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Reconstruction of Late Quaternary climate and seismicity using fluvial landforms in Pindar River valley, Central Himalaya, Uttarakhand, India

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A B S T R A C T

Fluvial landforms in the Pindar River valley are investigated to understand the role of temporal variability in the Indian Summer Monsoon (ISM) and the spatial changes in crustal deformation. Employing the conventional geomorphological and sedimentological concepts, supported by optical dating, three major phases of valley-fill aggradation separated by phases on non-deposition are discerned. An oldest aggradation phase is dated to 33.5 ka during relatively strengthened ISM corresponding to the later part of pluvial Marine Isotopic Stage-3 (MIS-3). Following this, alluvial fan sedimentation impersistently continued during the declining phase of the ISM (until around 21 ka). A second major aggradation phase (17.5 ka–13 ka) occurred during the post-LGM/lateglacial strengthening of the ISM in which contribution from tributary valleys overwhelmed the valley-fill sedimentation. A youngest aggradation phase dated to the middle to late-Holocene (8 ka–3.6 ka), represents the transitional climate during which sporadic high sediment fluxes both from the upper catchment and tributary streams led to the development of fossil valleys (abandonment of old channels).

The spatial variability in the incision/uplift rate, based on river strath terraces reveals that the terrain is undergoing differential crustal deformation. Two zones of relatively high crustal deformation are identified. These are located in the vicinity of the Main Central Thrust (MCT) and is attributed to the activity along the transverse fault and the in the inner Lesser Himalaya for which the thrust propagated fold associated with regional north-south compression is implicated. The study suggests that fluvial landforms (valley-fill and strath terraces) in the Pinder river valley are genetically related to the multi-millennial scale changes in the ISM and spatial and temporal changes in the crustal deformation associated with regional compression.

1. Introduction

Fluvial systems are one of the central Himalayas major geomorphic agents because of the monsoon dominated climate and the tectonic activity. The hill slope processes and bedrock incision magnitudes in the fluvial system are intimately associated with the spatial and temporal changes in the climatically and tectonically governed base level changes (Burbank et al., 1996; Alley et al., 2003). One of the consequences of the sensitive erosion and transport regime is that two broad categories of landforms of the main valleys can be classified as the aggradation landforms (valley-fill) and the degradation landforms (strath terraces) (Chaudhary et al., 2015). The aggradation landform in Himalaya receives sediment from two major sources notably paraglacial sediment released as the result of deglaciation (Church and Slaymaker, 1989; Schildgen et al., 2002) and slope wash/landslide generated colluvium, freshly generated under post glacial climate circumstances (Juyal et al., 2010; Chaudhary et al., 2015). It is observed that during periods of abnormal monsoon, the above sediment sources becomes active (Bookhagen et al., 2005) as a result the sediments temporary overwhelms the fluvial system's transport capability which eventually leads to the aggradation (Pratt-Sitaula et al., 2002; Chaudhary et al., 2015). Once the river becomes transport limited due to decrease in the discharge (weak monsoon in case of the Central Himalaya), the river began to incise its own sediment in order to attain the pre-aggradation base level (Juyal et al., 2010 and reference therein). According to Pratt-Sitaula et al. (2004), over

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timescales of $\leq 10^5$ years, Himalayan Rivers oscillate between bedrock incision and valley alluviation owing to changes in monsoon intensity which in turn modulates the sediment flux. Further, due to extreme topographic variability in a rugged Himalayan terrain, the incision is likely to be discontinuous due to (i) the climatically driven pulses of aggradation (Pratt-Sitaula et al., 2002) and the (ii) differential surface uplift (Hodgkinson, 2009).

