Geophysical Research Abstracts
Vol. 21, EGU2019-5392, 2019
EGU General Assembly 2019

The Importance of Non-vertical Flux in the Interpretation of Detrital Cosmogenic Nuclides Concentrations

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Detrital cosmogenic nuclides (DCN) concentrations are interpreted in terms of catchment-averaged erosion rate. This is based on the relationship that DCN concentration depends on the production of cosmogenic nuclides integrated over the catchment area per unit time divided by the volume of rock moved through that surface per unit time. The latter term is defined as a flux which is the volume of rock per area per unit time. Erosion rate is obtained by solving this ratio for vertical velocity, whereby the area cancels and erosion rate depends on production rate and DCN concentration. However, if rock motion is non-vertical, the surface area used for this flux is different from the catchment area. In this case, the area for the flux should be the catchment surface projected onto the plane normal to the direction of rock velocity. In this case the velocity of the rock derived from DCN concentrations can be an order of magnitude different from the conventional, vertical erosion rate. We present here two methods for this flux calculation. The first is to find the area enclosing the projection of the catchment surface onto the plane normal to rock velocity, then use this projected area for the flux instead of the catchment area. The second way is to discretise the catchment surface into a set of elemental surfaces, and calculate local flux vectors through these elemental surfaces, summing them into a catchment total flux. An example where this new formulation is important is the erosion of escarpments, for example, along passive margins. With a retreating escarpment, the surface moves approximately horizontally with respect to the rock, so erosional flux is horizontal. We have made a global compilation of DCN measurements of escarpment-draining catchments and applied our horizontal flux method. We find that escarpments are retreating horizontally at rates between 100-2500 m/Ma. Channel slope-drainage area scaling can be used to confirm the horizontal motion of rock. Channel steepness of escarpment-draining basins are calculated and regressed for the same DCN basin compilation. The channel steepness and escarpment retreat rates are consistent with the independent theoretical scaling relationship proposed by Willett et al. (Nature, 2018).