Journal of Palaeogeography, 2016, 5(3): 221–240 (00098)

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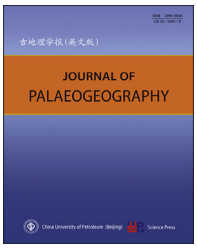

Lithofacies palaeogeography and sedimentology

Overprint of neotectonism along the course of River Chel, North Bengal, India

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Abstract This paper aims to unveil neotectonic imprints in topography, drainage and sediments in the 46.25 km long course of the River Chel from its source down to its alluvial fan at the base of the Himalayan Mountain Front in the Darjeeling–Jalpaiguri districts of India. A semi-circular ridge delimits its primary catchment. Within confinement of this watershed basin the drainage pattern is composite being convergent along the periphery and divergent on a butte inside. All these geomorphic neotectonic imprints are accompanied by ramp and flat structures and spectacular mylonitization of rocks.

High hypsometric index and convex shape of the hypsometric curve derived from the central near-straight course of the river between the primary catchment and the Main Frontal Thrust (MFT) also reflects tectonic youthfulness of the river course. It is well manifested also in widely variable stream index and stream gradient index ratios (SL/K) often exceeding 2. In response to neotectonism, this river course as a whole shifted westward between 1962 and 2007. Maximum reduction of the stream gradient on top of the MFT is eloquent enough about recent uplift of the thrust ridge. The high average slope gradient of canyon wall about 45.68° is well consistent with this uplift. Very low channel-width/valley-height ratio along the river further corroborates the uplift.

The alluvial fan system of the River Chel is comprised of five morphogenetic fans stacked one above another with a tendency to shrink and shift progressively upslope. They differ from each other in terms of tilt, axial orientation, primary depositional surface gradient and convexity in transverse section and thus present a writ of ongoing tectonism. Progressive upward increase in the share of distal crystalline rocks in clast composition within alluvial fan package is a clear proxy for southerly advancement of the MFT. Concomitant increase in maximum clast size is in good agreement with sediment source uplift. All the five fans are, however, dormant now. Present-day River Chel deeply incises through all of them and suggests further basement uplift in the context of frequent evidences of neotectonism all around, although the role of climate remains uncertain in absence of adequate data.

Keywords Uplift of Main Frontal Thrust, Neotectonism, Hypsometric index, Stream-gradient index, Alluvial fan system evolution, Fan attributes, Clast size and composition

Received 21 September 2015; accepted 3 March 2016; available online 10 May 2016

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Peer review under responsibility of China University of Petroleum (Beijing).
http://dx.doi.org/10.1016/j.jop.2016.05.004

1. Introduction

Rivers cut or fill, alter their channel courses and geometries, their valleys constrict or widen, fans at their mouths build up, shift or get abandoned in response to the rise and fall of their base profiles (Blum and Tornqvist, 2000). The position of a river base profile changes in response to tectonics and climate. Tectonics and climate also dictate delivery mechanism and nature of sediments laid down by rivers (Willett and Brandon, 2002; Whipple and Meade, 2006). River geomorphology and sediments may undergo similar changes under influence of tectonism and climate, only crucial combination of features can categorize one or the other as the prime cause. Work on river geomorphology was boosted with the advent of remote sensing in early 1970 (Schowengerdt, 1997) and enormously so by the introduction of free accessibility to the Google Earth (GE) (Google Inc., 2005). Invention of highly sophisticated GIS softwares each excelling over the previous further enhanced penetration of the related studies in leaps and bounds. Investigation can now cover a wide region, including areas under vegetation cover or inaccessible. Resolution in the study can be improved manifold by creating contour intervals of any denomination. Vertical profiles can be generated along any transect of choice. Topographic variability can be enhanced and features like drainage, deformational structures, lithologic changes can be highlighted by downplaying the 'noises' and above all, the related parameters can generally be quantified (Nadler and Smith, 1993; Wolff and Yaeger, 1993).

A similarly quantitative study has been presented here in relation to the River Chel in Eastern Himalayas with the aim to visualize the effect of neotectonism vis-à-vis climate (Fig. 1). The River has its source ensconced by the oldest thrust belt (Main Central Thrust, MCT) and traverses through the two other younger thrusts (Main Boundary Thrust, MBT and Main Frontal Thrust, MFT) and debouches onto the piedmont forming a formidable alluvial fan system. Selection of the River Chel for the present purpose was prompted by the fact that most of the Remote sensing views generated could be rechecked on the ground over the entire course of the River. The study was conducted separately in three separate segments because ambient conditions differed significantly between them. Within the catchment segment two rivulets, namely Kali and Sel merged to form the River Chel. In the course segment the river runs almost a straight course confined within a deep canyon; sediment is generally in move in this segment. In the piedmont area sediment is dumped in form of an alluvial fan system, and the sediments are studied for their intrinsic properties in this segment because only in this segment they are allowed to accrete in substantial proportion.

Besides generating a large body of new geomorphological data this paper clearly documents unidirectional lateral migration of the river, relatively more pronouncedly in the catchment and the piedmont

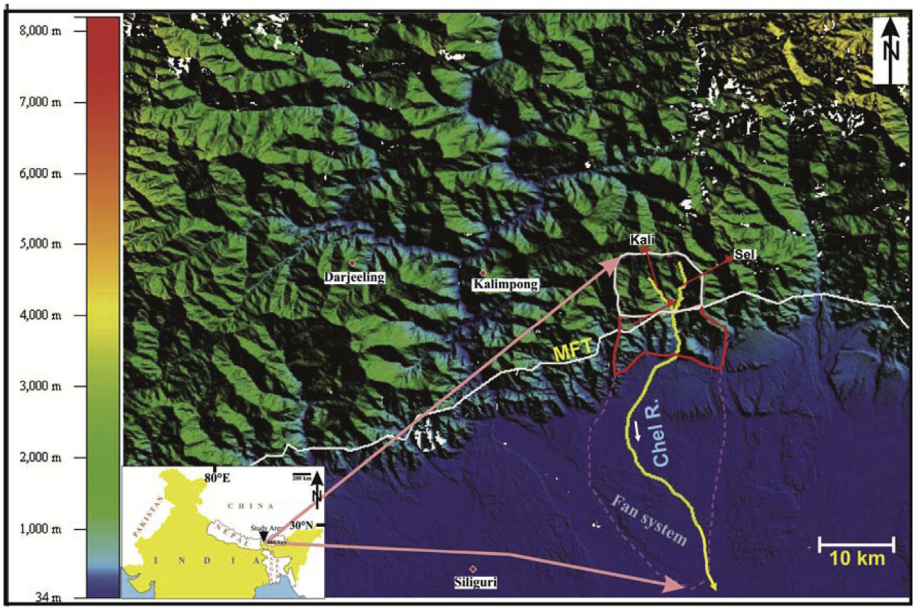

Fig. 1 SRTM DEM of eastern Sub-Himalaya and adjacent foothill zone across the MFT marked by solid white line. The study area is demarcated: light grey solid outline for the catchment areas, red solid outline for the hilly track and the pink dashed outline for the fan. Note contrasting topographic motif between the Sub-Himalayan hilly terrain and the piedmont (Map of northern India within inset).