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Multicomponent diffusion in the molten system K_2O-Na_2O-Al_2O_3-SiO_2-H_2O

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ABSTRACT

We have measured multicomponent chemical diffusion coefficients in a melt near to the low pressure water-saturated eutectic granite composition in the system K_2O-Na_2O-Al_2O_3-SiO_2-H_2O at 1.0 GPa and temperatures of 1300 and 1600 °C. The measured diffusion profiles can be accounted for within the analytical error by diffusion coefficients, which are not dependent on composition within the range of compositions accessed by our experiments. The multicomponent diffusion coefficient matrix $[D]$ has a highly degenerate set of real, positive eigenvalues that show a regular relation to melt viscosity on an Arrhenius diagram. The smallest eigenvalue is that associated predominantly with Si-Al exchange. The larger two eigenvalues are those associated with Si-Na and Si-K exchange and are effectively degenerate, with the result that exchanges of alkalis for silica or for each other can proceed in pseudo-binary fashion without inducing fluxes of other components. The eigenvalue associated with H-Si exchange is smaller than the alkali-silica eigenvalues, but analytical uncertainties make it also effectively degenerate with the alkalis. Uphill diffusion, notably of water and alkalis, was observed in several experiments, and this would lead to transient partitioning of water and alkalis across diffusion interfaces showing large Al_2O_3 concentration gradients. Such partitioning in natural systems would persist until Al concentration gradients were erased by continued, much slower Al-Si interdiffusion.