

The Exchange of Metals Between Low-Salinity Vapors and Felsic Melts

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The transport of metals to the upper crust, where ore deposits may form, is mediated by volatile phases that exsolve from melts. These volatile phases comprise water and a variety of aqueous metal species. The formation of these metal species is the result of an exchange of metals and ligands between the volatile phase and the melt. Here we present a comprehensive experimental technique to calculate apparent equilibrium constants for the exchange of metal chloride, fluoride, and hydroxide species between low-salinity vapors and felsic melts.

Experiments were carried out in internally-heated pressure vessels at a temperature of 800°C and a pressure of 200 MPa. The starting materials were either Bishop Tuff or Macusani rhyolite and an aqueous solution containing up to ~11 wt% NaCl equivalent \pm KF:NaF:2AlF₃. At the completion of the experiments, quench aqueous solutions and quench precipitates were completely recovered via a multi-step process. The recovered solutions were then analyzed by ion chromatography for chlorine, fluorine, and major cations and by ICP-MS for trace elements. The recovered run product glasses were analyzed for major elements by EPMA and trace elements by LA-ICP-MS. The concentrations of each chloride, fluoride, and hydroxide species, where possible, were determined by using existing thermodynamic data and the measured composition of quench fluids. From these data, apparent equilibrium constants were calculated for Li, Be, B, Al, K, Ca, Sc, V, Mg, Mn, Co, Cu, Zn, Ga, Rb, Sr, Y, Nb, Mo, Ba, Pb, Th, U, and REE's. Preliminary K's for Be, Ca, Cu, Zn, Pb, Mg, and Mg as chlorides; Be, Rb, Pb, Nb, Mo, Th, and select REE's as fluorides; and the majority of hydroxides are greater than 1 (favoring reaction products), whereas the remaining K's are typically less than one (favoring reaction reactants). The K's also vary as a function of the concentration of HCl in the quench fluid. These apparent equilibrium constants permit the exchange of metal species between volatile phases and felsic melts to be characterized and the efficiency by which metals can be extracted from the melt to be evaluated.