## Controls on weathering kinetics and the $\delta$ 7Li of Himalayan rivers

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Chemical weathering of the crust plays an important part in geochemical cycling by redistributing elements between Earth's surface reservoirs. On a geological time scale chemical weathering buffers Earth's climate as atmospheric  $CO_2$  is consumed during the breakdown of silicate minerals and eventually stored as carbonates in the ocean. However there are many problems involved in quantifying the chemical fluxes associated with silicate weathering and their climatic impact. The key problems involve distinguishing between silicate and carbonate sources of riverine dissolved loads and understanding the nature of the cycling of solutes along groundwater and river flow paths.

An emerging field in studying chemical weathering is the use of light stable isotopes which readily fractionate during weathering reactions. They are probably the most sensitive proxies for continental weathering and have the potential of fingerprinting specific weathering processes. A recently constructed palaeo-record of the  $\delta^7$ Li of seawater show a 9‰ net increase over the last 60 Ma coinciding with the uplift of the Himalayas (Misra and Froelich, 2012). As opposed to the traditionally used <sup>87</sup>Sr/<sup>86</sup>Sr ratio which in addition to silicate weathering also reflects that of carbonates, lithium isotopes are almost exclusively associated with silicate weathering. Although records of ocean composition, where it is forced by riverine dissolved loads may reflect changes in the weathering regime on the continents it is important to understand the processes responsible for these changes. By studying the isotopic composition of dissolved and sediment loads of rivers and their tributaries it is possible to better constrain these controls. High erosion rates associated with high topographic relief give rise to incongruent weathering reactions. The rate of chemical weathering in these areas is limited by the kinetics of the chemical reactions, as opposed to areas with low erosion rates where weathering is transport-limited and congruent. The formation of secondary clays during incongruent weathering heavily fractionates Li isotopes, as the light isotope (<sup>6</sup>Li) is partitioned into the forming clays. The heavy Li isotope (<sup>7</sup>Li) is left in the dissolved phase which gets increasingly heavier as more clavs form, i.e. the more incongruent the weathering is. This is the case for modern Himalayan rivers which have dissolved loads several per mille higher than drained source rocks. With increasing weathering intensity the difference in  $\delta^7 Li$  between source rocks and riverine dissolved loads decrease. Several studies have highlighted this link between  $\delta^7 Li$  and weathering intensity (e.g. Kisakurek et al., 2005).

In order to understand the relation between weathering intensity and stable isotopic fractionation it is important to constrain both the mineralogical reactions and the ground water flow paths. Weathering reactions likely take place continuously within catchments with water flowing through a range of shallow to deep paths as rock is progressively weathered during exhumation. To model this it is necessary to consider how kinetically-limited fluid-mineral reactions will evolve along individual water flow paths and to understand the range of inputs to river systems. We show how such modelling yields the minimum amount of controlling parameters and can offer insight to the isotopic evolution along the water flow path.

A new method of isotopic analysis is currently under development, allowing simultaneous separation of several stable isotopes in one column passing. Results from MC-ICP-MS analysis of Alaknanda river waters will be presented with the preliminary results from modelling of the isotopic evolution along the river flow path.

## References

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