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Inverting longitudinal profiles of rivers to constrain the history of tectonic rock uplift rate: Application to the Inyo Mountains in western Basin and Range, CA.

Liran Goren, Matthew R. Fox, and Sean D. Willett
Department of Earth Sciences, ETH Zurich, Zurich, Switzerland (liran.goren@erdw.ethz.ch)

One of the major controls over the evolution of landscapes is the rate of tectonic rock uplift. A growing body of evidence shows that temporal changes in the tectonic rock uplift rate generate spatial variations in river steepness and upstream migrating knickzones. A well-established mathematical formulation, the detachment-limited stream power law, relates the history of rock uplift rate to the space and time derivatives of river long profiles. However, the inverse problem of inferring the history of rock uplift rate from the longitudinal profiles of fluvial channels has only recently become a subject of investigation, despite its unique potential to constrain past and present tectonic uplift rate directly from digital topographic data.

The detachment-limited stream power law relates the change of channel elevation through time to tectonic rock uplift rate and to erosion rate. The erosion rate is described as a power law function of the upstream drainage area, A^m, and the local slope, S^n, where m and n are positive exponents. In this work, we present a close form integral solution to the above formulation for the linear case, where $n = 1$. The integral solution is formulated as an inverse problem and used to extract U/K as a function of K-scaled time, where K, the erodibility, depends on geological and climatic conditions. The inversion algorithm is unexpectedly simple and computationally efficient.

We apply the inversion procedure to the Inyo Mountain range in western Basin and Range, which forms part of the eastern California shear zone. The Inyo Mountains are bounded by a normal fault, and we analyze rivers that drain toward the fault. We first constrain the best-fit value of m for the analyzed rivers and then we invert their long profiles simultaneously. The inferred history of tectonic rock uplift rate represents the time-dependent dip-slip component of velocity along the normal bounding fault. In the next step, we calibrate our inversion results using thermochronological data in order to constrain K, and to resolve the real tectonic uplift rate through time. Our results show an increase in tectonic rock uplift rate from $\sim$1-1.5 Ma to the present.