Characterizing the sub-surface geometry of the Main Frontal Thrust in the Dhalkebar area of central Nepal

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The Main Frontal Thrust (MFT) represents the most frontal surface expression of the Himalayan fold and thrust belt. It is contained within the foreland deposits of this orogenic belt, the Siwalik Group. In Nepal this structure is thought to accommodate a large majority of the convergence between India and southern Tibet (~20 mm/yr; Lave and Avouac, 2000). This conclusion was based on uplift rates of river terraces in the Siwaliks. Flights os river terraces such as these are abundant in the hanging wall of the MFT, and can be dated to determine uplift rates. However, converting these uplift rates into slip rates requires knowledge about the geometry of the MFT at depth. To better constrain this geometry as well as the slip history of the MFT, we conducted seismic reflection surveys in Central Nepal around the town of Bardibas. Previous surveys in the research area have used surface data and shallow trenches to identify the surface rupture of the great 1934 earthquake (Sapkota et al., 2013). The seismic surveys are intended to (1) confirm that the rupture identified at the surface is a large through-going feature at depth; (2) image the geometry and kinematics of the fault, in order to assess both the slip in the 1934 rupture, based on surface measurements, and the behavior of the fault at longer timescales, and (3) assess how the many fault strands visible at the surface interact at depth. Ultimately, we hope to improve the assessment of seismic hazard along this fault zone, which forms one of the largest natural hazards in Nepal.

The surveys were conducted during a nine-week period from January through March, 2014. Using a 6300 kg vibroseis Minibuggy, we acquired ~34 km of data in three long transects cutting across the Main Frontal Thrust, with two additional shorter transects and a small hammer survey (red lines in Figure 1). The vibroseis data were acquired with a split-spread configuration, using 264 channels with 5 m spacing. The source consisted of an 8 sec sweep, which changed linearly from 10 Hz to 120 Hz. The record lengths are 6 sec. Six to twelve sweeps, depending on ambient noise, were done at each source location to improve the signal to noise ratio of the data. The seismic lines follow several of the dry river-beds in the area and generally are orthogonal to the range front. The hammer survey was done at the northern end of the vibroseis line acquired in Sir Khola using a 7 kg sledgehammer. The line had a length of 200 m and 96 channels were used with a spacing of 2 m. We used 10 hammer swings at each source location. The hammer survey was acquired to constrain the shallow (down to ~20 m depth) location of a thrust fault in the river bed of Sir Khola (Figure 1). Preliminary processing of this data suggests that the fault is readily observable in the shallow subsurface.

The Siwalik Group is strongly folded in this region. Measurements of bedding attitudes were done throughout the area to complement the seismic data (Figure 1). The bedding planes are consistently tilted with a NW-SE strike. The faults at the surface are mostly E-W. This discrepancy suggests the possibility of an oblique ramp in the thrust fault. The folding near the outcropping faults is asymmetric, typically with narrow steep fore-limbs and wide shallow back-limbs. The river terraces, however, are sub-horizontal and uplifted over large areas. This difference suggests a transition from fault-propagation folding to translation along the fault sometime before the formation of the terraces, although in a few locations the terraces are also gently folded. We expect to use the serial cross-sections obtained from the seismic data to generate a pseudo-3D view of the fault system in the area to help constrain this transition as well as any complexities in the fault-ramp structure. We plan to acquire additional seismic reflection data along other portions of the MFT in the winter of 2014-2015 to gain a better understanding of how the geometry and behavior of the fault changes along strike.

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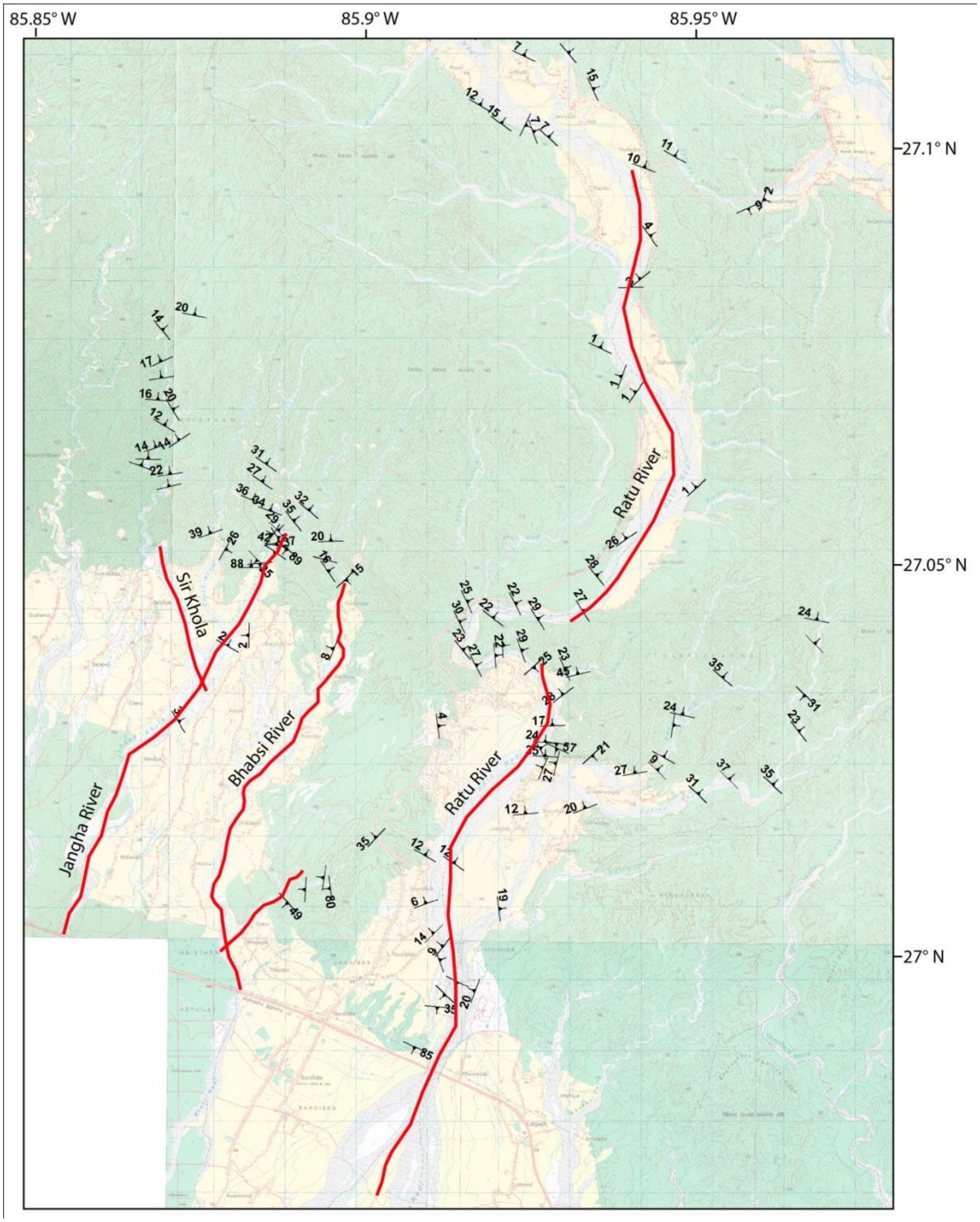

Figure 1. Topographic map of the study area showing location of acquired seismic lines (red lines) and measured bedding attitudes.

References

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