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Do changes in denudation rates correlate with a shift in hillslope processes? – A case study from the Quebrada del Toro, NW Argentina

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Mean basin erosion rates tend to increase linearly with mean basin slope up to a threshold of ∼25 to 30°. It has been suggested that once river incision creates hillslopes that are steep enough to initiate landsliding, any further increase in erosion rates is accommodated by an increase in landslide frequency and not by further steepening of hillslope angles. However, empirical evidence correlating erosion rates, mean hillslope angles and hillslope processes are limited.

In this study, we first compare *in-situ* ^{10}Be concentrations of fluvial sand from the Quebrada del Toro in the southern Central Andes with our mapped inventory of five distinct hillslope processes (deep-seated landslides, gullying, scree production, stream incision, diffusion) to investigate potential correlations among topographic metrics, erosion rates, and erosion processes. We find that sand-derived basin mean denudation rates increase non-linearly with mean basin slope, similar to what previous studies have observed. In addition, we observe a shift in the type of hillslope processes as mean basin slopes and denudation rates increase from stream incision to scree production, gullying and finally, to deep-seated landslides. We find that gullies, rather than deep-seated landslides, are particularly important in threshold areas.

Second, we test if a signal of those processes may also be recorded in sedimentary deposits. Mass-wasting processes on hillslopes contribute low-^{10}Be-concentration material to the fluvial system, due to the exponential decrease in ^{10}Be production with depth. Additionally, earlier studies have suggested that gravel is mainly produced by localized, deep excavation processes (such as landslides and debris flows), while sand is produced uniformly in the catchment. Following those assumptions, the shift in hillslope processes may also be recorded in sedimentary deposits by comparing the ^{10}Be concentration of two different grain sizes. We introduce the normalized sand-gravel index (*NSGI),* defined as the ^{10}Be concentration difference between the sand and gravel fraction normalized to their summed concentrations, as a potential proxy for hillslope-erosion processes. We measured the ^{10}Be concentration in fluvial gravels from 13 of the sampling locations. *NSGI* values show an overall positive linear increase with basin slope, implying an enhanced contribution of gravel with low ^{10}Be-concentrations in steeper catchments. However, we observe significant scatter in this correlation, particularly in lower-slope areas. We explain the majority of the scatter by reduced hillslope-channel connectivity due to sediment storage within the catchment. It appears as if only large differences in sand and gravel ^{10}Be concentration are a clear indication of the presence of non-diffusive hillslope processes in catchments where there is potential for transient sediment storage.