Multicomponent Diffusion in Basaltic Melts

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Numerous major components are present in natrual silicate melts. Therefore, diffusion in melts as a fundamental mechanism for mass transport is always of multicomponent in nature. Multicomponent diffusion is of great importance in many natrual processes, such as magma mixing and contamination, magma double-diffusivie convection, and mineral growth or dissolution in magmas.

Effective binary diffusion treatment has been widely used to treat chemical diffusion of monotonic profiles, but it is difficult to deal with the often-observed uphill diffusion profiles. Tremendous efforts have been made in developing simple and empirical treatments, as well as in studying multicomponent diffusion in both synthetic and natual silicate melts in different systems. Here we report a new study of multicomponent diffusion in basaltic melts.

Eighteen successful diffusion couple experiments were conducted in an 8-component SiO_2–TiO_2–Al_2O_3–FeO–MgO–CaO–Na_2O–K_2O system at 1350 and 1500 ºC and at 1 GPa. At least 3 traverses were measured to obtain diffusion profiles for each experiment. Effective binary diffusion coefficients (EBDC) of components with monotonic diffusion profiles were extracted. The EBDC of a given component such as SiO_2 is strongly dependent on its counter-diffusing component. Furthermore, multicomponent diffusion matrices at 1350 and 1500 ºC were obtained by simultaneously fitting the diffusion profiles of both the diffusion couple experiments and literature mineral dissolution experiments. Diffusion mechanism is inferred that the exchange between network-formers accounts for the slowest diffusion and the exchange of Na_2O with all others accounts for the fastest diffusion. Temperature dependence of diffusion matrix was also examined. Diffusion matrices in basaltic melts at different temperatures have been calculated and successfully applied to calculate diffusion profiles in mineral dissolution experiments in natural basaltic melts at ~1275 and ~1400 ºC.