Modelling of carbonate and silicate inputs to the riverine dissolved load

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Distinction of the fraction of cations derived from carbonate and silicate sources is essential to quantifying silicate weathering fluxes and important to understanding the controls on the composition of the dissolved load of rivers. Sets of tributaries draining single tectonic units of restricted geological provenance in the Alaknanda catchment, headwaters of the Ganga, exhibit coherent arrays on element and isotope ratio diagrams indicative of two component mixing (c.f. Singh et al., 1998). Extrapolation of mixing curves to zero Na allows calculation of element and isotope ratios of the carbonate end-member. This allows investigation of a number of aspects of the weathering processes. The carbonate end-member derived from the largely silicate gneisses of the High Himalayan Crystalline Series can be shown to be derived from a mixture of trace carbonate in the silicate rocks and carbonate from the rare massive calc-silicate horizons. Sr/Ca ratios of the carbonate end-member, inferred from the array of tributary compositions, are consistently ~ 80% higher than the mean Sr/Ca ratios of carbonate rocks within the individual catchments. Although this difference might be explained by precipitation of pedogenic carbonate (Galy et al., 1999), the amount carbonate so precipitated is unreasonably high. We suspect that the high Sr/Ca ratios in the waters arise from preferential dissolution of the more Sr-rich carbonate.

Determination of the end-member silicate component is more complex because it is not possible to characterise the silicate end-member with unique cation ratios. Modelling of $^{87}Sr/^{86}Sr$ ratios, and making the questionable assumption that the $^{87}Sr/^{86}Sr$ ratio of the silicate component is similar to that of average silicate bed rock, allows estimates of the composition of the silicate end-member.

References

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Tracking landscape-scale sediment generation and transport using in situ produced 10-Be and 26-Al

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Measurement of ^{10}Be in quartz-bearing sediment provides a unique means by which to trace sediment from its production on hillslopes through transport down drainage networks. We use 5 examples to illustrate the utility of this methodology at different spatial scales.

Quantifying basin-scale sediment generation rates

Forty sediment samples from the 178 km^2 Drift Creek watershed drainage network in maritime coastal Oregon demonstrate that cosmogenic estimates of sediment production (about 100 m/My) are similar to those derived by other means including suspended sediment yield and the filling and emptying rates of colluvial hollows.

More than 70 samples from drainage basins ranging in size from 1 to >300 km^2 in the humid, temperate Great Smoky Mountains show that erosion in this part of the southern Appalachians is spatially and temporally uniform and occurs at an average rate of about 30 m/My.

Sediment samples (n=52) from the 14,000 km^2 semi-arid Rio Puerco drainage network of northern New Mexico demonstrate the utility of cosmogenic sediment analyses at much larger scales. We find that small drainage basins have highly variable rates of sediment generation (7 to 355 m/My) but that variability dampens significantly downstream as sediment is well mixed by fluvial processes.

Understanding Sediment Transport

Yuma Wash is an active ephemeral stream draining 187 km^2 of arid southern Arizona. Samples taken from the main stem show a distinct downstream lowering in nuclide activity. Using mixing models, we quantify the percentage of low-activity bank sediments entering the stream by lateral erosion. When Yuma Wash enters the Colorado River, about 40% of the sediment it carries is derived from its banks and 60% from highland erosion.

Cosmogenic nuclide analyses of amalgamated surface sediment samples show that cosmic-ray dosing, and thus sediment transport, are remarkably regular down kms-long desert piedmonts, both those with incised drainages and those where rapid channel migration occurs. Simple interpretative models indicate that the average sediment grain moves down piedmont at speeds of dm per year on the four Mojave Desert piedmonts we have sampled so far.