

Palaeogeography, palaeohydraulics and palaeoclimate of the Mio–Pliocene Siwalik Group, eastern India

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Abstract South–southwestward palaeocurrent swerved to east–southeast and then broadly to southeast over the transition from alluvial fan to axial channel and then to the flood plain in the Mio–Pliocene foreland system within which the Siwalik Group deposited in Darjeeling–Jalpaiguri Districts, eastern India. Palaeocurrent pattern is found to be multi-modal on the fans, virtually unimodal on the axial channel zone and again multi-modal, more profoundly, on the flood plain. Coarse siliciclastic mass-flows were progressively eliminated and gave way to predominant bed-load transport downfan and the axial river, and then to suspension-load dominance in fine siliciclastics on the flood plain. Distal flood plain lacustrine sediment included most of the coals and the entire bulk of the dolomitic limestone. Further resolution in palaeogeography within the frame of aforementioned facies associations is elicited in twenty-six distinctive facies altogether.

Critical evaluation of chemical indices (CIA, CIW, ICV, PIA, as well as Rb/Sr ratio) for weathering and depleted $\delta^{18}\text{O}$ values indicate a high precipitation rate. The contention is further corroborated by the high discharge rate calculated from cross-set thicknesses within the main channel deposits. Reconciliation of various relevant data sets collected or calculated from all known worksites along the entire 2000 km-long exposure belt of the Siwaliks along the Himalayan foothills reveal confluence of two tributaries, one from the west and the other from the east, close to the present study area before escaping onto the Indian plains. Channel parameters, channel-belt width and discharge thus attained maxima in the present study area. The precipitation rate and temperature increased eastward overall as a prelude to the modern trend in this regard. ^{13}C enrichment indicates that the transition from C_3 to C_4 vegetation had already set in.

Key words Mio–Pliocene Siwalik Group, Darjeeling Himalayas, spatial variation, axial river reconstruction, vegetation

1 Introduction

Sedimentological account of the almost exclusively siliciclastic Siwalik Group deposited in the Darjeeling Himalayas, North Bengal, India is too meagre to achieve

high-resolution process-product relationship in sedimentation (Figure 1; Banerjee and Banerjee, 1982; Acharyya, 1994). Broad stratigraphic classification and the corresponding palaeogeographic interpretations of the Siwalik Group have been borrowed from work done in the western Himalayas where exposures are much better in quality because of the relative aridity (Pilgrim, 1919; Parkash *et al.*, 1980; Kumar and Tandon, 1985; Tokuoka *et al.*, 1986; Wa-

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heed and Wells, 1990; Burbank and Beck, 1991; Khan *et al.*, 1997; Zaleha, 1997; DeCelles *et al.*, 1998; Nakayama and Ulak, 1999; Brozovic and Burbank., 2000; Sharma *et al.*, 2001; Ulak and Nakayama, 2001; Thomas *et al.*, 2002; Garzione *et al.*, 2003; Kumar *et al.*, 2003a, 2003b; Kumar *et al.*, 2004; Ulak, 2005; Szulc *et al.*, 2006; Kumar *et al.*, 2007; Sinha *et al.*, 2007; Shah *et al.*, 2009; Shukla *et al.*, 2009; Ullah *et al.*, 2009; Khan and Tewari, 2011; Sigdel *et al.*, 2011). This paper intends to improve the sedimentological insight about the Siwalik Group in the frame of a foreland where its deposition took place (Acharyya, 1976, 1994; Raina, 1976; Tandon, 1991; Willis, 1993; Burbank *et al.*, 1996; DeCelles *et al.*, 2000, 2001; Lave and Avouoc, 2000; Mukul, 2000; Najman and Garzanti, 2000; Richards *et al.*, 2006; Robinson *et al.*, 2006; Yin, 2006; Mitra *et al.*, 2010; Long *et al.*, 2011; Ray and Neogi, 2011). The exposures are in inferior quality, notwithstanding the present study recognizes a large number of distinctive facies, which can be grouped in four associations. While the facies reflect the sedimentation dynamics, the associations

relate to palaeogeography. Palaeohydraulic parameters have also been estimated from the sandstones deposited within the main river channel system of the Siwaliks. To overcome the limited extent of sections, facies logs have been erected in 75 locations. Palaeocurrent patterns and directions are determined separately for each of the associations. Oxide and elementary siliciclastic rock chemical features offer significant insight about contemporary palaeoclimate; $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of carbonates allow further revalidation or refinement. Results of similar analyses carried out at different locales all along the 2000 km-long of the Himalayan belt, while taken together, offer an opportunity to delve into the significance of spatial variations that may exist.

