

1.2.36

Li and $\delta^7\text{Li}$ behaviour in mantle metasomatic processes

C. WAGNER¹ AND E. DELOULE²

¹UPMC, Paris 6, CNRS-FR32, France (cw@ccr.jussieu.fr)

²CRPG-CNRS, Nancy, France (deloule@crpg.cnrs-nancy.fr)

Lithium becomes increasingly used to trace global scale processes and constrain the composition of earth's reservoirs. However, tighter constraints require better knowledge of Li behaviour in mantle where its distribution among phases and isotope fractionation has yet to be evaluated. In this work we examine the Li signatures to identify metasomatic processes that affect the lithospheric mantle.

Li abundances and isotopic composition were measured by ion microprobe for co-existing phases in mantle xenoliths from the Devès (Massif central). Samples consist of two anhydrous and three modally metasomatised amphibole-bearing fertile spinel lherzolites. In anhydrous samples, Li is preferentially incorporated into olivine (ol: 1.3-3 ppm) compared to pyroxenes (opx, cpx: 0.8-1.5 ppm). Hydrous metasomatised samples clearly show enrichment of Li in ol (1.5-5 ppm), opx (1.2-2.5 ppm) and cpx (2.7-5.4 ppm). Amphibole (amp) incorporates less Li than the co-existing pyroxenes (1.1-1.5 ppm). The following partition relationships have been established : ol > opx ≥ cpx for anhydrous samples and cpx > ol > opx for metasomatised samples. In the metasomatised samples the distribution of Li has achieved equilibrium between ol and opx but not with cpx. Bulk Li content (about 1.1-1.5 ppm) of anhydrous samples is in accordance with estimation for fertile to moderately depleted lithospheric mantle. Metasomatic overprint increases the bulk Li content up to 4 ppm. Anhydrous samples are characterised by $\delta^7\text{Li}(\text{ol}) = +13.8$ to $+14.5$ ‰, $\delta^7\text{Li}(\text{opx}) = +10.7$ to $+11.3$ ‰ and $\delta^7\text{Li}(\text{cpx}) = +8.9$ to $+9.4$ ‰. The different phases from the metasomatised samples are isotopically zoned. In samples with the highest abundance of modal amphibole (20 %) $\delta^7\text{Li}(\text{ol})$ ranges from $+11.9$ to $+16.0$ ‰, $\delta^7\text{Li}(\text{opx})$ from $+21.3$ to $+11.4$ ‰ and $\delta^7\text{Li}(\text{cpx})$ from -8.1 to $+12$ ‰, respectively in core and rim. $\delta^7\text{Li}(\text{amp})$ is highly variable: $+21.2$ ‰ in the core of coarse grain to $+15.3$ ‰ in the rim while small grains show lower $\delta^7\text{Li}$ values $+3.2$ ‰ to $+5.2$ ‰. We suggest that the percolating fluid has primarily a high positive $\delta^7\text{Li}$ signature, as recorded by coarse amphibole core. Interactions with the mantle phases lower its isotopic composition. The complex variations of $\delta^7\text{Li}$ in the different minerals can be explained by interactions or repeated interactions with this evolving fluid. The extreme variations of $\delta^7\text{Li}$ shown by cpx has to be further documented.

1.2.37

The geodynamic cycle of chlorine based on $\delta^{37}\text{Cl}$

M. BONIFACIE¹, N. JENDRZEJEWSKI¹, P. AGRINIER¹,
F. PINEAU¹, J.-L. CHARLOU² AND C. MONNIN³

¹ Lab. Géochimie Isotopes Stables, IPG Paris, France
(bonifaci@ipgp.jussieu.fr)

² Lab. Géochimie & Métallogénie (charlou@ifremer.fr)

³ Lab. Méca. Transfert Géologie (monnin@lmtg.ups-tlse.fr)

Chlorine is one of the main volatile elements on Earth and occurs in all surface reservoirs. To constrain Cl isotope behaviour in geological processes involving silicate phases, we have optimized the method of Cl extraction by pyrohydrolysis to determine $\delta^{37}\text{Cl}$ by IRMS on CH_3Cl gas. We will discuss analytical conditions which are mandatory (extraction yields >95%, low blanks and reproducibility) to determine $\delta^{37}\text{Cl}$ of natural samples.

To characterize mantle signatures and chlorine behaviour during oceanic crust alteration we have analyzed 20 fresh MORB glasses, 5 altered basalts, 8 serpentinized peridotites and an altered gabbro, but also fluids of both high (ridge axis hydrothermal vent fluids, n=11) and low temperature (n=6). Five aorian lavas and 4 meteorites (EH, CI and Ordinary) were also analyzed.

All solid samples analyzed (n=43) are depleted in ^{37}Cl ($\delta^{37}\text{Cl}$ between -1.6 to -0.2 per mil) relatively to seawater, Cl content being between 40 and 9200 ppm. Despite a large range of chlorinity (from 250 to 821 mM), high temperature hydrothermal vent fluids have $\delta^{37}\text{Cl}$ similar to that of seawater ($\delta^{37}\text{Cl} = 0.0$ per mil) whereas low temperature fluids (mean chlorinity 550 ± 6 mM), have $\delta^{37}\text{Cl}$ between -1.9 and -0.1 per mil.

The $\delta^{37}\text{Cl}$ of fresh MORB samples range from -1.6 to -0.6 ‰, however the $\delta^{37}\text{Cl}$ dispersion is greater the higher the Cl content. The seawater alteration of oceanic crust produces a Cl enrichment, but the $\delta^{37}\text{Cl}$ range of altered rock and high Cl content fresh oceanic samples are similar. The $\delta^{37}\text{Cl}$ distribution of fresh MORB samples can be explained by a 2 end-member mixing : a depleted mantle signature (low Cl content, low $\delta^{37}\text{Cl}$), and an « altered material signature » (assimilated or recycled) with higher Cl content and a more variable but typically higher $\delta^{37}\text{Cl}$.

The $\delta^{37}\text{Cl}$ homogeneity of hydrothermal fluids suggests that the phase separation process, widely responsible for chlorinity variations, does not fractionate chlorine isotopes. $\delta^{37}\text{Cl}$ on low temperature fluids may be explained by a seawater-rock interaction model with varying W/R ratios and temperature. Nevertheless, transport processes like filtration or diffusion may also have influenced the $\delta^{37}\text{Cl}$ of low temperature fluids.

Fresh and altered rocks from the Earth's mantle have systematically negative $\delta^{37}\text{Cl}$ values, unlike previously published data. This implies that the chlorine cycle, has to be reconsidered.