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Quaternary N-S extension near the Himalayan crest: An investigation using river profiles and low-temperature thermochronology

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The Himalayan-Tibetan orogenic system is characterized by two vastly different tectonic regimes: (1) north-south directed convergence along the Himalayan range due to the continued collision between India and Eurasia, and (2) east-west directed extension across the southern Tibetan Plateau. The tectonic significance of this strain discontinuity, and the corresponding physiographic transition, is debated. Although the location of this transition is roughly coincident with the extensional South Tibetan fault system (STFS), and many consider the STFS to play a critical role in the extrusion of the greater Himalayan sequence and the evolution of the Himalaya, most models restrict activity on the STFS to Early-Middle Miocene. Restricting activity on the STFS to this time frame allows >10 Myr of erosional etching of the topographic front developed during active extrusion. Intriguingly, an examination of the transverse rivers that head on the Tibetan Plateau reveals abrupt increases in gradient (knickpoints) near the crest of the Himalaya on nearly all major river networks. These knickpoints typically mark the start of deep gorges downstream and commonly correspond to an abrupt increase in hillslope and local relief to the south. The suggested abrupt increase in erosion rate downstream of the knickpoints should cause the knickpoints to migrate upstream as a function of drainage area. However, larger drainages have not cut farther back into the plateau than smaller ones, suggesting that these knickpoints may be pinned in space. Differential uplift across young (Quaternary) faults is the simplest explanation for such pinned knickpoints – if uplift balances the faster erosion rates downstream of knickpoints, no migration of the knickpoint is expected. The geometry requires uplift of the Himalaya relative to the southern plateau, consistent with the persistence of N-S extension on fault systems near the range crest at least into the Quaternary.

We explore the possibility that the transverse river knickpoints identified near the Himalayan range crest are fault controlled by examining three field sites where river profiles indicate potentially active faults: 1) the Kali Gandaki River valley in the Dhaulagiri Himalaya, central Nepal, where Quaternary N-S directed extension has been documented, but not constrained, by previous workers, 2) the Ama Drime Range near Everest in southernmost Tibet, which regionally has experienced both N-S directed extension and E-W directed extension at various times, and 3) the Bhote Khosi River valley near Nyalam, south-central Tibet, where no active faulting has yet been documented. In all three locales, the prominent knickpoints identified in river profiles appear to be structurally controlled, although the style of faulting varies from N-S striking extensional faults bounding the Ama Drime to low-angle, E-W striking detachments in central Nepal and possibly south-central Tibet. These data strongly point to tectonic control of knickpoints at the Himalayan crest and suggest recent N-S extension may be controlling the position and nature of the physiographic transition in several locations along the Tibetan Plateau-Himalaya orogenic system.