

H profiles in mantle xenoliths: Constraints from diffusion data

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Hydrogen concentration gradients reported in olivines from several peridotite xenoliths (Demouchy, 2004; Peslier and Luhr, 2006) have been interpreted as evidence of hydrogen loss during ascent to the surface. However, a review of hydrogen diffusion data in anhydrous minerals (Ingrin and Blanchard, 2006) provides new constraints on the possible origin of these heterogeneities.

The amount of hydrogen in mantle silicates is likely controlled by the relative kinetics of three diffusion mechanisms. The first level of kinetics is controlled by the diffusion of hydrogen. H diffusivities are very high (10^{-10} – 10^{-11} m²/s at 1173 K). The H contents of xenolith phases are therefore in equilibrium with the water fugacity fixed by the transporting magma. H diffusivity in cpx is slightly higher than in olivine, garnet and opx but the differences are extremely small. Each mineral therefore rapidly records any subsequent change of water fugacity. A second level of kinetics constrains the concentration of vacancies at octahedral sites. This is controlled, for example, by oxygen fugacity and directly affects H solubility in olivine and pyroxene. Diffusion of octahedral vacancies is 2–4 log units lower than that of hydrogen. Vacancy diffusion in olivine is probably less than one order of magnitude higher than in pyroxenes (Ingrin and Blanchard, 2006). As no H gradient was observed in pyroxene coexisting with the zoned olivines, it is unlikely that vacancy diffusion generated the observed concentration gradients. Cation diffusion also controls H solubility in minerals. H solubility in olivine is more sensitive to trace element substitution and facies conditions than pyroxenes (Berry et al., 2005; Grant et al., 2006). As cation diffusion through minerals is slow (8 log units lower than H), thousands to millions years are required to produce chemical zoning by this mechanism. H profiles in natural olivine are probably the result of this third level kinetics. They were produced prior to xenoliths sampling and thus provide little information on the ascent rates.

References

- Berry, A., Hermann, J., O'Neill, H.S.C., Foran, G.J., 2005. *Geology* **33**, 869–872.
- Demouchy, S., 2004. Ph.D. Thesis, Bayreuth Universität, p. 182.
- Grant, K., Ingrin, J., Lorand, J.P., Dumas, P., 2006. *Contrib. Mineral. Petrol.* submitted for publication.
- Ingrin, J., Blanchard, M., 2006. *Reviews in Mineralogy and Geochemistry*. **62**, in press.
- Peslier, A.H., Luhr, J.F., 2006. *Earth Planet. Sci. Lett.* **242**, 302–319.