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Geomorphic and stratigraphic evidence for dynamic river channel development in the Dehra Dun region, northern India

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The Ganga and Yamuna rivers drain the Garhwal Himalaya of northern India and cut cross several active faults as they pass into the Gangetic Plain and the northern Indian foreland. Unlike rivers in the central or eastern Himalayas, which debouch directly into the foreland and have built large depositional fan complexes, the Ganga and Yamuna rivers have been funnelled into an intermontane basin, the Dehra Dun, by Quaternary upper-crustal faulting and growth of the Mohand anticline. Sediments in the Dun record a complex history of aggradation and erosion during the Quaternary, as seen by alternate episodes of fan progradation and incision in stratigraphic records. Here, we summarize existing work on the evidence for, and timing of, these episodes, and explore the consequences of proximal sediment storage or evacuation, as well as local sediment sources derived from the active structures bounding the Dun, on the downstream character and behaviour of the river systems. 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. We argue that, while the trapping of sediment in the Dun is ultimately caused by growth and lateral propagation of the Himalayan frontal fault system and the Mohand anticline, variations in storage or excavation on short time scales (50-100 ka to present) are most likely driven by climatically-modulated changes in sediment supply from the catchments upstream of the Dun. We show that active upper-crustal faulting does, however, leave a consistent imprint in the present-day morphology of the rivers as they flow across the Dun. Finally, we place bounds on the volumes of sediment sourced from the active structures bounding the Dun, including the Mohand anticline, and the approximate time scales over which this sediment has been liberated.

An open question is whether or not the proximal sediment storage ‘filter’ of the Dun plays a significant role in modulating the sediment flux in the Ganga and Yamuna systems. It seems likely that such a filter will amplify climate-related fluctuations in sediment supply from the Higher and Lesser Himalaya. For example, widespread trapping of sediment in the Dun would be expected to trigger downstream incision across the Gangetic Plain, which in turn would inhibit large-scale avulsion of the river course. The relative lack of proximal storage in eastern Gangetic river systems, such as the Kosi River in north Bihar, coupled with their higher sediment fluxes and precipitation rates, may be a contributing factor to their long-term hyper-avulsive behaviour. The degree of proximal storage may thus play an important contributing role in determining large-scale flood hazard across the Gangetic Plain. Only a better understanding of the timing of river incision and aggradation in the Gangetic Plain, as well as the magnitude and duration of sediment storage in the Dun and other intermontane valleys, will enable this hypothesis to be more fully tested.