

Lithium isotopic fractionation during continental weathering

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Lithium is a fluid-mobile element whose isotopes are increasingly being used to trace fluid processes in and on the Earth. It is well established that natural waters are isotopically heavy due to preferential partitioning of ^7Li into fluids in equilibrium with minerals (Chan et al., 1992). Thus, weathering horizons developed on crystalline rocks are expected to become progressively depleted in Li and isotopically lighter as the degree of weathering (hence lithium leaching and exchange between bedrock and fluids) increases. However, the opposite trend is found for weathering of MOR basalts on the sea floor (Chan et al., 1992) and subaerial weathering of basalts in Hawaii (Huh et al., 2002). In these cases, both $\delta^7\text{Li}$ and Li ppm increase progressively with weathering, as seawater lithium (+32‰ $\delta^7\text{Li}$) is fixed in the alteration products (for MORB) or is introduced through sea spray (in the Hawaiian basalts).

We measured the lithium concentration and $\delta^7\text{Li}$ of two well-characterized weathering profiles in saprolites developed on crystalline rocks (a granite and a greenschist) in the coastal plain of South Carolina (Gardner et al., 1981, Gardner and Nelson, 1991). The greenschist is relatively unweathered, as measured by its "chemical index of alteration" value (CIA, Nesbitt and Young, 1984) of 51 and has a high Li concentration (30 ppm) and light isotopic composition ($\delta^7\text{Li} = -4\text{‰}$) for a mafic igneous rock, which must relate to its metamorphic history. $\delta^7\text{Li}$ of the overlying saprolite shows a negative correlation with CIA ($r^2 = 0.6$), with the most severely weathered samples having the highest CIA (95) and lowest $\delta^7\text{Li}$ (down to -20‰) and the least weathered saprolites having both CIA and $\delta^7\text{Li}$ approaching that of the greenschist. Lithium concentrations show a more scattered ($r^2 = 0.4$), negative correlation with CIA. These data are thus consistent with equilibrium fractionation of lithium between surface waters and rock, where progressive weathering results in leaching of lithium, leaving behind a isotopically light regolith. Preliminary data for the granite weathering profile show $\delta^7\text{Li}$ increasing with depth but over a much more restricted range in $\delta^7\text{Li}$ values (-6.8 to $+2.3\text{‰}$).

References

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Cosmogenic Radionuclides in Large Iron Meteorites

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Long-lived cosmogenic nuclides, ^{10}Be ($T_{1/2}$: 1.5 my), ^{26}Al (0.71 my), and ^{53}Mn (3.7 my) have been measured in Gibeon (IVA) iron meteorite and some large iron meteorites. Gibeon has the lowest content, 0.035% of phosphorus, which gives no extra-production of ^{26}Al . The distribution of these nuclides as a function of the depths in a 2 pi geometry seems to be common. Not only the metallic phase, but also some inclusions of troilite have been examined. Canyon Diablo, Odessa, Sikhote Alin, and Cape York were used to separate schreibersites. They were dissolved in HCl leaving phosphides residues. Comparisons with Gibeon have been made for Campo del Cielo and for the Brenham pallasite.

For ^{10}Be and ^{26}Al , AMS method was applied. For ^{53}Mn a neutron activation method was performed using neutrons in the JRR3 reactor. Because of higher sensitivity of the method, ^{10}Be data have been most reliable and we could use them as the reference among all. The depth profile can be approximated with simple exponential relations having a definite slope. The deepest Gibeon sample seems to contain 50000 times lower than that of the surface. In spite of such differences there is no way to judge before the determinations. The sampling was to be performed entirely randomly.

^{26}Al content in troilite has been found to be increased by production of ^{26}Al in S target. Some schreibersite inclusions have been separated from other irons, and higher productions of ^{26}Al in P target can be determined. These smaller mass differences between products and targets are quite similar to that for ^{53}Mn in Fe. The depth profiles can be compared with those for ^{10}Be in irons and in metallic phase of Brenham pallasite. Another example can be found for ^{26}Al production in Si target in olivine of Brenham. In spite of different compositions between stone and metal, the similar mass loss cause almost identical with the profiles with ^{53}Mn in metal. Although profiles of ^{10}Be and ^{26}Al in metal are similar, those of ^{10}Be in lower mass targets are entirely different.

Reference

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