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Br diffusion in phonolitic melts: Comparison with fluorine and chlorine diffusion

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Abstract

Bromine diffusion was measured in two natural phonolitic melts: (1) a K_2O-rich (~10 wt%) one synthesized from the white pumice phase of the 79 AD eruption of Vesuvius (Italy), and (2) a Na_2O-rich (~10 wt%) one corresponding to the most differentiated melt of the 12 000 BC eruption of the Laacher See (Germany). Experiments were performed at 0.5 and 1.0 GPa, 1250 to 1450 °C, at anhydrous and hydrous (2.65 ± 0.35 wt% of dissolved water) conditions. Experiments conducted with the diffusion-couple technique in the piston cylinder were performed with only bromine diffusing and with the simultaneous diffusion of a halogen mixture (F, Cl, Br) to evaluate the interactions between the halogens during diffusion. The diffusion profiles of Br were measured by X-ray fluorescence using synchrotron radiation microprobe (SYXRF), ID18F, at the European Synchrotron Radiation Facility (ESRF, France). Bromine diffusion displays Arrhenian behavior under anhydrous conditions that is similar when it diffuses alone and when it diffuses with F and Cl. The Br diffusion coefficients range between 2×10^{-12} m²/s at 1250 °C and 1.5×10^{-11} m²/s at 1450 °C for the Na-rich melt and between 3×10^{-12} m²/s at 1250 °C and 2.5×10^{-11} m²/s at 1450 °C for the K-rich melt, at 1.0 GPa. Although Br mobility is independent of F and Cl in anhydrous phonolitic melts, its behavior may be dependent on the dominant alkali in the melt, as previously observed for Cl, but not F. For hydrous experiments, although the data are scattered, the Br diffusivity increases slightly with water and the Na/K ratio seems to influence Br diffusivity. Similarly to noble gases, halogen diffusivity at a given temperature in the phonolitic melts appears related to the ionic porosity of the silicate structure. Compared to basaltic melt, Br diffusivities are approximately one order of magnitude lower in the Na-phonolite melt, because of the difference of the pre-exponential factor. Br mobility appears to be decoupled from melt viscosity, considering the results here.

Keywords: Bromine, phonolite, diffusivity, ionic porosity, alkali; Halogens in Planetary Systems