Differential weathering inferred from cosmogenic nuclides in multiple detrital minerals

CLIFFORD S. RIEBE[1], HEATHER E. ROGERS[1], ANGUS K. MOORE[2] AND DARRYL E. GRANGER[2]

[1]Department of Geology and Geophysics, University of Wyoming (correspondence: criebe@uwyo.edu)
[2]Department of Earth, Atmospheric, and Planetary Sciences Purdue University

Cosmogenic nuclides in detrital minerals reflect the amount of time they have been exposed to cosmic radiation near Earth's surface. This makes them useful in quantifying erosion rates averaged over the contributing area of the detrital minerals. However, accurate quantification of erosion rates is complicated by the fact that different minerals weather at different rates; minerals that are relatively resistant to chemical weathering are lost from the soil more slowly and thus have longer residence times than other, less resistant minerals. This introduces bias in the build up of cosmogenic nuclide concentrations in different minerals; those with longer residence times will become enriched in their cosmogenic nuclides relative to concentrations that would be measured in the absence of differential weathering. If unaccounted for, this bias can introduce significant errors in cosmogenic nuclide studies of erosion; erosion rates inferred from cosmogenic nuclides in quartz, for example, can be in error by a factor of two or more in intense weathering environments [1].

Here we show how the chemical erosion bias can be exploited to quantify differential weathering when measurements of cosmogenic nuclides are available in multiple minerals. The approach measures differential weathering of two minerals by gauging the departure of the measured nuclide ratio from the ratio of the nuclide production rates at the surface. An analysis of data from the literature suggests that these departures may be as big as a factor of two or more for some mineral pairings, implying that the nuclide ratio is a sensitive function of differential weathering. We show that the approach can be applied to the same nuclide in different minerals, such as ^{10}Be in quartz and magnetite, or, more generally, to different nuclides in different minerals, such ^{3}He in olivine and ^{10}Be in magnetite. We discuss applications of the approach to a 2500 m altitudinal transect spanning the Southern Sierra Critical Zone Observatory.

[1] Riebe & Granger (2013) *Earth Surf. Proc. Land.* **38**, 523-533.