Li diffusion and isotopic fractionation in olivines crystals

CEDRIC HAMELIN[1], MARC CHAUSSIDON[2], JEAN-ALIX BARRAT[1], PIERRE BECK[3] AND MARCEL BOHN[4]

[1]CNRS UMR 6538, U.B.O.-I.U.E.M., place Nicolas Copernic, 29280 Plouzané Cedex, France (cedric.hamelin@sdt.univ-brest.fr; barrat@univ-brest.fr]
[2]CRPG-CNRS UPR 2300, 15 rue Notre-Dame des Pauvres, 54501 Vandoeuvre-les-Nancy Cedex, France (chocho@crpg.cnrs-nancy.fr)
[3]Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road NW, DC 20015-1305 Washington, USA (pbeck@ciw.edu)
[4]CNRS UMR 6538, IFREMER, BP70, 29280 Plouzané, France (bohn@ifremer.fr)

In order to constrain the behavior of lithium isotopes in crystals during magma cooling, the study of a fresh pillow-lava with large olivine crystals has been undertaken. An ion-microprobe was used to measure lithium abundances and isotopic compositions both in olivine phenocrysts and in the pillow rim glass. Profiles in δ^7Li conducted through olivines show very different patterns correlated with their cooling history. Olivines embedded in the pillow rim glass display no variation in Li abundance ([Li] = 1.2 $\mu g.g^{-1}$) and isotopic composition (δ^7Li = +6 ‰). However, a large Li isotopic zoning is found from crystal cores (δ^7Li = +6 ‰, [Li] = 1.1 $\mu g.g^{-1}$) to rims (δ^7Li = -11 ‰, [Li] = 1.4 µg.g-1) for olivines set in microcrystalline groundmass. The cores of large olivine phenocrysts are equilibrated with the pillow rim glass (δ^7Li = +6 ‰, [Li] = 3.4 µg.g-1).

Recently, detailed investigation of the Li isotopic composition of large phenocrysts in various magmatic environments demonstrated that microscale δ^7Li variations were due to fractionation of lithium isotopes during late stage chemical diffusion (Barrat *et al*., 2005; Beck *et al*., 2006; Jeffcoate *et al*., 2006). In our case, the diffusion-induced Li isotopes fractionation is the only process able to explain such diverse zoning in olivines from one single pillow lava. Our study brings new constraints on the Li fractionation during the diffusion process and suggests that the pristine δ^7Li values can be completely erased in small phenocrysts, even in the case of rapidly cooled volcanics. The use of Li isotopes in crystals for tracking mantle heterogeneities should be taken with extreme caution.

References

Barrat J.A., Chaussidon M., Bohn M., Gillet P., Gopel C., and Lesourd M., (2005), *Geochimica et Cosmochimica Acta* **69**, 5597-5609.

Beck P., Chaussidon M., Barrat J.A., Gillet P., and Bohn M., (2006), *Geochimica et Cosmochimica Acta* **70**, 4813-4825.

Jeffcoate A.B., Elliott T., Kasemann S.A., Ionov D., Cooper K., and Brooker R., (2007), *Geochimica et Cosmochimica Acta* **71**, 202-218.

δ^7Li systematics of mantle xenoliths from Kilbourne Hole: Unraveling metasomatic & diffusional processes

S.J. HAMMOND[12], I.J. PARKINSON[1], R.H. JAMES[1], N.W. ROGERS[1] AND J. HARVEY[3]

[1]Dept. of Earth Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK. (s.hammond@open.ac.uk)
[2]Dept. of Earth Science and Eng., Imperial College London, South Kensington Campus, London, SW7 2AZ, UK.
[3]Boston University TIMS Facility, Department of Earth Sciences, 675 Commonwealth Avenue, Boston, MA 02215, USA.

We present a detailed Li isotopic study of spinel-peridotites from Kilbourne Hole, New Mexico, including whole rock and hand picked mineral separate δ^7Li data (measured by MC-ICP-MS) and in-situ δ^7Li data measured by ion microprobe. From this detailed approach the effects of mantle metasomatism and diffusion can be unravelled.

The xenolith suite can be divided into those which are in textural equilibrium, and those which have interacted with the host lava. Whole rock values for the sample suite range from +4.5 ‰ to -2.9 ‰. Of the samples which are in textural equilibrium, mineral separates reveal that olivine, orthopyroxene, and clinopyroxene are all in isotopic equilibrium, and grains analysed by ion microprobe are homogeneous in both Li and δ^7Li across grains, with the exception of the outer 50 µm in some clinopyroxene grains. The two lightest δ^7Li are found in equilibrated LREE enriched harzburgites, which is consistent with these samples having completely equilibrated with a melt with a slightly negative δ^7Li (-3 ‰), possibly from a garnet pyroxenite/eclogite source (although partial equilibration with a heavy δ^7Li melt can also explain these data).

Kilbourne Hole peridotite xenoliths have rapid transit times (~0.2 days), which is long enough to produce the Li isotope perturbation observed in the clinopyroxene grains by more rapid diffusion of ^{6}Li compared to ^{7}Li from the host lava.

The extent of clinopyroxene reaction correlates with a decrease in whole rock δ^7Li, which can be explained by reaction driven diffusion with the host lava. Li diffusion in clinopyroxene is at least ten times faster than in olivine [1], and so interactions between peridotite and melt produce clinopyroxene with lighter δ^7Li than co-existing mineral phases. Clinopyroxene data that have very light δ^7Li values (e.g. [2]) have been used to argue a very light δ^7Li component in the mantle. However, without evidence of Li isotopic equilibrium, the existence of such a component must be treated with caution.

References

[1] Parkinson *et al*., (2007), *Earth. Planet. Sci. Lett.* doi:10.1016/j.epsl.2007.03.023

[2] Nishio *et al*., (2004), *Earth. Planet. Sci. Lett.* **217** 245-261.