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Diffusion of molybdenum and tungsten in anhydrous and hydrous granitic melts

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Abstract

To better understand the transport of Mo and W in granitic melts and the formation mechanism of porphyry ore deposits, we have investigated the diffusivities of Mo and W in granitic melts with 0.04–5.1 wt% H_2O at 1000–1600 °C and 1 GPa using a diffusion couple approach and a Mo saturation approach with Mo sheet serving as the source. The Mo and W diffusivities obtained from diffusion profiles measured by LA-ICP-MS can be described as:

$$D_{Mo,anhy} = 10^{-1.47\pm0.73}\exp[-(387 \pm 25)/RT],$$
$$D_{W,anhy} = 10^{-1.28\pm1.05}\exp[-(396 \pm 35)/RT],$$
$$D_{Mo,2.7wt\%H_2O} = 10^{-5.37\pm0.52}\exp[-(211 \pm 18)/RT],$$
$$D_{Mo,5.1wt\%H_2O} = 10^{-6.87\pm0.69}\exp[-(133 \pm 20)/RT],$$

where D is diffusivity in m^2/s (with the subscripts denoting water contents and "anhy" representing nominally anhydrous melt), R is the gas constant, T is the temperature in K, and the activation energies in the exponential are in kJ/mol. When the influence of H_2O is incorporated, Mo diffusivity in granitic melts with <5.1 wt% H_2O can be modeled as:

$$\log D_{Mo} = -(1.94 \pm 1.58) - (0.87 \pm 0.36)w - [(19\,341 \pm 2784) - (2312 \pm 620)w]/T$$

where w is H_2O content in the melt in wt%. The diffusion behavior (low diffusivities, high activation energies, and strong H_2O effects) of Mo and W indicates that they exist and diffuse in the melt in the form of hexavalent cations. Their low diffusivities imply that the bulk concentrations of Mo and W in exsolved hydrothermal fluid and those in the melt are probably not in equilibrium. However, because of the large fluid-melt partition coefficients of Mo and W, they can still be enriched in the hydrothermal fluid, although to a lesser extent than equilibrium partitioning would allow. Slow Mo and W diffusion can be a significant rate-limiting step for the formation of porphyry Mo/W deposits.

Keywords: Porphyry deposits, molybdenum, tungsten, diffusivity, granitic melt