Monsoon-generated fluvial sequences: Climatic control in the Quaternary of the Himalayan Foreland Basin

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The Himalayan Foreland Basin is among the world's most tectonically active regions, with huge earthquakes on Foothills thrust faults, on faults below the plains, and on the cratonic foreland to the south. It would be reasonable to infer that the alluvial fill is "controled" by tectonism. In testing this hypothesis, much of our knowledge of Himalayan foreland-basin dynamics comes from the Neogene Siwalik Group, exposed in the Foothills, with little information from the modern plains. However, excellent cliffs with floodplain deposits extend along the Ganga and other rivers towards the craton in the western plains, some 1200 km inland. The successions date back to ≈130 ka, spanning the last glacial cycle.

A remarkable aspect of the cliffs is the presence of discontinuity-bounded sequences a few meters to tens of meters thick, the bounding surfaces of which can be traced for tens of kilometers. Some surfaces are gullied erosional surfaces with local groundwater cements and a mantle of reworked gravel. Others represent large badland gully systems, and include former gullies up to 10 m deep filled with colluvium and reworked carbonate gravels. Still others represent an abrupt change from floodplain to lacustrine and eolian deposits, implying major changes of paleoenvironment.

Fluctuations in monsoonal precipitation – driven by changes in sun's energy and glacial boundary conditions – have affected large parts of Asia, as documented from computer-based modeling and facies evidence. For example, precipitation in some parts of northern India was probably double present values about 10 000 years ago. Such changes in monsoon intensity should have exerted a strong driving force on the plains stratigraphy.

Suites of OSL, TL, and radiocarbon dates were obtained to bracket the age of key surfaces in the cliff exposures, for comparison with the proxy modeling record. The resulting age model shows a first-order correlation between precipitation changes inferred from modeling and periods of incision and accumulation observed in the field. Wider correlations show that incision and valley formation affected rivers across northern India and Nepal as monsoonal precipitation intensified following the Last Glacial Maximum – in the foreland basin, in extensional basins in Gujarat, and in mountain valleys. A corresponding large sediment pulse is recorded in the Ganga-Brahmaputra Delta and Bengal Fan. Carbonate-filled joint sets that terminate upwards at one discontinuity surface testify to earthquake events, suggesting that faults were active locally.

In areas such as Asia where the monsoon exerts an overwhelming effect, changes in fluid and sediment discharge affect the sediment transport capacity of rivers, resulting in floodplain incision and accumulation cycles. The study area is too far inland to record sea-level changes, which generated paleovalleys fills no farther than 300 km inland. Thus, even in tectonically active basins such as the Himalayan Foreland Basin, precipitation (climatic) change may control much of the architecture of the river deposits. Although tilted successions and unconformity-bounded sequences in the Foothills reflect tectonic activity, climate-controled architecture may be prominent over most of the foreland basin, especially where long-term subsidence rates are modest (≈0.3 mm/year) towards the cratonic margin.