Halogen diffusion in dry rhyodacitic melt

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1. Introduction

Volatiles in magmas are the main driving force controlling the style of volcanic eruptions. Halogen diffusion properties (e.g. Dingwell et al. 2009 and phase equilibria (e.g. Manning 1981) and can also have an impact on atmospheric and environmental processes (e.g. Alletti et al. 2007). Even though the halogens, in particular F and Cl, are amongst the most important constituents of magmatic volatiles (e.g. Symonds et al. 2008), our knowledge of their characteristic properties during degassing, such as diffusion and solubility as a function of composition and P-T conditions, is still poor. Recent advances showed that F and Cl are expelled from the ascending magma at relatively shallow depths in basaltic systems (Spilliaert et al. 2006). Monitoring may therefore help to distinguish degassing and magma ascent (Alletti et al. 2009). Studies investigating F and Cl (and Br) diffusion in melts were carried out on basaltic (Symonds et al. 2008) and phonolitic glass (Böhm et al. 2014). Where diffusion data for Cl is available on those systems (e.g. Böhm & Kienast 2010), data for F, Br and I are still mostly lacking.

8.2. Objective

Characterize halogen diffusion in anhydrous rhyodacitic melt at temperatures relevant for natural systems.

4. Results

Concentration data obtained by EPMA and SIMS are fitted to the equation for one-dimensional diffusivity between two semi-infinite media in a cartesian coordinate system (Crank, 1975).

\[ \frac{C(x,t)}{C_0} = \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{1}{n} \exp \left( -D_n \pi^2 \frac{x^2}{t} \right) \]

Fig. 4: Concentration vs. distance (EPMA and concentration ratio vs. distance (SIMS) diagrams of the highest temperature sample (HX8 - 950 °C). Grey curves represent fitted functions. \( D_1 \) and \( D_2 \) agree well between the different analytical techniques.

5. Conclusions & Outlook

- Halogen diffusion in rhyodacitic is slow in the relevant temperature range
- Correlation of diffusivity and atomic radius most pronounced in rhyodacitic
- Diffusivity and diffusion mechanism depend on melt structure
- Fractionation may occur under conditions of magma ascent and bubble growth

Next steps:
- Collect more SIMS data
- Hydrous experiments with different H2O contents
- Model fractionation during degassing and validate in the field

References


Photography encouraged