Fluvio-sedimentary response to late Quaternary climate at the Himalayan frontal thrust, central Nepal

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Indo-Asian monsoonal fluctuations throughout the late Quaternary have likely altered the depositional environment in the frontal Himalaya. The Indian summer monsoon is responsible for more than 80% of the annual rainfall in the subtropical regions of the Himalayan foreland to the Indo-Gangetic-Bengal basin, significantly impacting river discharge and sediment flux in the system. The effect of monsoon on sedimentation (deposition vs incision), however, exhibit regional variabilities. While downstream variations may be explained by sediment supply tapering off downstream and increased effect of sea-levels on rivers, variations among other areas in the frontal foreland are not well understood, and are likely due to the differences in the size of the river/catchment, the distance downstream, and the amount of tectonic activity.

To reconstruct the late Quaternary evolution of the fluvio-sedimentary environment at the frontal foreland of central Nepal, we study the sedimentary facies and chrono-stratigraphy over the last 50 ky from ten boreholes across the Main Frontal Thrust there, using optically stimulated luminescence and radiocarbon dating. Previous seismic survey along the riverbed imaged ~100 m thick sediments above the incised bedrock, and onlap of strata onto folded strata, implying recent enhanced effect of sedimentation and changes in river base-levels (Almeida et al. 2018). Drilling penetrated 50-100 m of these sediments below the surface. We observe three types of facies along the depth: (a) poorly-sorted gravels with silt to sand, interpreted to be coarse-grained braided channel facies, (b) moderately-sorted silt to sand with gravels sandwiched by thin floodplain silts, interpreted to be fine-grained braided channel facies, and (c) massive, well-sorted clayey silt with bioturbation, alternating redox state and occasional sand beds, interpreted to be fluvio-lacustrine facies. Facies (c) likely deposited in a depocenter formed by the damming of the river due to the uplift on the thrust anticline. A major transition from facies (b) and (c) to facies (a) occurred at the early Holocene to latest Pleistocene (~12-13 ka, or slightly younger), inferred from preliminary age results, in which sediments were finer prior to this period, and coarser afterwards.

Given the sediment age range and the observed variations in <~40 ky timescales, the most relevant features comparable are likely to be monsoonal climate variations. The observed facies transition around the early Holocene likely coincide with the strengthened monsoon that is reported at ~15-12 ka and ~10-6.5 ka from cave speleothems in northern India (Sinha et al. 2005; Dutt et al. 2015), correlating with the time the northern hemisphere summer solar insolation increased towards the peak, around the Bolling-Allerod interstadial and/or across the last glacial to interglacial boundary. We interpret that strengthened monsoon have led to increased river discharge and advance of coarse bedload-dominant braided channels. Weak monsoon periods, in contrast, decreased river discharge and formed finer-grained channel environment with high lateral mobility.

Further age results from the samples will enable to constrain the variations in deposition rates, and the timing of incision and on-lap surfaces imaged in the seismic section. Deposition rates infer rates of aggradation and/or progradation, reflecting sediment supply, which is not necessarily dependent on river

discharge. Monsoon have likely affected the base-levels through varying river discharge and sediment supply.

Understanding the large-scale processes that govern sediment supply and base-levels in the foreland will allow us to generalize the processes elsewhere and help in interpreting various rates from sediment age including tectonic deformation. Study of sedimentary processes and the effect of climate in these depositional fan systems will impact our overall understanding of sediment fluxes within this large system.

Keywords: Himalayan foreland basin, Indian monsoonal climate, Main Frontal Thrust

