Correlation of Li and Si isotopes in Himalayan river waters

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Important controls on chemical weathering rates of silicate minerals include erosion rates, hydrology, precipitation, temperature and vegetation. Determining these in the more rapidly eroding terrains that provide the feedbacks that impact global climate is problematic.

Li and Si in river waters are both controlled by dissolution of silicate minerals coupled with uptake into clay minerals, a process which fractionates their isotopes. In Himalayan catchments in the headwaters of the Ganges we find a positive correlation between dissolved δ^7Li and δ^{30}Si from [1] (R^2=0.73 or 0.91 excluding two samples). Samples from the floodplain [2,3], excluding tributaries from the south, the Yamuna and two samples from the headwaters, lie close to this correlation (R^2=0.78). The excluded samples mostly lie at higher δ^{30}Si and may have been fractionated by uptake of Si by biogenic processes [3].

The evolution of Li isotopes along flow paths may be modelled by a simple 1-dimensional reactive transport model which considers dissolution, precipitation and advective flux [4]. Li isotopic variations are described by two dimensionless variables; (1) a Damköhler number, N_D, which relates the silicate dissolution rate to the fluid flux and fluid flow path length, and (2) the net partition coefficient of Li during weathering, K_{net}, combining a partition coefficient of Li between secondary clay minerals and water, and a stoichiometric removal coefficient. Combining this model with a modified version of a reactive transport model for Si isotopes [1], provides independent constraints on the Damköhler number and hence catchment hydrology and reaction rates.

Unlike Li which is a trace element, Si is a stiochiometric element of primary and secondary minerals. Given the stoichiometry of clay-producing reactions from common silicate minerals, the partition coefficient of Li between river waters and secondary clay minerals can be further constrained, and comparisons between catchments with different weathering reactions can be made.

[1] Fontorbe et al. (2013), *EPSL 381*, 21-30, [2] Frings et al., (2015), *EPSL 427,* 136-148. [3] Pogge von Strandmann et al. (2017), *GCA 198*, 17-31, [4] Bohlin and Bickle (2019), *EPSL 511*, 233-243