American Mineralogist, Volume 95, pages 362–368, 2010

REE diffusion in olivine

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ABSTRACT

Diffusion of rare earth elements has been characterized in synthetic forsterite and natural olivine (Fo_{90}) under dry conditions. Experiments were prepared by enclosing source material [mixtures of rare-earth element (La, Dy, or Yb) aluminate and synthetic forsterite powders in 3:1 proportions] and polished forsterite in platinum capsules. For buffered experiments on natural olivine, samples were placed with the source in AgPd capsules, sealed under vacuum in silica glass ampoules with a solid buffer (NNO, IW, or graphite). In some experiments, ground natural olivine was also incorporated into the source material. Prepared capsules were annealed in 1 atm furnaces for one hour to several weeks at 850 to 1300 °C. REE distributions in olivine were profiled by Rutherford backscattering spectrometry (RBS).

The following Arrhenius relation is obtained for Dy diffusion in forsterite:

$$D_{\mathrm{Dy}} = 8.0 \times 10^{-10} \exp(-289 \pm 21 \text{ kJ mol}^{-1}/\mathrm{RT}) \text{ m}^2/\text{s}.$$

Diffusivities of Yb and La in forsterite and for Dy in natural olivine are similar. Experiments run on natural olivine show little dependence of diffusion on crystallographic orientation. The Arrhenius relation yields diffusivities about three orders of magnitude smaller than those determined for REE diffusion in olivine by Spandler et al. (2007) and suggests that timescales for preservation of REE signatures in olivine-hosted melt inclusions may be relatively long. REE diffusivities in olivine are an order of magnitude faster than those of REE^{+3} in enstatite (Cherniak and Liang 2007) and in diopside under most conditions (Van Orman et al. 2001). Hence, REE signatures in olivine are more likely to be altered by diffusion than those of clinopyroxene or orthopyroxene.

Keywords: Rare earth elements, olivine, diffusion, Rutherford backscattering spectrometry