

## Trace element diffusion rates in olivine: experimental data and observations in natural rocks

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Olivine represents one of the first mineral phases to crystallize from primitive mantle-derived melts and is stable over a large temperature range, providing a great potential to record the differentiation of its host magma “from source to surface” [1]. Intra-mineral variations of minor and trace element contents (i.e. zoning) in olivine can reflect changes in the composition of the host magma due to e.g. magma mixing, and/or result from rapid, disequilibrium crystal growth. The diffusive relaxation of such zoning in olivine depends on the diffusivity of those elements – which has been debated controversially (e.g. [2]) – and may be complicated by a coupling of trace element diffusion [3]. In order to investigate these aspects, we have conducted a series of diffusion experiments using crystallographically oriented San Carlos olivine crystal cuboids (Fo<sub>91</sub>) buried in a synthesized olivine powder that was enriched in Fe (Fo<sub>-60</sub>), Li (~20 ppm) and Al (>1000 ppm) and depleted in several other minor and trace elements (Ca, Sc, V, Cr, Mn, Ni) relative to San Carlos olivine. The crystal / powder source diffusion couples were annealed in Al<sub>2</sub>O<sub>3</sub> crucibles in a gas-mixing furnace at atmospheric pressure, covering a temperature range of 1100-1300°C. In-situ analyses of major, minor, and trace elements were performed by femtosecond-LA-sector field-ICP-MS using lateral linescans as well as depth profiling. Furthermore, we have analyzed trace element zoning in olivine crystals from volcanic rocks (intra-plate basanites and island arc basalts), some of them showing coupled Fe-Mg chemical and isotopic zoning which strongly indicates a diffusion origin of the zoning. Our results suggest that the diffusion rates of most minor and trace elements occupying the metal site in olivine differ by less than one order of magnitude from that of Fe-Mg interdiffusion. Moreover, our experimental samples indicate a diffusive coupling of Li and Al and a clear diffusion anisotropy for Li, with  $D_{\text{Li}}^{[001]} > D_{\text{Li}}^{[100]} > D_{\text{Li}}^{[010]}$ .

References:

[1] Gordeychik et al. (2020), *J. Petrol.* 61, 1-23.

[2] Jollands et al. (2018), *GCA* 220, 407-428.

[3] Lynn et al. (2020), *Front. Earth Sci.* 8, 135.