Climatic reconstruction based on the lacustrine, fluvial sequences and speleotheme records from the Himalayan region show considerable variability in the ISM during the late glacial stage

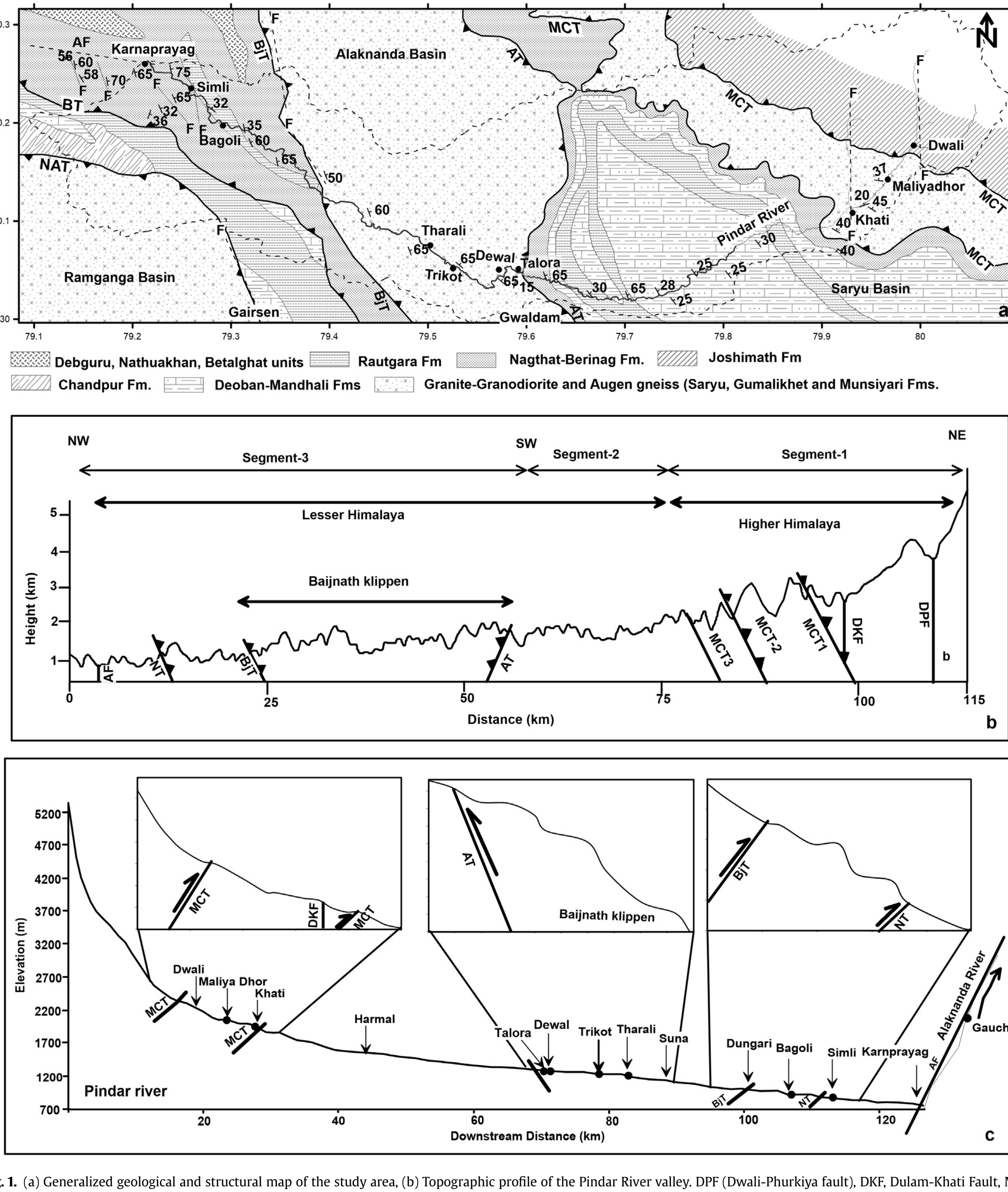

Fig. 1. (a) Generalized geological and structural map of the study area, (b) Topographic profile of the Pindar River valley. DPF (Dwali-Phurkiya fault), DKF, Dulam-Khati Fault, MCT (Main Central Thrust), AT (Askot Thrust), BjT (Baijnath Thrust), NT (Narayanbagad Thrust), and AF (Alaknanda Fault). (c) Longitudinal profile of the Pinder river (inset) is the segments in Pinder river that are undergoing high differential uplift (indicated by convex up profile).

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