Numerical simulation of Au-Cu-Ag-Mo vapor-transport applied to magmatic-hydrothermal ore formation

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Single-pass flow through reactor scheme: constant density (300 kg/m³) for different fluid compositions

Magmatic-hydrothermal ore deposits represent a major source of Cu and Mo ore as well as a significant source of Au, W, Ag, Re and Te. Ore formation in porphyry Cu-Au-(Mo) systems involves the exsolution of metal-bearing fluids from magmas and the transport of the metals in magmatic-hydrothermal plumes that are subject to pressure fluctuations. Exsolving magmatic fluids typically have a salinity of 5 – 15 wt.% NaCl, which means that low- and intermediate-density fluids are commonly the dominant volatile phase, and therefore are the most likely agents of metal transport to sites of ore deposition. The role of water as a solvent is the key to understanding metal transport in aqueous fluids, which can be decompressed from a liquid-like to a vapor-like fluid density above the critical temperature and pressure without crossing phase boundaries.

In this study, the capacity of vapor-like fluids to transport metals was investigated using GEM-Selektor based on empirically fitted thermodynamic data of metal solubility experiments between 280 – 550 °C at low to moderate pressure (Hurtig et al., in press.). The relative mobility of Au, Ag, Cu and Mo in vapor-like fluids was simulated as a function of fluid chemistry, temperature, and pressure. We also compared the simulated metal concentrations and ratios to those of vapor-like fluid inclusions, volcanic gas condensates and ores in porphyry deposits. Based on these comparisons, we evaluated the contributions of the simulated processes to metal enrichment and identified the key drivers of porphyry ore genesis within a magmatic-hydrothermal plume.

Metal mobility in vapor-like fluids depends strongly on pressure and temperature. As a result, vapor-like fluids can deposit large amounts of metals without undergoing phase separation upon decompression. This observation is critical when considering the efficiency of mineral precipitation from vapor-like fluids compared to that of brines, where cooling and/or fluid-rock reaction would be the driving mechanisms for mineral precipitation. The observation that gold solubility reaches a maximum at 340–510ºC, argues strongly for the hypothesis that Au is preferentially remobilized to shallow, cooler environments such as those of epithermal systems.

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