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The Neogene evolution of topography and rivers along the Indus-Yarlung Suture Zone, southern Tibet

Marissa M. Tremblay (1), Sean D. Willett (2), David L. Shuster (3,4), Matthew Fox (5), Peter K. Zeitler (6), Jennifer L. Schmidt (6), Carmen Winn (7), and Karl E. Karlstrom (7)

(1) Scottish Universities Environmental Research Centre, East Kilbride, United Kingdom, (2) Department of Earth Sciences, ETH Zurich, Zurich, Switzerland, (3) Department of Earth and Planetary Science, University of California, Berkeley, Berkeley, CA, United States, (4) Berkeley Geochronology Center, Berkeley, CA, United States, (5) Department of Earth Sciences, University College London, London, United Kingdom, (6) Department of Earth and Environmental Sciences, Lehigh University, Bethlehem, PA, United States, (7) Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM, United States

In the Himalaya-Tibet collisional orogen, the Indus-Yarlung Suture Zone (IYSZ) joins the Lhasa terrane of Eurasian affinity to its north with the Himalayan sequences of Indian affinity to its south. Today, the Yarlung River flows eastward along the IYSZ for ∼1700 km before descending ∼2 km over a 100 km reach in the eastern Himalayan syntaxis, draining > 105 km2 of the Tibetan plateau interior. However, there is abundant geomorphic evidence–including barbed tributaries, high-elevation lakes, and indicators of reduced carrying capacity–that suggests large-scale drainage reorganization occurred along the IYSZ at some point in its geologic past. Inversion of a compilation of thermochronometric data to obtain exhumation rates from the Lhasa terrane and Tethyan Himalaya constrains the timing of establishment of deeply incised drainage prior to 10 Ma when a rapid reduction in erosion rates (< 0.15 km/Ma) occurred across the region, allowing the geomorphic evidence of the original drainage pattern to be preserved. Between ∼20 and 10 Ma the region experienced substantially higher erosion rates (> 0.8 km/Ma), requiring a greater erosive capacity of the drainage network at that time and possibly higher rock uplift rates. We explore two possible tectonic-geomorphic-climatic scenarios for generation of high-relief and high erosion rates in the Miocene. First, high erosion rates could have been generated by a network of steep, deeply incised trans-Himalayan rivers capable of steering precipitation into the Tibetan plateau interior. These trans-Himalayan rivers would have been defeated ca. 10 Ma due to rapid rock uplift associated with midcrustal duplexing in the Lesser Himalaya. Episodic trans-Himalayan connections to the Lhasa terrane since 10 Ma have been documented in eastern Himalayan foreland deposits by the presence of detrital zircons sourced from the Gangdese batholith. Detrital evidence for pre-10 Ma connections, however, has not been observed, in part due to limited exposure of sedimentary units of this age. An alternative hypothesis is that high relief was a consequence of low elevations of the IYSZ, but with the current river configuration including the longitudinal morphology of the Yarlung and upper Indus. Recent geochemical and paleontological observations from exposures of the Kailas Formation and Liuqu Conglomerate along the IYSZ suggest that these sedimentary sequences were deposited in much warmer, wetter environments than the present day, potentially indicating that parts of the IYSZ were at low elevations before 20 Ma. Low elevations along the IYSZ prior to the onset of high erosion rates in the Lhasa terrane and Tethyan Himalaya ca. 20 Ma would permit high relief with steep, short rivers draining both from the Lhasa terrane in the north and from the Tethyan Himalaya in the south into a low-elevation longitudinal valley with a western outlet. Subsequent to 10 Ma, this longitudinal valley would have been uplifted and tilted eastward, losing its erosional capacity and reversing the flow direction of parts of the Yarlung River, resulting in an eastern outlet.