Li isotopic evidence for subduction induced mantle heterogeneity

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Cycling of Li through the hydrosphere causes significant (~30‰) fractionations of $^{7}Li/^{6}Li$. As a result, a flux of isotopically heavy Li is ultimately transferred to the mantle via subduction. Although little of this heavy Li appears to be lost to subduction zone lavas, the slab itself becomes isotopically light during dehydration. The Li isotopic system thus provides two valuable tracers of the ancient subduction, a heavy signature in past mantle wedge (and possibly subducted serpentinised mantle lithopshere) and a light signature in the slab itself.

Deviations of the Li isotopic compositions of mantle derived basalts from a terrestrial baseline can provide evidence of these recylced components within the convecting mantle. Such a terrestrial baseline, however, has not previously been well defined, but recent high precision analyses (±0.3‰) have put quite tight constraints on the composition of primitive mantle. The composition fertile peridotites determined by analysis of constituent minerals yield values of $\delta^{7}Li$ 3-4‰, overlapping with measurements of depleted mid-ocean ridge basalts (MORB). These values are also compatible with Li isotopic measurments of eucrites and type 3 chondritic meteorites from a range of groups (CO, CV, LL, H).

Compared to these reference values, the variability of Li isotopic ratios in ocean island basalts (OIB) is dramatic and provides clear evidence for the role recycling. $\delta^{7}Li$ ranges from values close to the mantle baseline (~3‰) up to very heavy values of 11‰. In general, OIB from locations that display with extreme radiogenic isotopic compositions (EMI, EMII and HIMU) also show isotopically heavy Li,. This implies that the most marked forms of mantle heterogeneity result from mixing of subduction modified mantle wedge, or serpentinised subducted lithopshere, back into the convecting mantle. These signatures are widespread and also evident in enriched MORB. In contrast, the much invoked role of the recycled slab in generating mantle heterogeneity is not evident in the Li isotopic system. OIB all tend towards higher $\delta^{7}Li$ than the mantle baseline and no lighter Li isotopic compositons have been measured in whole rock samples. Whilst some very light mineral phases from peridotite nodules have been reported, it appears that these are likely generated by late diffusive processes on a grain length-scale and are not representative of bulk compositions.