# Li isotope studies of mantle-derived olivine by SIMS

DAVID R. BELL[1], RICHARD L. HERVIG[2] AND PETER R. BUSECK[3]

[1]Department of Chenistry & Biochemistry and School of Earth and Space Exploration, Arizona State University, Tempe AZ 85287-1604, USA (David.R.Bell@asu.edu)
[2]School of Earth and Space Exploration, Arizona State University, Tempe AZ 85287-1604, USA (Hervig@asu.edu)
[3]Department of Chenistry & Biochemistry and School of Earth and Space Exploration, Arizona State University, Tempe AZ 85287-1604, USA (pbuseck@asu.edu)

We report Li isotope variations analyzed by SIMS in olivine from terrestrial mantle xenoliths and mantle-derived magmas. The dependence of the $\delta^7$Li measured by SIMS on olivine composition was calibrated for compositions between Fo94 and Fo74 and amounts to 1.3 ‰ per Fo unit. Separated olivine grains were analyzed in epoxy mounts on the Cameca IMS-3f and IMS-6f SIMS at ASU. Precision of individual analyes including sample and standard uncertainties is typically ~1.5 - 3‰ (2$\sigma$).

Samples include spinel- and garnet-peridotites from Archean and Proterozoic mantle, pyroxenites, olivine megacrysts from kimberlites, and olivine phenocrysts in Hawaiian basalts. Samples display varying degrees of isotopic heterogeneity, from homogeneous $\delta^7$Li compositions with or without minor variations at grain margins, to large internal variations up to 16‰ within individual xenoliths. Significant variability may also occur among petrologically related samples that appear internally homogeneous.

Southern African low-temperature garnet peridotites display a range in $\delta^7$Li = -0.8 to +8.9 ‰. An orthopyroxenite has $\delta^7$Li at the high end of this range. The majority of Archean peridotites from Siberia display a relatively restricted range (mean $\delta^7$Li = 2.9 ± 3‰, 2$\sigma$, n=9) with minor internal heterogeneity, but exceptional xenoliths are isotopically heterogeneous with grains, or portions of grains extending to -14‰. Fertile spinel lherzolites from SW USA including hydrous xenoliths from the Colorado Plateau appear relatively homogenous in $\delta^7$Li, with minor intra-grain isotopic zonation. In contrast, refractory peridotites from San Carlos, AZ display excursions up to +27‰, with strong intra-mineral zonation. Megacrysts from South African kimberlites, interpreted as melt-rock reaction products, have internal variations up to 10‰. Hawaiian phenocryst olivines and dunite xenoliths display internal heterogeneity up to 6‰.

$^7$Li/$^6$Li fractionation during magmatic and metasomatic processes limits the use of Li isotopes as a tracer of crustal components in mantle-derived samples. However, with appropriate calibration of $^6$Li and $^7$Li diffusivity, the spatial and inter-mineral distribution of Li isotope variations can provide quantitative constraints on the kinetics of mantle and magmatic processes.

# Experimental shock decomposition of siderite and the origin of magnetite in Martian Meteorite ALH84001

M.S. BELL[1,2]

[1]Geosciences Department, The University of Houston, Houston, Texas 77204
[2]Jacobs @NASA/Johnson Space Center, Bldg. 31, Room 222, Mail Code KT, Houston, TX 77058 (mary.sue.bell1@jsc.nasa.gov)

## Methods

Shock recovery experiments to determine whether magnetite could be produced by the decomposition of iron-carbonate were initiated. Naturally occurring siderite was first characterized by electron microprobe, transmission electron microscopy (TEM), Mossbauer spectroscopy, and magnetic susceptibility measurements to be sure that the starting material did not contain detectable magnetite. Samples were shocked in tungsten-alloy holders (W=90%, Ni=6%, Cu=4%) to further insure that any iron phases in the shock products were contributed by the siderite rather than the sample holder. Each sample was shocked to a specific pressure between 30 to 49 GPa.

## Discussion of results

Transformation of siderite to magnetite as characterized by TEM was found in the 49 GPa shock experiment. Compositions of most magnetites are > 50% $Fe^{+2}$ in the octahedral site of the inverse spinel structure. Magnetites produced in shock experiments display the same range of single-domain, superparamagnetic sizes (~50 to 100nm), compositions (100% magnetite to 80% magnetite - 20% magnesioferrite), and morphologies (equant, elongated, euhedral to subhedral) as magnetites synthesized by Golden *et al*. (2001) or magnetites grown naturally by MV1 magnetotactic bacteria, and as the magnetites in Martian meteorite ALH84001. Fritz *et al* (2005) previously concluded that ALH84001 experienced ~32 GPa pressure and a resultant thermal pulse of ~100-110$^o$C. However, ALH84001 contains evidence of local temperature excursions high enough to melt feldspar, pyroxene, and a silica-rich phase.

## Conclusions

This 49 GPa experiment demonstrates that magnetite can be produced by the shock decomposition of siderite as a result of local heating to > 470$^o$C. Therefore, magnetite in the rims of carbonates in Martian meteorite ALH84001 could be a product of shock devolatilization of siderite as well.

## References

Golden *et al*., (2001), *Am. Min*. **86**, 370-375.
Fritz *et al*., (2005), *MAPS* **40**, 1393-1411.