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Cosmogenic nuclides in the Earth's largest rivers – lessons for deriving global denudation and buffering timescales of sediment transport

Hella Wittmann[1], Marcus Oelze[1,2], Jerome Gaillardet[3], Eduardo Garzanti[4], and Friedhelm von Blanckenburg[1,5]

[1]Deutsches GeoForschungszentrum GFZ, Oberflächennahe Geochemie, Potsdam, Germany (wittmann@gfz-potsdam.de)
[2]BAM Bundesanstalt für Materialprüfung und -forschung, Berlin, Germany
[3]Institut de Physique du Globe, Paris, France
[4]Department of Earth and Environmental Sciences, Università di Milano-Bicocca, Milano, Italy
[5]Institute of Geological Sciences, Freie Universität Berlin, Germany

Knowledge of the flux of material eroded and transported from mountains to oceans is a key factor across the Earth Sciences, for constraining global carbon cycling, interpreting the sediment record properly, and environmental management. The analysis of cosmogenic nuclides in sediment of large rivers has been shown to derive mean denudation rates of the sediment-producing areas, averaging out the local variations commonly found in small rivers. When analyzed in Earth largest rivers, cosmogenic nuclides provide the possibility to constrain global mean denudation rates that integrate over millennial time scales and to compare those longer-term fluxes to those from decadal-scale river monitoring. Using this approach, we measured *in situ* cosmogenic ^{26}Al and ^{10}Be in sand of >50 large rivers over a range of climatic and tectonic regimes covering 32% of the Earth's terrestrial surface.

In 35% of the analyzed rivers, we find ^{26}Al/^{10}Be ratios to be significantly lower than these nuclides´ surface-production-rate ratio of 6.75 in quartz, indicating radioactive decay over periods exceeding 0.5 Myr. We invoke a combination of slow erosion, shielding in the source area, and sediment storage and burial during long-distance transport to explain these low ratios. In the other 65% of studied rivers we find ^{26}Al/^{10}Be ratios to be within uncertainty of their surface production-rate ratio, indicating cosmogenic steady state. For these rivers, we obtain a global source area denudation rate of 141 t/km^2/yr (54 mm/kyr of rock-equivalent) that translates to a flux of 3.07 +/- 0.56 Gt/yr. By assuming that this sub-dataset is representative of the global land surface, we upscale this value to the total surface area for exorheic basins, thereby obtaining a global denudation flux of 15.2 +/- 2.8 Gt/yr that integrates over the past 11 kyr. This value is slightly lower than published values from cosmogenic nuclides from small river basins (23 (+53/-16)) Gt/yr) upscaled using a global slope model, and also lower than modern sediment and dissolved loads exported to the oceans (24.0 Gt/yr). Our new approach confirms an estimate of global dissolved and solid matter transfer that converges to an encouragingly narrow range of within 35% of previous estimates. The use of paired nuclides in large rivers hence provides estimates of the

buffering timescales of sediment transport. The Myr-scale duration of this buffering derived for rivers with low Al/Be ratios has important implications for interpreting the sediment record obtained from these mostly dry and slowly eroding river basins. Evidently in these basins, the eroding mountain source is not directly linked to downstream sediment archives, resulting in poor connectivity within the sediment routing system.