Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.10575

Experimental investigation of diffusion-driven metal stable isotope fractionation and trace element diffusion rates in olivine

MR. MARTIN OESER[1], RALF DOHMEN[2] AND STEFAN WEYER[3]

[1]Leibniz University Hannover
[2]Ruhr-Universität Bochum
[3]Leibniz Universität Hannover
Presenting Author: m.oeser@mineralogie.uni-hannover.de

Olivine is one of the most abundant magmatic minerals and frequently displays chemical and isotopic zoning which has been used to determine timescales of magmatic processes by diffusion modeling (e.g. [1-3]). Furthermore, combining the information from chemical- and Fe-Mg- or Li isotopic zoning has been shown to be a powerful tool to elucidate complex crystal growth and diffusion histories, thus, providing a detailed picture of magma evolution prior to a volcanic eruption [2,3]. However, the extent of diffusion-driven Fe-Mg isotope fractionation in olivine (typically termed as β_{Fe} and β_{Mg}), and the parameters that control them, are not yet well constrained. The latter may bear a potential to better determine the boundary conditions of diffusion in order to (1) better unravel complex diffusion histories and (2) receive more precise diffusion timescales.

Here, we have performed a series of diffusion experiments where a powder source was used to produce Fe-Mg chemical and isotopic diffusion profiles in crystallographically oriented San Carlos olivine crystal cubes. Additionally, the powder source used in these diffusion experiments was enriched in Li (~20 ppm) and Al (>1000 ppm) and depleted in several other minor and trace elements (Ca, V, Cr, Mn, Ni) relative to San Carlos olivine. Chemical and isotopic diffusion profiles were analyzed by electron microprobe (Fe-Mg concentrations), by femtosecond-laser ablation-ICP-MS (minor and trace elements), and by fs-LA-MC-ICP-MS (Fe-Mg and Li isotopic variations). We have been investigating the dependence of β_{Fe} and β_{Mg} on temperature, crystallographic orientation, and composition, along with diffusivities of several minor and trace elements. Our preliminary results indicate that the Fe-Mg isotope fractionation during diffusion parallel to the crystallographic a- and b-axes is larger than that for diffusion along the c-axis. Furthermore, coupled diffusion may significantly influence the diffusion rates of some minor and trace elements in olivine.

References:

[1] Albert et al. (2015), *Journal of Petrology* 56, 1945-1966.
[2] Sio & Dauphas (2017), *Geology* 45, 67–70.
[3] Oeser et al. (2018), *American Mineralogist* 103, 582-599.