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Old sediment in young rivers- a multiple cosmogenic nuclide study in the Amazon basin

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The burial dating technique using in-situ produced cosmogenic isotope pairs (26Al and 10Be) of stationary geomorphic units like terrace deposits has become a valuable tool in deriving sediment deposition chronologies or paleo-denudation rates. In this study, we use 26Al/10Be ratios in detrital sediment from Amazonian rivers to explore the degrees of pre-erosional floodplain burial duration and burial depth as well as degrees of sediment mixing between the active modern rivers and old floodplain reservoirs. 26Al/10Be ratios below a surface production rate ratio of ∼6.5 indicate sediment burial, as production of nuclides ceases due to deep shielding in the floodplain and differential decay of 26Al over 10Be causes 26Al/10Be ratios to decrease. Burial depths and durations can be constrained from a modified version of the erosion island plot (26Al/10Be ratio vs. 10Be nuclide concentration diagram) calculated for continuous irradiation during shallow burial.
In order to constrain sediment mixing, we analyzed >40 samples for their 26Al/10Be ratios, encompassing the Andean as well as the Guyana and Brazilian Shield headwaters, and the main Amazonian lowland rivers that receive sediment from these differently eroding source areas (Solimões, Amazon, Madeira, Tapajós). The following first-order implications emerge: (i) samples from rapidly denuding Andean headwater streams typically are not affected by burial. (ii) in the Guyana and Brazilian Shield headwaters, average 26Al/10Be ratios are ∼5.0, with burial durations between 0.5-1.0 Myr at burial depths around 3 m. (iii) in lowland rivers of central Amazonia that mostly drain the cratonic headwaters (Tapajós, Madeira), coarser grain sizes (> 500 μm) yield 26Al/10Be ratios similar to their cratonic headwaters, whereas finer grain sizes (125-500 μm) reflect the unburied modern stream sediment. (iv) in lowland rivers receiving most sediment from Andean headwaters (Solimões, Amazon), no trend for burial ratio vs. grain size is observable, and typical 26Al/10Be ratios of the main Amazon River are ∼5.3, with associated average burial durations of <1 Myr at average depths of ∼12 m. Here, also finer grain sizes show deeper burial at ratios <5.0. We observe that when plotted in an erosion island plot, central Amazonian samples evolve along mixing lines between a non-buried Andean end member (represented by modern fluvial sediment produced from hillslope erosion in the source area under continuous cosmic-ray exposure), and a deeply buried end member represented by ∼Miocene floodplain sediment. The slope of the mixing lines is hereby a function of the prevailing denudation rate prior burial. For the Miocene floodplain end member, very low burial ratios of ∼ 3.0 and long burial durations of ∼10 Myr have been measured (Wittmann and von Blanckenburg, 2009). This buried sediment is incorporated into modern, Andean-derived sediment during channel avulsions. Using this dataset, we cannot only constrain the mixing of sediments from different provenances in the classical sense, but can also trace mixing fractions and account for floodplain burial of sediment along the long transfer of sediment from their source areas to the central Amazonian lowlands.(Wittmann, H., and von Blanckenburg, F., 2009, Cosmogenic nuclide budgeting of floodplain sediment transfer: Geomorphology, v. 109, no. 3-4, p. 246-256.)