Geophysical Research Abstracts,
Vol. 11, EGU2009-5047-1, 2009
EGU General Assembly 2009

Tectonic interpretation of erosion rates at different spatial scales in an upliting block

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A theoretical framework is still lacking to interpret erosion rate data at differing spatial scales in active mountains in terms of erosion laws, climate or tectonics for transient landscapes. We explore the extent to which it is possible to convert erosion rate data into uplift rate or erosion laws, using a landscape evolution model. Transient stages of topography and erosion rates of a block uplifting at a constant rate are investigated at different spatial scales, for a constant climate, and for various erosion laws and initial topographies. We identify three main model types for the evolution of the mountain-scale mean erosion rate: "linear"-type, "sigmoid"-type and "exponential"-type. Linear-type models are obtained for topographies without drainage system reorganization, in which river incision rates never exceed the uplift rate and stepped river terraces converge upstream. In sigmoid-type and exponential-type models (typically detachment-limited or transport-limited models with a significant transport threshold), drainage growth lasts a long time, and correspond to more-than-linear transport laws in water discharge and slope. In exponential-type models, the mean erosion rate passes through a maximum that is higher than the rock uplift rate. This happens when the time taken to connect the drainage network exceeds half the total response time to reach dynamic equilibrium. River incision rates can be much greater than the uplift rate in both cases. In the exponential-type model, river terraces converge downstream. Thus, documenting erosion rates and the geometry of river terraces together should allow us to better constrain the limiting erosion processes. Observations of a mountain in the Gobi-Altay range in Mongolia support the exponential-type model. This suggests that the erosion of this mountain is either detachment-limited or transport-limited with a significant transport threshold. This study shows that drainage growth could explain differences in erosion rate measurements on different spatial scales in a catchment.