Lithium Isotope History of Cenozoic Seawater: Changes in Silicate Weathering and Reverse Weathering

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A stepwise nine per mil rise in lithium isotope ratios in seawater (^{7}Li / ^{6}Li, δ^7Li_{SW}) over the past 60 million years requires large changes in continental chemical weathering and cation fluxes through the sea, implying episodes of tectonic uplift and CO_2 drawdown. Weathering of uplifted continental rocks plays a central role in controlling both climate and seawater chemistry by consuming CO_2 and releasing cations to the ocean. Lithium isotopes provide a unique record of these changes because lithium, unlike other tracers of ocean chemistry change, is hosted entirely in silicates. This new 68 Ma record of seawater chemical change reveals shifts in global tectonic forces connecting Earth-ocean-climate processes. From the Paleocene (60 Ma) to the Present, δ^7Li_{SW} rose 9‰, requiring large changes in continental forward weathering and seafloor reverse weathering consistent with pulsed tectonic uplift, more rapid continental denudation, increasingly incongruent continental weathering (lower chemical weathering intensity) and more rapid CO_2 drawdown.

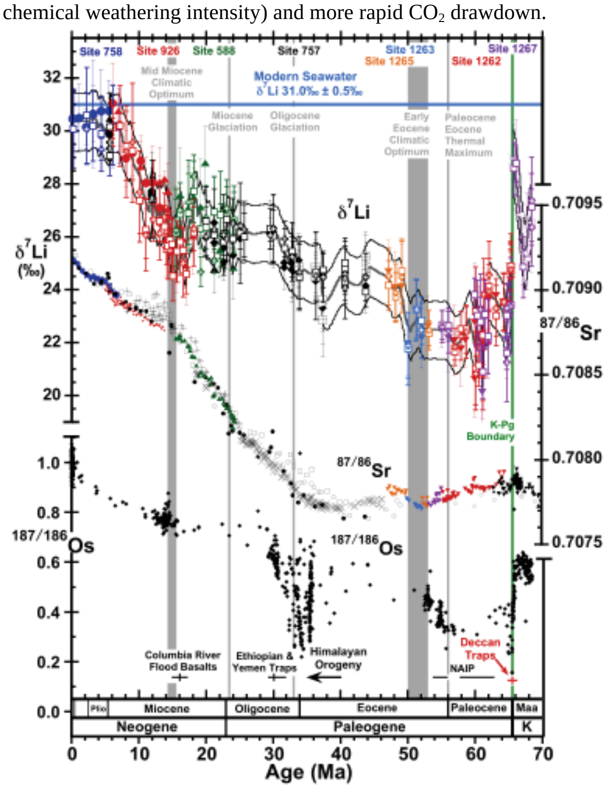

Figure: Li-, Sr-, and Os-isotope records over the past 68 Ma. The Li and Sr isotope records were reconstructed from forams in the same DSDP and ODP drill cores [1]. The Os-isotope data are from Peucker-Ehrenbrink & Ravizza (GTS 2012).

[1] Misra and Froelich (2012) *Science* (in press) (DOI: 10.1126/science.1214697).

Seawater Lithium Isotope Excursion Across the K-Pg Boundary: Chicxulub Impact vs. Deccan Traps

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A 4‰ drop in the ^{7}Li/^{6}Li ratio of seawater (δ^7Li_{SW}), from about 29‰ in the Late Cretaceous to 25‰ in the Early Paleocene, occurs within less than 0.5 Ma across the Cretaceous-Paleogene boundary (K-PgB, 65.68 Ma). Because δ^7Li_{SW} is sensitive to both very large Li-isotope fractionation factors and to changes in silicate sources and sinks on time scales of the Li residence time in seawater (τ_{Li} ~1.2 Ma) [1], this negative excursion must reflect a large and fast influx of ^{6}Li to the ocean, presumably from continental or seafloor silicates, the primary Li-reservoirs in the Earth's crust. It can not be due to rapid addition of isotopically light Li from (a) the Chicxulub bolide itself nor its impact crater, even if pulverized and instantaneously dissolved in the ocean, or from (b) congruent weathering of the simultaneously erupted Deccan Traps Large Igneous Province (δ^7Li_{Basalt} ~3.4‰). One possibility is that estimates of the volume of Deccan basaltic lavas 'missing" in the Geologic Record is an order of magnitude too low. Another possibility is that the conflagration from the Chicxulub impact deforested large portions of the continents and induced rapid acid-rain chemical weathering of incinerated continental soils that then washed into the ocean. In any event, the cause of this large fast δ^7Li_{SW} drop across the K-Pg boundary remains enigmatic.

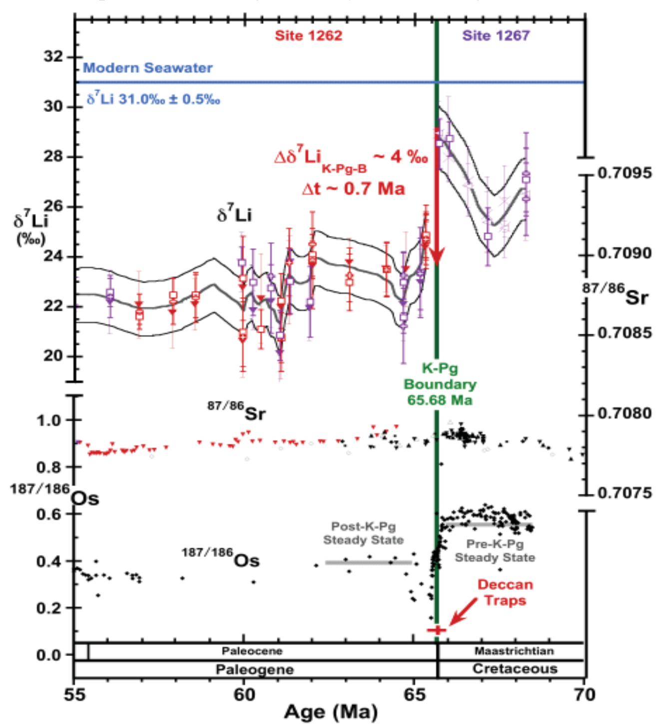

Figure: Li-, Sr-, and Os-isotope records across K-PgB. The lithium and strontium isotope records were recovered from forams in the same drill cores at ODP sites 1262 and 1267 [1]. Osmium isotope data are from Peucker-Ehrenbrink & Ravizza (GTS 2012)

[1] Misra and Froelich (2012) *Science* (in press).
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