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Coupled Li-He isotope systematics in Icelandic basalt glasses

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We present new Li isotope data from a series of sub-glacially erupted basaltic glasses from the Miðfell-Mælifell fissure system, Reykjanes Peninsula, Iceland [1]. Previous work on these samples has shown that $^3He/^4He$ ratios are well correlated with major and trace element compositions [2]. The observed variation in $^3He/^4He$ values has been attributed to either small-scale mantle heterogeneity or variable addition of crustally derived radiogenic ^4He. The new Li data correlate well with the helium data. The high $^3He/^4He$ values have typical mantle δ^7Li values (+3.8 to +5.0‰) [3], whereas the more radiogenic $^3He/^4He$ samples show heavier δ^7Li values similar to altered oceanic crust [4]. Recycled oceanic crust can be excluded because during sub-duction and dehydration negative δ^7Li values are gene-rated [5]. The observed trend more likely originates from the Icelandic crust. Low lithium abundances of basaltic glasses with low $^3He/^4He$ ratios indicate that deeper part of the oceanic crust has been admixed.

We conclude that the magma supplying the Miðfell-Mælifell fissure system was derived from at least 2 different reservoirs: i) A high-$^3He/^4He$ (~20R_a) compo-nent with normal unaltered mantle δ^7Li values and, ii) An altered oceanic crust component with low Li content, high δ^7Li values and a lower time-integrated $^3He/^4He$ ratio.

References

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Li isotope signatures of ocean island basalts

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It is well established that there is a fundamental difference in the geochemistry of mantle derived basalts sampled at ocean islands and mid-ocean ridges. The causes of the difference in 'enrichment' have major implications for the structure and history of the mantle. A 'recycled' origin for the enriched material in OIB has long been inferred from a combination of non-volatile radiogenic isotope tracers (Sr, Pb, Os). Stable isotope measurements are a powerful means of ground-truthing this interpretation as their variations are dominantly imparted by low temperature (near surface) processes. Here we use Li isotope measurements, that are a particularly sensitive tracer of recycled material. Lithium has two stable isotopes (^6Li and ^7Li) that are strongly fractionated in the hydrological cycle, such that subducting oceanic crust has heavy δ^7Li and is also strongly elementally enriched in Li.

We have studied the Li isotope ratios of a wide number of OIB that span most of the global range of radiogenic isotope compositions. A striking feature of our results is that there is a notable range in δ^7Li, □□□□□□4‰, compared to an analytical uncertainty of ~±0.25‰. As a first order observation, this demonstrates variable contributions of recycled material in OIB sources. Individual OIB localities show a significant range in δ^7Li □lthough averages vary between localities. δ^7Li ranges from values close to N-MORB (~3-4‰) in Iceland to as high as 7‰ in Fogo, Cape Verde. HIMU lavas from the South Pacific also show relatively heavy values, δ^7Li~5‰.

At face value, the range in δ^7Li in OIB to values significantly heavier than N-MORB implies contributions from subducted oceanic crust with heavy δ^7Li. However, dehydration during subduction transfers heavy δ^7Li from the altered oceanic crust to the overlying mantle. This is inferred from recent work on exhumed oceanic eclogites [1] and the compositions of arc lavas [2]. Thus the heavy δ^7Li of many OIB likely reflect the involvement of down-dragged mantle, viscously coupled to the slab, rather than the subducted plate itself. Indeed there is scant evidence for the presence of the dehydrated altered oceanic crust in OIB sources. This material should have very light δ^7Li values which are not observed. Thus inferences on the nature of OIB sources from Li isotope systematics are strikingly different those from radiogenic isotopes.

References

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