Fe-Mg chemical and isotopic zoning in magmatic crystals: Shapes, processes, and time scales

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Recent studies have demonstrated that an investigation of Fe-Mg isotopic variations in olivine provides a powerful means to reliably trace Fe-Mg inter-diffusion occurring on the mineral scale during magma evolution [1] [2], because diffusion results in large kinetic isotope fractionations even at magmatic temperatures [3]. Modeling of distinctly diffusion-generated zoning in olivine yields constraints on the time scales of magma differentiation processes. However, in natural samples a combination of e.g. crystal growth and diffusion processes may significantly affect intra-mineral chemical and isotope variations. In order to theoretically examine this, we modeled the effects of Fe-Mg inter-diffusion, crystal growth and crystal dissolution on chemical and isotopic zoning of olivines in general. The model results were applied to natural olivines from MORBs and intra-plate basalts in order to simulate observed Fe-Mg isotopic (and chemical) variations which were determined by *in situ* Fe-Mg isotope analyses using fs-LA-MC-ICP-MS [2].

The results of the theoretical approach and of our *in situ* analyses demonstrate that combining the information of chemical and isotopic zoning in olivine allows to distinguish between diverse proccesses occurring during magma evolution. Fe-Mg inter-diffusion, in general, leads to inversely correlated Fe-Mg isotopic profiles [4] and appears to be the dominant process that drives isotope fractionation in magmatic olivine. Still, the specific shapes of such profiles differ considerably from each other depending on whether (and when) episodes of crystal growth or dissolution played a major role in modifying the chemical and isotopic zoning of olivine, as recorded by some of our investigated crystals.

Further investigations will address potential Fe-Mg isotopic zoning in chemically zoned cpx in order to elucidate diffusion-driven processes in magmatic systems that operate on different times scales than Fe-Mg diffusion in olivine.

[1] Sio et al. (2013) *GCA* **123**, 302-321. [2] Oeser et al. (2014), *GGR* **38**, 311-328. [3] Richter et al. (2003) *GCA* **67**, 3905-3923. [4] Dauphas et al. (2010) *GCA* **74**, 3274-3291.