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Exploring the use of silicon isotopes as a (palaeo)weathering proxy

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Interpretation of metal(loid) stable isotope compositions in the Critical Zone (CZ) is often predicated on the assumption that the CZ can be treated as a steady-state batch reactor with only a limited number of important processes. Recently formalised as a series of mass-balance equations [1], this approach predicts that the isotopic composition of a river solute is directly related to the fraction of an element solubilised during weathering that is exported as a fractionated solid. It further suggests sedimentary isotope records can reflect palaeoweathering intensity, i.e. the ratio of chemical to total denudation.

To validate the palaeoweathering proxy, we explore these issues and the underlying assumptions further with a detailed silicon isotope mass balance at three sites defining a gradient of weathering intensity. These run from the tectonically inactive and supply-limited Sri Lankan highlands to kinetically limited Rhone Valley in the Swiss Alps, via Providence Creek in the Sierra Nevada mountains. At each site, we predict the Si isotope compositon of the streamwater using a mass-balance model based on silicon isotope ratios of bedrock, bulk soil and clay separates, long-term denudation rates from cosmogenic ^{10}Be, and Zr-normalised elemental depletion profiles. Compared to measurements, these calculated values are systematically lower by 0.4 to 1.5‰, a pattern also repeated elsewhere. In other words, the data suggest more heavy ^{30}Si is being exported than is crossing the weathering front, or more light ^{28}Si is retained.

We explore possible explanations and their implications for the use of isotopic palaeoweathering proxies, including (i) the absence of steady-state weathering, (ii) the export of biotically fractionated Si (i.e. phytoliths), (iii) the preferential erosion of secondary phases relative to primary minerals and (iv) vertical heterogeneity in weathering processes.

[1] Bouchez, J., von Blanckenburg, F. & Schuessler, J. A. (2013) *Am. J. Sci.* 313, 267-308, doi:10.2475/04.2013.01