

Metal transport in low and intermediate-density fluids: Implications for ore-formation in magmatic-hydrothermal systems

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Magmatic-hydrothermal ore deposits are a major source of Cu and Mo 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 aqueous 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 eq., which means that low (vapor-like) and intermediate density fluids are commonly the dominant aqueous 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.

Here we discuss experimental data from metal solubility studies of Au, Ag, Mo, Cu, Te and Re in low and intermediate-density fluids, their implementation in thermodynamic models and the role of the latter in predicting metal behavior in natural hydrothermal systems. The capacity of low and intermediate-density fluids to transport metals was investigated using the GEM-Selektor software based on empirically fitted thermodynamic data from metal solubility experiments conducted between 280 – 550 °C at low to moderate pressure [1]. The relative mobility of metals in vapor-like fluids was simulated as a function of fluid composition, temperature, and pressure. Based on comparisons of simulated metal concentrations and their ratios with those of fluid inclusions, volcanic gas condensates and ores in porphyry deposits, we evaluate key drivers for metal precipitation relevant to porphyry ore genesis. 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 low and intermediate-density fluids compared to that of brines, for which cooling and/or fluid-rock reaction would be the driving mechanisms for mineral precipitation.

[1] Hurtig N.C., Migdisov A.A. and Williams-Jones A.E. (2021) *Econ. Geol.* 116(7), p. 1599-1624.