2 Geological background

The predominantly siliciclastic Siwalik Group was deposited in a Mio–Pliocene foreland system in the Himalayas (Johnson *et al.*, 1985; Gautam and Appel, 1994; Meigs

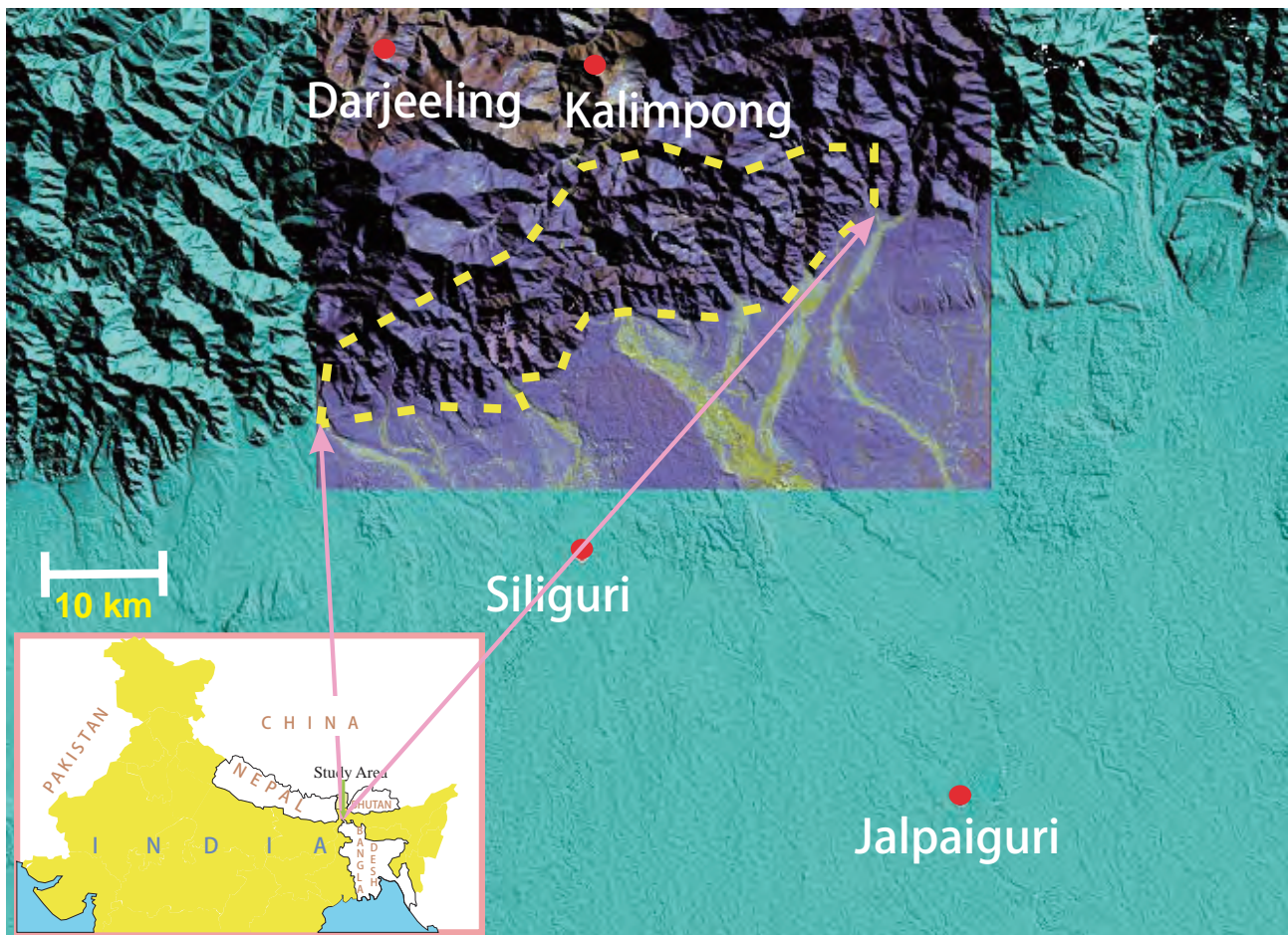


Figure 1 Study area demarcated on LISS–III image superimposed on SRTM DEM in the foothills of eastern Himalayas.

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