Dual ^{10}Be isotope systems constrain the source of sediment and rate of erosion for the tropical Barron River catchment, Queensland, Australia

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Abstract

In order to understand source of sediment and rate of erosion for Barron River catchment, which heads on the Atherton Tablelands of northeast Australia, crosses the northern Queensland escarpment and drains into the Coral Sea, we collected fluvial sediment and measured both in situ and meteoric ^{10}Be contents on the medium sand fraction. We collected fourteen samples from rivers and streams including large regional drainages and small tributaries. The upland basins are characterized by lower relief and less precipitation than the steeper and wetter escarpment basins. One sample is quartz sand from the Coral Sea beach at Yorkey's Knob, below the escarpment. Sand from the Barron River upstream of the escarpment integrates the upland basins and has an in situ ^{10}Be concentration of 2.31±0.84 x10^5atoms/g and an erosion rate of 17.2 m/My (calculated using the CRONOS on-line calculator). This is similar to a major upland tributary (2.51±0.40 x10^5 atoms/g; 15.2 m/My) and two smaller upstream tributaries (20.5 m/My and 21.4 m/My). Escarpment streams have less in situ ^{10}Be in their sediment (mean = 1.64±0.55 x 10^5 atoms/g, n=8) and higher basin area-weighted erosion rates (37.2 m/My). Based on the in situ measurements, the uplands are eroding at approximately half the rate of the escarpment basins. The beach sand has an in situ ^{10}Be concentration (2.75±0.19 x 10^5 atoms/g) similar to the upland sediment suggesting that the source of beach sand is the larger but more slowly eroding Tablelands. In contrast, the meteoric ^{10}Be concentrations of Barron River sand-sized sediment collected above the escarpment is ~4 fold lower ($2.55x10^7$ atoms/g) than the average meteoric ^{10}Be concentration of the 8 escarpment samples (9.94 ± 4.49 $x10^7$ atoms/g). This discrepancy cannot be explained by differences in annual average precipitation which ranges only from 1.9 to 2.3 m/yr but likely results from the deep mobility of meteoric ^{10}Be in oxic Tableland soils. Considering meteoric ^{10}Be as a tracer gives results consistent with the in situ ^{10}Be measurements. Beach sand ($3.98x10^7$ atoms/g) has a similar meteoric ^{10}Be concentration to upland river sand implying preservation of the soil-derived meteoric ^{10}Be signal both downstream in the fluvial system and during littoral transport. We can estimate the basin-wide erosion rates considering meteoric ^{10}Be concentrations and estimated meteoric 10Be delivery rates (1.46 to 1.71 x 10^6 atoms/(cm2*y). Using the measured meteoric ^{10}Be concentration of Barron River sand upstream of the escarpment results in a Tableland model erosion rate >200 m/My, about an order of magnitude higher than the in situ estimate from the same sample. The results are similar for the 5 other upland samples The average meteoric ^{10}Be-derived escarpment erosion rate is ~50 m/My, about 20% higher than the in situ erosion rate estimate and well within the uncertainty of long-term meteoric ^{10}Be delivery rates. These data suggest that basin wide erosion rates derived from sand sized meteoric ^{10}Be measurements may not be reliable in oxic soil environments.

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