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Spatial variability of erosion rates from frequency distribution of cosmogenic ^{3}He in olivine grains from Hawaiian river sediments.

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To constrain the spatial distribution of erosion rates in a drainage basin we constructed a frequency distribution of cosmogenic ^{3}He concentrations (^{3}He$_c$) from helium isotopic measurements in olivine grains from a single sample of river sediment. The sediment sample is from the Waimea River, on the western side of the island of Kauai, Hawaii. Helium measurements were made in 26 aliquots of $\sim$30 olivine grains each. The ^{3}He$_c$ concentrations were calculated using: (i) the $^3He/^4He$ ratio measured by crushing and (ii) the ^{3}He and ^{4}He concentrations measured by melting the resulting powder. The average ^{3}He$_c$ concentration from the 26 aliquots was used to estimate a basin wide average erosion rate of 0.056 mm/yr. However, forward models of sediment generation rates suggest that the observed ^{3}He$_c$ frequency distribution is unlikely to be explained by a single, basin wide erosion rate. Instead, a distribution of erosion rates, ranging from $\sim$0 to 4 mm/yr, may account for the observed frequency distribution. The variation in erosion rates can be modeled by both nonlinear slope- and curvature-dependent erosion rates with power law exponents ranging from 2.0-2.5. Nevertheless, the spatial distribution of predicted cosmogenic nuclide concentrations for slope- and curvature-dependent erosion rates are distinct, and we propose strategies to test further the extent to which erosion rates may be partially controlled by macroscale topographic features. Our study indicates that constructing frequency distribution of cosmogenic nuclides in river sediments combined with numerical modeling of erosion rates, can provide unique insights into both the spatial variability of erosion rates in a drainage basin and constraints on the form of parameterized erosion laws.