

## Ti diffusion in olivine

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Diffusion of Ti has been characterized in natural olivine (Fo<sub>90</sub>) and in synthetic forsterite. Experiments were conducted with pre-fired mixtures of oxide powders and ground olivine as sources of diffusant; experiments on natural olivine were run in sealed silica ampoules with solid buffers (NNO and IW) to investigate the dependence of diffusion on oxygen fugacity. The effects of olivine crystallographic orientation were also explored. Following diffusion experiments, Ti distributions in the samples were profiled with Rutherford Backscattering Spectroscopy. For Ti diffusion in synthetic forsterite, we obtain the following Arrhenius relation for diffusion parallel to the c-axis, over the temperature range 900 – 1400°C:

$$D_{\text{Fo100}} = 5.97 \times 10^{-14} \exp(-203 \pm 19 \text{ kJ mol}^{-1}/RT) \text{ m}^2 \text{ sec}^{-1}.$$

For the natural olivines under NNO-buffered conditions, we obtain the Arrhenius relation:

$$D_{\text{Fo90}} = 2.98 \times 10^{-14} \exp(-198 \pm 41 \text{ kJ mol}^{-1}/RT) \text{ m}^2 \text{ sec}^{-1}.$$

Ti diffusion in olivine appears relatively insensitive to oxygen fugacity and orientation. Additional experiments at higher pressures are underway to evaluate effects of the presence of hydrous species on Ti diffusion in olivine.

Ti diffusivities in olivine are similar to those of the trivalent REEs [1], but considerably slower than those of Fe-Mg [2] and Cr [3] in olivine. Ti diffusivities in olivine and pyroxene (diopside and orthopyroxene) are comparable over investigated temperature ranges, differing by about half a log unit at 900°C, but have increasing variance at lower temperatures given the higher activation energies for Ti diffusion in pyroxene compared with olivine [4]. These large differences in cation mobility among Ti, Cr, Fe-Mg and the REE in pyroxene and olivine may allow us to distinguish dominant process that gives rise to the chemical disequilibria in olivine and pyroxene. With decreasing temperature, Ti and REE are preferentially partitioned from olivine to pyroxene in ultramafic rocks. Diffusive exchange models with temperature-dependent diffusion and partition coefficients have been developed for the olivine-pyroxene bi-mineralic and tri-mineralic systems, allowing us to assess cooling rates and closure temperatures of the ultramafic rocks.

[1] Cherniak (2010) *Am. Mineral.* **95**, 362-368 [2] Dohmen *et al* (2007) *CMP* **34**, 389-407 [3] Ito & Ganguly (2006) *GCA* **70**, 799-806 [4] Cherniak & Liang (2012) *GCA* **98**, 31-47