New estimates of minimum geological convergence for the eastern Himalaya, India

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1. Motivation

- Geological studies along the HFT inferred geological convergence rates of 13.8 mm/yr in the western Himalaya (Woosnisky et al., 1999), 21 mm/yr in the central (Lave & Avouac, 2000), 20.8 mm/yr in Bhutan (Berthet, et al., 2014), 23 (Burgess et al., 2012) and 27 mm/yr (De Sarkar et al., 2014) in the eastern Sub-Himalayan zone.
- GPS convergence studies reveal convergence rates of 13 mm/yr in the Kashmir Himalaya (Schiffman et al., 2013), 18 in the eastern Nepal Himalaya (Ader et al., 2012), 16-20 in the eastern Indian and Bhutan Himalaya (Jade et al., 2007; Deukpa et al., 2012, Vernant et al., 2015).

- Suggested clockwise rotation of the Brahmaputra Valley (Vernant et al., 2014) has led to the decrease in the convergence velocity eastward from 18-12 mm/yr east of Sikkim.
- Previous estimates of higher geological convergence rate estimates for the eastern Himalaya are inconsistent with the GPS estimates.

- Burgess et al. (2012) proposed a slip rate of ~5 mm/yr for the frontal thrust of the eastern Himalaya, India.
- Present study draws motivation from the inconsistency between the geological and GPS rates proposed for the eastern Himalayan front.

2. Geomorphological Setup

- Geomorphic studies along the HFT inferred geological convergence rates of 13.8 mm/yr in the western Himalaya (Woosnisky et al., 1999), 21 mm/yr in the central (Lave & Avouac, 2000), 20.8 mm/yr in Bhutan (Berthet, et al., 2014), 23 (Burgess et al., 2012) and 27 mm/yr (De Sarkar et al., 2014) in the eastern Sub-Himalayan zone.
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3. Methodology Employed & Chronology Of Landforms

- Six sediment samples, CH1, HR1, N1, N2, C1 and R1, collected from the Quaternary landforms were dated using Optically Stimulated Luminescence to determine the time frame of their deposition, rate of tectonic uplift and bedrock incision.

- For terrace T3, previously reported depositional ages of 13.9 ± 3.3, 10.4 ± 1.4, 9.6 ± 1.4 and 5.7 ± 0.7 ka, in addition to T1 ± 2 ka in the present study (CH1), brackets its deposition between ~11 and 14 ka.

- Ages of 9.0 ± 0.9, 7.2 ± 0.7, 5.6 ± 0.8, 2.6 ± 0.4, 3.8 ± 0.6 and 1.1 ± 0.2 ka obtained in previous studies for T2 terrace, along with T1 ± 0.8 ka in the present study (HR1) suggests its deposition between ~11 and 7.2 ka.

- Two samples obtained from the terrace T1 in the present study yielded ages 7 ± 1.5 ka (N1) and 2.4 ± 0.5 ka (N2) bracket its deposition between ~7 and 2 ka.

- The previously undated lower terrace T0 (flood plain) has been dated in the present study yielding ages 19 ± 3 ka (CT) and 26 ± 5 ka (RPT).

4. Holocene Convergence

- Uplift (or incision) rates are measured from dated fluvial terraces, assuming the approximate height of the bedrock strath from the river bed as the total uplift and their chronology obtained from the alluvial cover of the strath (Woosnisky et al., 1999, Lave & Avouac, 2000; Kumar et al., 2006; Srivastava & Misra, 2006; Burgess et al., 2012).

- Srivastava and Misra (2008) estimated an uplift rate for the sub-Himalayan zone between ~7.5±1.9 mm/yr.

- Burgess et al. (2012) inferred an incision rate of 3.4 ± 0.4 mm/yr.

- We used 25 ± 5° as the dip angle for the frontal thrust and the vertical uplift rate of 0.44 ± 0.09 mm/yr to derive slip and horizontal shortening rates of 1.04 ± 0.02 and 0.95 ± 0.02 mm/yr across the NT during the Holocene.

- The calculations are based on a simple trigonometric equation $S = \frac{U}{\tan \theta}$ and $H = \frac{U}{\tan \theta}$ (where S and H are the slip and horizontal shortening rates along the NT, I is the vertical incision rate, and $\theta$ is the dip angle).

5. Highlights

- The vertical uplift, slip and shortening rates of 0.44, 1.04 and 0.95 mm/yr in the present study are contrastingly lesser than that previously inferred in the western, central and eastern Himalaya.

- Together with the previous studies, the present study thus broadly indicates a contrastingly eastward decrease in the Indo-Eurasian convergence rates between the Brahmaputra Valley and southern Tibet east of Sikkim.

- Our study across the NT provides new implications towards the geological convergence and regional seismotectonics of the eastern Himalaya.

- The ages of samples C1 (1983 ka) and R1 (2863 ka) suggest that the deposition of older sediments by the Kameng River to the south of the frontal thrust due to rampant erosion and incision in the upstream by significant tectonic uplift.

- We suggest that, during Holocene or later (~3 ka), the bed rock incision has contrastingly lesser than that previously inferred in the western, central and eastern Himalaya.