

## Diffusion of Yttrium in olivine

C. Crépeau (1), H. St.C. O'Neill (1), J. Hermann (1), and C. Spandler (2)

(1) Research School of Earth Sciences, Australian National University, Canberra, Australia (hugh.oneill@anu.edu.au), (2) School of Earth and Environmental Sciences, James Cook University, Townsville, QLD, Australia

Olivine is the liquidus phase in primitive basalts and olivine phenocrysts often host melt inclusions that may aid in understanding basalt petrogenesis. Diffusion in olivine is one factor that determines the survival times of anomalous inclusions (e.g., Spandler et al. 2007). Diffusion profiles in olivine xenocrysts can yield information on the timescales of magmatic processes. Rare Earth Element diffusion in olivine is of interest on both counts but is presently controversial. Spandler et al. (2007) and Spandler and O'Neill (2010) measured diffusion rates for REE in olivine at 1300°C that were similar to those of Mg-Fe interdiffusion, as did Qing et al. (2009) in natural olivine xenocrysts at ~1000°C. However, Cherniak (2010) reported REE diffusion measured on short profiles by Rutherford Backscattering Spectroscopy that was ~ 4 orders of magnitude slower.

To investigate this discrepancy we have undertaken a detailed study of the diffusion of Y, a REE proxy, in both synthetic forsterite and natural San Carlos olivine at 1200°C to 1500°C, mostly at 1300°C. In the three-component system MgO-SiO<sub>2</sub>-Y<sub>2</sub>O<sub>3</sub>, the chemical potentials are buffered at specified T and P by three-phase assemblages, of which there are four containing forsterite (Mg<sub>2</sub>SiO<sub>4</sub>). These are, in order of decreasing silica activity, a(SiO<sub>2</sub>): (1) Mg<sub>2</sub>SiO<sub>4</sub> + MgSiO<sub>3</sub> + Y<sub>2</sub>Si<sub>2</sub>O<sub>7</sub>; (2) Mg<sub>2</sub>SiO<sub>4</sub> + "Y-Mg-apatite" + Y<sub>2</sub>Si<sub>2</sub>O<sub>7</sub>; (3) Mg<sub>2</sub>SiO<sub>4</sub> + "Y-Mg-apatite" + Y<sub>2</sub>SiO<sub>5</sub>; (4) Mg<sub>2</sub>SiO<sub>4</sub> + Y<sub>2</sub>SiO<sub>5</sub> + MgO.

Powders of each assemblage were synthesized and painted onto polished faces of forsterite cut parallel to [100], [010] and [001]. Experiments at 1300°C in air were run from 17 hrs to 31 days and the resulting profiles measured by Laser-Ablation ICP-MS and electron microprobe. The equilibrium concentrations of Y at the interface was 380 ppm in (4), ~600 ppm in (1), and slightly higher in (2) and (3), consistent with substitution of Y in forsterite as YMg<sub>1/2</sub>Vac<sub>1/2</sub>SiO<sub>4</sub>. Diffusion is isotropic with log D (m<sup>2</sup>/s) = -14.9 in the high a(SiO<sub>2</sub>) assemblages. Diffusion rates in (4) are roughly similar but the shape of the diffusion profiles is non-Fickian, and can be modeled by a linear dependence of diffusion coefficient on Y concentration, implying that vacancies enhancing diffusion rates are created by the diffusion of Y itself. Results on San Carlos olivine are slightly faster (log D (m<sup>2</sup>/s) = -14.8 at 1300°C and QFM) and do not show the anomalous diffusion at low a(SiO<sub>2</sub>). These results agree with those of Spandler et al. (2007) and Spandler & O'Neill (2010).

**References** Cherniak D (2010) *Amer. Mineral.* **95**, 362-368. Qing Q, O'Neill HSC, Hermann J (2009) *Geology* **38**, 331-334. Spandler C., O'Neill HSC & Kamenetsky V (2007) *Nature* **447**, 303-306. Spandler C & O'Neill HSC (2010) *Contrib. Min. Pet.* **159**, 791-818.