveals the seawater composition.

We have singled out diagenetic effects by analyzing individual mineral grain's isotope composition by the new technique of UV femtosecond LA-ICP-MS at the 30-100µm scale. In the Archean Old Wanderer BIF from the Shurugwi Greenstone Belt (Zimbabwe), diagenetic reduction of Fe (hydr)oxide by organic matter oxidation led to the formation of variable proportions of magnetite and siderite depending on the Fe(III):C ratio, which in turn governs the development of layering. Primary signatures are preserved in bulk layer composition, where δ^{56}Fe and δ^{30}Si values covary from layer to layer and are between 0 to 0.5‰ and -2.6 and -1.0‰, respectively. The variability on such short time scales suggest that the basin was not at steady state, fertlized rythmically by hydothermal plume solutions. In contrast Proterozoic BIFs of the Hamersley and Transvaal sequences (Australia and South Africa) are more uniform over the thin section scale. Most mineral compositions are controlled by early diagenesis, but in some cases primary signatures in siderite and hematite reveal ancient seawater with -0.8 to 0‰ in δ^{56}Fe, which is similar to modern seawater composition [1]. δ^{30}Si values in chert layers is uniformly light between -1.2 and -0.8‰ – too light for any source known today and implying either a complementary heavy sink or extraordinary hydrothermal activity, leading to non-steady state Si.

[1] Lacan *et al.* (2008) *Geophys. Res. Lett.* **35** L24610.