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Proximal storage and controls on sediment flux in large Himalayan river systems

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The central and eastern Himalaya are drained by the Ganga River and its tributaries, which flow southeastward across the Gangetic Plain in the northern Indian . Rivers in the eastern Gangetic Plain are generally characterized by high sediment fluxes and frequent avulsions in the foreland, leading to the deposition of very large, low-gradient alluvial fans. Rivers in the western Plain, in contrast, are typically confined to narrow meander belts and show a complex Quaternary history of incision and deposition. To first order, this contrast has been explained by spatial gradients in rock uplift and precipitation, leading to large-scale variations in sediment supply across the Ganga basin. Here, we explore an additional mechanism that may control river development - sediment storage and release in intermontane basins, known locally as ‘duns’, that occur along the Himalayan mountain front. Duns are present along several, but not all, segments of the mountain front and are formed by active anticlinal folds associated with the Himalayan Frontal Thrust (HFT) system. Where duns coincide with the outlets of major transverse river systems, they can act as proximal sediment traps, although their capacity is typically limited by the dimensions of the dun and the ability of the rivers to incise through the folds. Estimates of fold erosion and deeply incised Quaternary sediments in several duns indicate that the duns also serve as intermittent sediment sources. Thus, the duns act as a ‘filter’ that is superposed between the sediment source in the Greater and Lesser Himalaya and the routing systems of the Gangetic Plain, and that amplifies climate-related fluctuations in sediment supply.

We contrast the behaviour of the Yamuna and Ganga rivers in the western Gangetic Plain with the Kosi River in the east. Sediment in the Yamuna and Ganga must pass through the Dehra Dun, which records a complex history of aggradation and erosion during the Quaternary. Hinterland sediment sources, upstream of the Main Boundary Thrust (MBT), are composed of relatively resistant Greater and Lesser Himalayan rocks. Accommodation generation is controlled by slip on both the HFT and MBT, leading to widespread but thin sediment deposition. Correlation of fan depositional surfaces across the Dun allows us to constrain both the volumes of Quaternary fill in the Dun and the amount of material excavated during episodes of fan incision. Holocene excavation of Dun sediments alone yields an additional sediment source term that, even when averaged over the last 10-12 ky, represents several percent of the present-day sediment load carried by the two rivers. In contrast, the Kosi River debouches directly into the Gangetic Plain, and late Quaternary deformation appears to be concentrated on the HFT system. Because of this, relatively weak Middle and Lower Siwalik foreland basin deposits in the HFT hangingwall contribute a large volume of sediment to the Kosi River. We argue that this high sediment supply and the lack of proximal dun storage has led to near-continual aggradation of the Kosi River and construction of a large-scale fan system. The Gandak River, which has both a dun ‘filter’ and very high hinterland sediment flux, has built a hyperavulsive but more spatially limited fan system and may represent an intermediate case between these two extremes.