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Quaternary Indus River Terraces as Records of Summer Monsoon Variability, NW Himalaya, India

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If we are to interpret the marine stratigraphic record in terms of evolving continental environment or tectonics, and accurately produce paleoenvironmental reconstructions, it is essential to understand how transport processes buffer sediment storage and release from the mountain sources to the marine archives.

We investigate the role that climate plays in controlling erosion and sediment flux to the Indus delta fan by looking at the Indus River system, which is dominated by the strong forcing of the Asian monsoon and the tectonics of the western Himalaya.

Lake, paleoceanographic, and speleothem records offer long term, high-resolution histories of Quaternary monsoon intensity. These proxies suggest the summer monsoon reached peak intensity at ~9–10 ka in central India, followed by a steady decline after ~7 ka, with a steep decline after 4 ka (Gupta et al., 2003; Fleitmann et al., 2003). Lake core records (Tso Kar and Tso Moriri), however, suggest a more complex pattern of monsoon weakening between 7–8 ka in the Greater Himalayan region, which contrasts with strong monsoonal forcing in central India (Prasad et al., 2008). This disagreement suggests that the floodplains of the major river systems may not experience the same climatic conditions as their mountain sources, resulting in contrasting geomorphologic responses to climate change. Initial work suggests that the timing of sediment release is modulated by periods of strong precipitation and that sediment storage and reworking through Indus mountain terraces may be the greatest source of sediment (~80%) to the post-glacial Indus (Clift and Giosan, 2012). Earlier research has established that the northern part of the Indus floodplain adjacent to the mountains experienced incision after ~10 ka, yet the timing of Himalayan terrace reworking is not well-constrained.

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High altitude river valleys, at least north of the Greater Himalaya, appear to be sensitive to monsoon strength because they lie on the periphery of the present rainfall maximum (Bookhagen, 2006) and in the Himalayan rain shadow. These steep river valleys may be affected by landslide damming during periods of strong monsoonal precipitation, where damming provides sediment storage through valley-filling and later sediment release through gradual incision or dam-bursting. A newly dated sequence of river terraces of a major tributary to the Indus, the Zanskar River, indicates valley-filling ~6 ka in the Padum Basin. This age data coincides with other landsliding events in the NW Himalaya (Bookhagen et al., 2005) and Tso Kar pollen data (Demske et al., 2009; Wünneman et al., 2010) that indicate increased moisture transport to the Zanskar region of the Trans-Himalaya. The timing of formation and incision of these river terraces are likely a result of strong monsoonal precipitation that immediately postdates the monsoon maximum.

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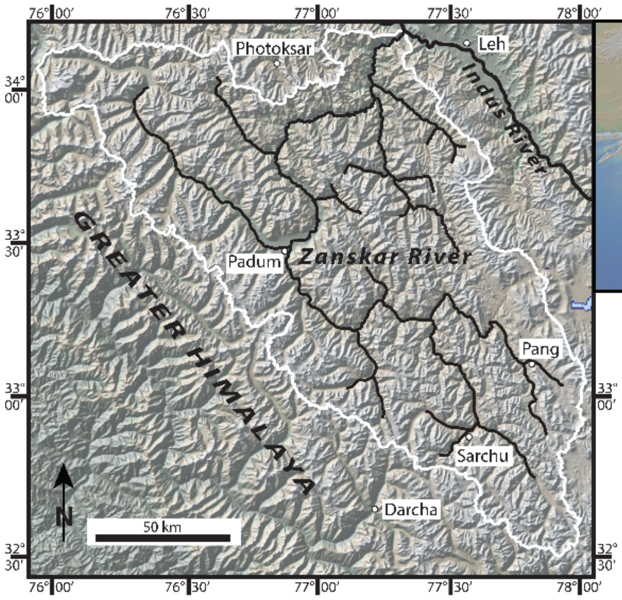

Fig. 1. Map of the Zanskar catchment study area, where black lines inside the catchment indicate Zanskar River and major tributaries and white line indicates catchment boundary.

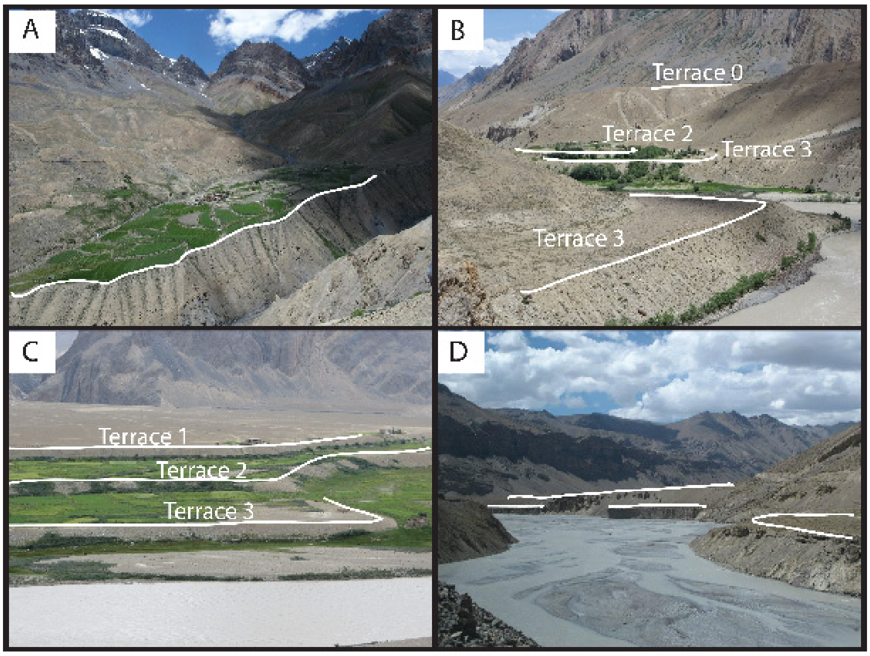

Fig 2. Views of terraces of the Zanskar River catchment.
(A) Skiumpata village sits on a terrace east of Lingshed; (B) A sequence of three terraces at Hanumil on the trunk Zanskar; (C) Three terraces and the active floodplain at Pishu ~20 km north of Padum on the trunk Indus; and (D) Two Pleistocene (?) terraces on the Tsarap-Chu tributary, ~5 km east of Sarchu.