Variation of lithium isotopic composition in terrestrial systems

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Considerable advance has been made in the last two decades toward accurate and precise lithium isotope measurement. Consequently, Li isotopic compositions of many of Earth's reservoirs are now known. A summary of the current knowledge is presented here, together with an examination of the global isotope balance.

Li isotopic compositions (δ^7Li relative to L-SVEC) of fresh mid-ocean ridge basalts vary between 1.5 and 5‰. Hawaiian shields display a similar range (2.5 to 5.7‰). Based on these analyses the mantle has $\delta^7Li = 4.2 \pm 0.8$‰. On the continent, Canadian Shield rocks fall within the range of 6.7 ± 2.8 ‰. Shales have 5.6 ± 1.4‰. Island arcs span a range from -0.3 to 11.2 ‰ with an average of 3.7 ± 1.6 ‰. A Chinese loess sample yields 3.9 ‰. These values suggest that there is no large isotopic fractionation associated with the extraction of crustal material from the mantle. Unaltered 0.6 Ma rhyolites from the Yellowstone National Park are exceptionally light (-3.6 to 0.7‰) due to crustal contamination associated with caldera collapse.

Seawater is homogeneous in Li isotopic compositon (32‰), its principal sources being rivers and hydrothermal fluids from mid-ocean ridges. δ^7Li of river waters vary widely (6 – 37‰), reflecting lithology and weathering intensity. The global mean is 24‰. River suspended materials (-2 to 6‰) are lighter than the dissolved load as a result of large fractionaton during the weathering process. Marine sediments have a similar range, –0.3 to 5.6‰ (average 2.7 ± 1.6‰). Oceanic crust altered at low temperature by seawater is enriched in Li and isotopically heavy (up to 21‰) due to incorporation of marine Li in the alteration phases. In contrast, hydrothermally altered crust is light; the complementary high temperature fluids have δ^7Li of 7.5 ± 1.6‰. Li isotopic compositions of subducted sediments and altered oceanic crust provide important constraints on the recycling of crustal material in the subduction environment.

The total Li isotope range in terrestrial systems is about 60 ‰ (-11 to 47 ‰). The lightest compositions are found in eclogites and the heaviest in groundwaters and highly reacted sediment pore waters. Using reasonable estimates for the inventory of major reservoirs and the known isotopic ranges, the integrated δ^7Li of non-mantle reservoirs is similar to that of the mantle.

Precise determination of REE and Y in GSJ standard rock samples JP-1 (peridotite) by microconcentric desolvating nebulisation ICP-MS

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Compiled values of trace and rare earth element (REE) concentration for GSJ standard rocks JP-1 (peridotie) are mostly preferable rather than recommended ones. Major limitations are its extremely low concentration (at ng g^{-1} level) and ultramafic properties. We determined REE and Y concentrations of JP-1 by taking the advantages of high sensitivity and low oxide interference of ICP-MS fitted with a microconcentric desolvating nebulizer.

Digestion of powder sample followed a modified acid method. Sample was first treated with HF/HNO_3 in ultrasonic bath before attacked by $HF/HClO_4$. The whole procedure was done in a class 100 clean room that confidently reduced blank contributions to be ignored (1% for all analyte except Eu and Sm which were around 3%). Low blank is fatal important when ultra low concentration sample is measured.

A low flow desolvating nebulizer (Aridus® MCN6000; CETAC) was used for sample introduction to ICP-MS (PQ3, VG Elemental). Sensitivities achieved were 430,000 and 270,000 cps/ppb for ^{115}In and ^{209}Bi, respectively. Moreover, oxide levels are reduced by 2 order compared with a normal operating mode, so that middle REEs evidently avoided from polyatomic interferences, such as BaO on Eu and PrO on Gd.

Our new data for JP-1 produced a smooth, coherent REE pattern exhibiting no convex curve of LREE, nor anomalies of Ce and Sm (Makishima and Nakamura, 1997). The new data for JP-1 are critically different to suggested values of GSJ (Imai et al., 1995). With high sensitivity and desolvating performance of ICP-MS, the internal precisions were highly improved, especially for MREE. The precisions here are equivalent to or better than those obtained by sector high-resolution ICP-MS for same type samples (PCC-1 and DTS-1; Jain et al., 2000). The overall reproducibility with the procedure are 2-5% (1s) for REEs except for Nd, Sm, Eu and Gd which are around 6% (1s). On the basis of demonstrated excellent precision and REE pattern, we conclude that our new values for JP-1, yielded by ICP-MS fitted with MCN6000 are the best estimate.

References

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