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Role of initial basin width in partitioning total shortening in the Lesser Himalayan fold-thrust belt: Insights from regional balanced cross-sections

Kathakali Bhattacharyya *, Farzan Ahmed

Department of Earth Sciences, Indian Institute of Science Education and Research – Kolkata (IISER K), Mohanpur 741246, West Bengal, India

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ABSTRACT

Published, regional, balanced cross-sections constructed across various transects along the Himalayan fold-thrust belt (FTB) suggest significant lateral variations in the magnitude and partitioning of total minimum shortening among various lithotectonic units. The variation in shortening is greatest in the Lesser Himalayan sequence (LHS). Western Nepal Himalaya records the highest shortening. Shortening variation shows non-uniform spatial distribution along the length of the FTB, with regions of lower shortening estimates lying in between regions of higher shortening estimates.

We measured the initial and final lengths of the Lesser Himalayan sequence (LHS) from existing published balanced cross-sections. There is a direct correlation between the initial width of the LHS and the total minimum shortening distribution accommodated in all the lithotectonic units of the FTB. This indicates that the initial width of the LHS controlled the lateral variation in the total minimum shortening, and provides a new interpretation for minimum shortening variation in the FTB. The initial width of the LHS also controlled the lateral variation in structural architecture of the LHS by affecting the geometry and total number of LHS imbricates and horses along the FTB. The variation in structural geometry of the LHS along the Himalayan FTB resulted in non-uniform distribution of lateral variation in initial and current LHS outcrop widths.

1. Introduction

At convergent plate boundaries, crustal rocks deform at various scales to accommodate the contraction or shortening associated with the convergence. This shortening is manifested by formation of fold-thrust belts (FTB) along such plate boundaries (Dahlstrom, 1970; Boyer and Elliott, 1982). The minimum shortening accommodated along specific transects of these FTB can be estimated from construction of restorable, kinematically viable, transport-parallel, regional balanced cross-sections along such transects (e.g., Price and Mountjoy, 1970; Hossack, 1979; Elliott, 1983; Stockmal and Waldron, 1993; Srivastava and Mitra, 1994; McQuarrie and DeCelles, 2001; McQuarrie, 2004). Comparing these estimates from the Himalayan FTB to address how and why the minimum shortening distribution vary laterally have been the focus of some recent studies (DeCelles et al., 2002; Mitra et al., 2010; Long et al., 2011; Bhattacharyya, 2010; Bhattacharyya et al., 2013, 2015a).

In the Himalayan FTB, ∼580–900 km of convergence–related. This shortening is manifested (Le Pichon et al., 1992; DeCelles et al., 2002) has been accommodated primarily by a folded thrust system (Medlicott, 1864; Heim and Gansser, 1939; Gansser, 1964; Valdiya, 1980; Srivastava and Mitra, 1994; Pearson and DeCelles, 2005). From north to south these are the Main Central thrust system (MCT), the Pelling–Munsiari thrust (PT), the Ramgarh thrust, the Lesser Himalayan duplex, the Main Boundary thrust (MBT) and the Main Frontal thrust (MFT) (Fig. 1). A compilation of minimum shortening estimates from the published, regional balanced cross-sections constructed along the FTB reveals a lateral variation in the total minimum shortening, and its partitioning among the different thrust sheets (Fig. 2; DeCelles et al., 2002; Mitra et al., 2010; Long et al., 2011; Bhattacharyya et al., 2015a). The lithotectonic unit structurally bounded above by the MCT and below by the MBT is the Lesser Himalayan sequence (LHS) that lies in the middle of the FTB. The LHS preserves the highest number of imbricates in the FTB with greater connectivity than the major Himalayan thrust faults forming the Lesser Himalayan duplex. The lateral variation in the geometry of these imbricates

* Corresponding author.
E-mail address: kathakali@iiserkol.ac.in (K. Bhattacharyya).

