



Diffusion of major and trace elements in natural silicate melts as a tool to investigate timescales in magma mixing

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New melt injection into a shallow magma chamber is regarded as one of the potential triggers for explosive volcanic eruptions. Chemical diffusion occurring between the two mixing melts is a time-dependent process, and thus has the potential to shed light on the timescales involved in magma mixing events leading to an eruption. In order to achieve this, a complete database of diffusion coefficients in natural melts is a necessary prerequisite.

We have carried out a set of 12 diffusion couple experiments in order to determine diffusion coefficients (D) of major and trace elements in two natural silicate melts. Two end-members from the Vulcano island (Aeolian archipelago, Italy) have been chosen for the experiments: a shoshonite (Vulcanello lava platform) and a rhyolitic obsidian (Pietre Cotte lava flow, La Fossa cone). Glasses from each end-member with added water contents of 0 wt%, 1 wt% and 2 wt% were produced in an Internally Heated Pressure Vessel (IHPV). Two glass cylinders with similar water content but different base composition are inserted in Au-Pd capsules and experiments are run in the IHPV at 1200°C with pressure from 0.5 to 3 kbar. Experiment capsules are rapidly quenched and analyzed by FTIR, EPMA and LA-ICP-MS for H₂O, major and trace elements, respectively, along 2 mm linear profiles extending across the interface. A Boltzmann-Matano approach is used to obtain concentration-dependent diffusivities.

The obtained concentration-distance profiles are asymmetric and extend deeper into the shoshonite relative to the rhyolite, indicating that diffusion is slower in the latter. Results show that diffusivities are notably accelerated by the presence of H₂O in the melt. Experiments performed by using water-free glass show diffusivities one order of magnitude lower compared to glasses containing up to 2 wt% H₂O. The effect of pressure, in the investigated range, is negligible and falls within measurement error. Among major elements, Si and Ti are the slowest diffusing components, while Na is the fastest. Uphill diffusion minima are observed in Al, Na and some trace elements (Y, Nb, Pb). In contrast to other trace elements, light REE show prominent minima next to the interface between the two melts, with the minimum depth diminishing towards HREE.