Geophysical Research Abstracts,
Vol. 11, EGU2009-0, 2009
EGU General Assembly 2009

New ways of using an old isotopic system – meteoric 10-Be is back and ready to do geomorphology

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Meteoric 10-Be, produced in the atmosphere and delivered in precipitation, is an important tracer of sediment and geomorphic processes. This talk will review several decades of work measuring 10-Be adhered to soil and sediment collected from varied terrains around the world. We will then present new data and modeling approaches demonstrating the rich potential but complex, dynamic nature of this isotope system. Considering all of these data, we will examine the utility of meteoric10-Be, produced in the atmosphere and delivered in precipitation, as a tracer of watershed and hillslope sediment transport processes at a variety of spatial scales. We will finish the talk by examining uncertainties that require additional research to resolve.

After a brief hay-day in the 1980s, tracing sediment down rivers, dating a few terraces, and following sediment through subduction zones, meteoric or garden variety 10-Be was largely forgotten. It's been lurking somewhere in the dark corners of isotope geoscience while its more famous but difficult-to-measure twin, the 10-Be produced in quartz, got all the attention. Recently, several research groups have again begun to build upon the excellent foundation constructed by those working in the 1980s and early 1990s.

New data from a series of soil pits on hillslopes from around the world suggest that meteoric 10-Be is mobile in the soil column moving from the more acidic, organic-rich A-horizon to the B-horizon. Meteoric 10-Be concentrations are well correlated with both soil pH and extractable Al suggesting that Be is retained in Al-rich grain coatings that we know, from numerous attempts to purify riverine quartz, survive fluvial transport all too well. The important take-away message is that meteoric 10-Be is mobile in soil fluids while in situ 10-Be only moves with the quartz grains in which it resides. Depth profiles of in situ and meteoric 10-Be can be quite different, helping us to learn about rates of soil stirring and 10-Be translocation.

Both new (New Zealand and central Appalachians) and existing data (Potomac, Europe, South America) suggest that the concentration of 10-Be adhered to sediment can be used to estimate basin-scale rates of denudation as well as to trace, through mixing models, the source of sediment in a watershed. The approach is founded on the work of Brown et al. (1988) and employs similar thinking to the approach taken when in situ 10-Be is used to estimate basin scale rates of erosion (Bierman and Steig, 1996; Granger et al., 1996; Brown et al., 1995) and mixing at tributary junctions. Comparison of in situ and meteoric 10-Be concentrations measured in the same sediment samples can suggest the depth and style of erosion when the depth dependence of meteoric 10-Be has been constrained by soil pit profiles and a bit of guesswork.

Lingering uncertainties (and significant opportunities for research) include poorly constrained delivery rates of 10-Be from the atmosphere over both time and space as well the effect of sediment grain size and mean annual precipitation on meteoric 10-Be concentration.