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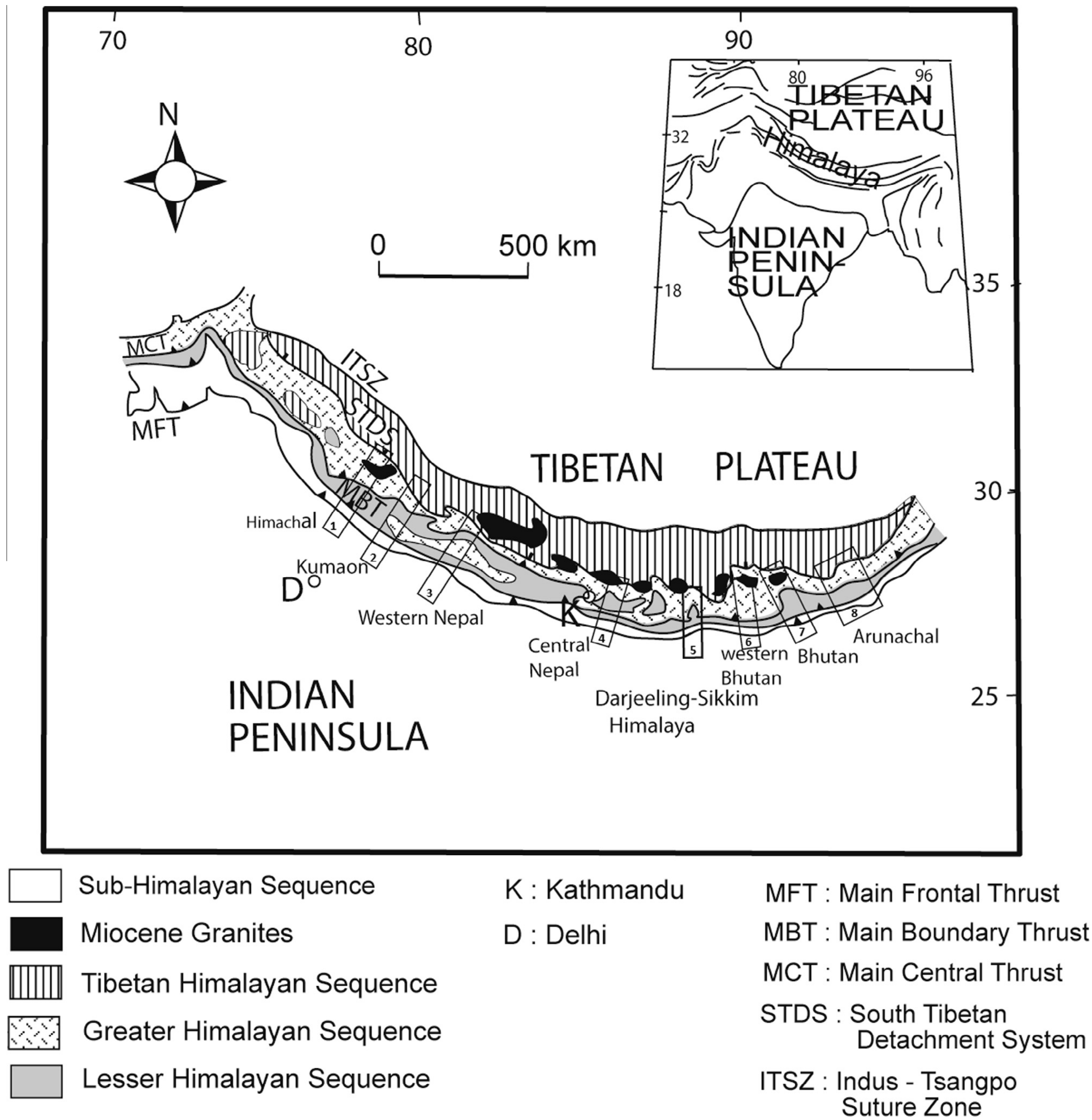

Fig. 1. Regional map of the Himalayan FTB showing the major longitudinal lithotectonic subdivisions separated by major faults. The Lesser Himalayan sequence (LHS) is bounded by the Main Central thrust (MCT) in the north and the Main Boundary thrust (MBT) in the south. Rectangular boxes show the locations of the studied 12 published balanced cross-sections. 1. Webb, 2013; 2. Srivastava and Mitra, 1994; 3. Robinson et al., 2006; 4. Khanal and Robinson 2013; Robinson and Martin, 2014; 5. Bhattacharyya et al., 2015a; 6. McQuarrie et al., 2013; 7. Long et al., 2011; 8. Yin et al., 2011.

result in the greatest lateral variation of minimum shortening within the LHS (Fig. 2; Bhattacharyya et al., 2015a).

The published cross-sections do not incorporate penetrative strain from the different thrust sheets, and smaller-scale contractional structures. In all these transects, the hanging wall cut-offs wherever not preserved, are assumed to lie immediately above the current erosional surface. Thus, they provide minimum shortening estimates, which we refer to throughout this paper. The hanging wall cutoffs of the LHS are not preserved in any of the studied balanced cross-sections. In spite of this limitation, there is a significant lateral variation in the LHS minimum shortening in the FTB (Fig. 2) suggesting a possible causative factor that is independent of the preservation of the LHS. Recent studies have evaluated some of the causative factors that may have led to the observed lateral variation in total minimum shortening along the FTB (DeCelles et al., 2002; Mitra et al., 2010; Long et al., 2011; Bhattacharyya et al., 2013, 2015a). These studies have demonstrated that the minimum shortening variations do not completely mimic the width of the Tibetan plateau, as was suggested by DeCelles et al. (2002) (Mitra et al., 2010; Long et al., 2011). The minimum shortening estimates also do not show a progressive increase toward the eastern Himalaya, as was predicted by an increase in convergence rate (Guillot et al., 1999). Similar eastward increase in shortening estimates was also predicted due to an