



Halogen diffusion in basaltic melt

M. Alletti (1), D. R. Baker (2), C. Freda (3)

(1) Dipartimento di Chimica e Fisica della Terra, Università di Palermo, Italy, (2) Earth and Planetary Sciences McGill University, Montreal, Canada, (3) Sezione di Sismologia e Tettonofisica, Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy.
(marina.alletti@tin.it)

The diffusion of the halogens chlorine, fluorine and bromine was measured in a hawaiitic melt from Etna at 500 MPa and 1.0 GPa, 1250 to 1450 °C at anhydrous conditions. The diffusion of F and Cl in the melt was also studied in the melt with a small amount of dissolved water, 3.5 wt%. Experiments were performed using the diffusion-couple technique in a piston cylinder. Most experiments were performed with only one halogen diffusing between the halogen-enriched and halogen-poor halves of the diffusion couple, but a few experiments with a mixture of halogens (F, Cl, Br) were also performed in order to investigate the possibility of interactions between the halogens during diffusion.

Chlorine and fluorine diffusivity show a very similar behavior, slightly diverging at low temperature. Bromine diffusion is a factor of about 2 to 5 lower than the other halogens in this study. Diffusion coefficients for chlorine range between $1.1 \cdot 10^{-11}$ and $1.3 \cdot 10^{-10}$, for fluorine between $2.3 \cdot 10^{-11}$ and $1.5 \cdot 10^{-10}$ and for bromine between $9.4 \cdot 10^{-12}$ and $6.8 \cdot 10^{-11} \text{ m}^2 \text{ s}^{-1}$. No pressure effect was detected at the conditions investigated.

Measuring diffusion coefficients in experiments with mixed halogens demonstrated that diffusivity slightly decreases by a maximum of a factor of 3, showing a more uniform behavior for the three species. However, activation energies for diffusion do not appear to differ between experiments with individual halogens diffusing or when they are all mixed together.

The effect of water increases the diffusion coefficients of F and Cl by no more than a factor of 3 compared to the anhydrous melt ($D_{Cl} = 3.0 \times 10^{-11} - 1.9 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$; $D_F = 4.0 \times 10^{-11} - 1.6 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$).

Comparing our results to the diffusion coefficients of other volatiles in nominally dry basaltic melts, chlorine and fluorine diffusivities are about one order of magnitude lower than H₂O and a factor of 2 to 5 higher than CO₂ and S, while Br is two orders of magnitude lower than water and about one order lower than CO₂ and sulfur. The contrasting volatile diffusivities may affect the variable extent of volatile degassing upon melt depressurization and vesiculation, and can help our understanding of the compositions of rapidly grown magmatic bubbles.