Back-structures (backfolds and backthrusts) in the Lesser Himalaya, Bhagirathi river section, NW Himalaya (India): field findings

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Fieldwork during September-October 2014 in the Bhagirathi river section of the Lesser Himalaya, India revealed three prominent discrete backthrust/backshear zones BSZ-1, BSZ-2 and BSZ-3, showing top-to-N/NE (compressional) shear. BSZ-1 is ~12 km west of Uttarkashi and is near Raturi Sera Bridge. BSZ-2 is ~ 12.2 km SSW of BSZ-1 and is near Patara. BSZ-3 falls within the Tehri region. BSZ-1, 2 and 3 were documented in natural vertical sections of rocks that trend ~ 350^0, 350^0 and 40^0N, respectively. Besides, sporadic backshear of the same sense has also been noted along with more dominant top-to-S/SW foreshear within the rest of the Lesser Himalaya, such as at locations Sainj village (where the Main Central Thrust-Lower passes), Tambakhani tunnel (near Uttarkashi), and Shah-en-Shahi Ashram (where the Main Boundary Thrust passes; Bose, 2014). Interestingly, no foreshear was found inside those three backshear zones. The 'anomalous' backshear is defined by curviplanar/sigmoidal P-planes bound by (sub)parallel Y-planes. Both the P- and the Y-planes usually dip towards S/SW. The Y-plane is weavy regionally, and is sub-horizontal locally. Only at a single location NNE of BSZ-2, near Kachdu Deuta Mandir, the steeper backshear cuts moderately dipping foreshear. This indicates that the backshear postdated the foreshear. At Mussourie hill, antithetic top-to-NE brittle shear was found inside top-to-S/SW shear. The former are *not* considered as backthrusts. Similarly, within back-shears, antithetic fore-shears were observed, e.g. at south to Raturi-Sera bridge. Backfolds with axial planes dipping S/SW (~ 220^0N) were documented both inside and south to the BSZ-3, at Bilond pool (Tehri Garhwal district), and near Wynberg Allen School in the Mussourie hill. Forefolds with NE dipping axial planes are abundant NE of BSZ-2. Backthrusts have also been reported from Archean Proterozoic schists and gneisses of the Higher Himalaya in the Bhagirathi section (Mukherjee 2013), and also from the faulted clasts of the Pleistocene Upper Siwalik conglomerates in the Dehradun-Roorkee route from the northern limb of Mohand anticline (Biswas 2014; Dutta 2014). This work is the first report of backthrusting in the Lesser Himalaya from the Bhagirathi section. In this fieldwork, we focused only the ~ N-S and ~ NE-SW natural sections and skipped especially the NW-SE sections that are more abundant in the southern part of the field area. Could subduction of the Eurasian plate below the Indian plate, or wedging between the two plates be the reason for this regional backthrusting? Analogue- and numerical models of Himalayan tectonics are to be refined to explain these field findings. Collisional tectonic regimes with backthrusts could result in seismicity in the recent past, and can also indicate ramp and flat geometry/curviplanar nature of thrusts in regional-scale (Dubey and Jayangondaperumal 2014). A critical taper mechanism of deformation of the Lesser Himalaya in the Bhagirathi section is postulated.