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Rapid Ag diffusion in granitic melt: Implications for Ag mineralization and melt inclusion record

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Element diffusion in silicate melts is an important process in the transport and enrichment of metals in magmatic and magmatic-hydrothermal systems, but the diffusivity of Ag, unlike other metals such as Cu, Mo, and W, is still unknown. In this study, Ag diffusion in granitic melts with up to 6.9 wt% H_2O was investigated at 973–1673 K and 0.1–1 GPa in a piston cylinder apparatus and a cold seal vessel, using both a diffusion couple approach and an argentite (Ag_2S) dissolution approach. Silver concentration profiles were analyzed by LA-ICP-MS on recovered samples. Silver solubility, determined by Ag concentration at melt-argentite interface, increases with increasing temperature. Silver diffusivity is found to increase with increasing temperature and water content but to decrease with pressure. At 1 GPa, Ag diffusivity in granitic melt can be described by the following expression:

$\ln D_{Ag,\ 1\ GPa} = (-13.77\pm0.46) - [(13341\pm534)-(700\pm39)w]/T$

where D is the Ag diffusivity in m^2/s, w is the water content in wt%, and T is the temperature in K. The pressure effect over 0.1–1 GPa gives an activation volume of 11.3 cm^3/mol for Ag diffusion. While not being on a par with the mobility of Na and Li, Ag diffusion is among the most rapid, comparable to Cu and faster than other species including H_2O and Fe. This implies that Ag diffusion in melt is unlikely to be a rate-limiting step for Ag enrichment into exsolved fluid bubbles or sulfide blobs. Furthermore, melt inclusions in silicate minerals are expected to record Ag concentration in the bulk melt instead of an elevated concentration in the presence of an Ag-rich boundary layer. Our Ag diffusivity data also suggest that a few tens of hours are long enough to homogenize Ag concentration in melt in solubility or partition experiments at temperatures above 800°C.