Interdiffusion of major elements at 1 atmosphere between natural shoshonitic and rhyolitic melts

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ABSTRACT

The diffusive mass exchange of eight major elements (Si, Ti, Al, Fe, Mg, Ca, Na, and K) between natural, nominally dry shoshonitic and rhyolitic melts was studied at atmospheric pressure and temperatures between 1230 and 1413 °C using the diffusion couple method. For six elements, effective binary diffusion coefficients were calculated by means of a concentration-dependent method to obtain an internally consistent data set. Among these components, the range in diffusivities is restricted, pointing to a coupling of their diffusive fluxes. We find that the calculated diffusivities fit well into the Arrhenius relation, with activation energies (E_a) ranging from 258 to 399 kJ/mol in rhyolitic (70 wt% SiO_2) melt and from 294 to 426 kJ/mol in the latitic melt (58 wt% SiO_2). Ti shows the lowest E_a, while Si, Fe, Mg, Ca, and K have a similar value. A strong linear correlation is observed between $\log D_0$ and E_a, confirming the validity of the compensation law for this system. Uphill diffusion is observed in Al in the form of a concentration minimum in the rhyolitic side of the couple, (at ca. 69 wt% SiO_2), and in Na indicated by a maximum in the shoshonitic side (ca. 59 wt% SiO_2). Fe shows weak signs of uphill diffusion, possibly due to the contribution of ferric iron. The data presented here extend the database of previously published diffusivities in the shoshonite-rhyolite system (González-García et al. 2017) toward the water-free end and allows us to better constrain the water-dependence of major element diffusion at very low water concentrations. Combining both data sets, we find that $\log D$ is proportional to the square root of water concentration for a range between 0 and 2 wt% H_2O. These results are of particular interest in the study of mass transfer phenomena in alkaline volcanic systems.

Keywords: Chemical diffusion, major elements, alkaline melts, magma mixing, Vulcano Island