Paleoseismic evidence from trench investigation along Hajipur fault, Himalayan Frontal Thrust, NW Himalaya: Implications of the faulting pattern on landscape evolution and seismic hazard

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**Article Info**

**Abstract**

The study area falls within the mesoseismal zone of 1905 Kangra earthquake (Mw 7.8). Two parallel NNW–SSE striking active fault scarp named as *Hajipur Faults* (HF1 and HF2) along the northwestern end of the Janauri anticline in the foothill zone, have displaced floodplain sediments of the Beas River. The HF1 and HF2 represent the imbricate faults of the Himalayan Frontal Thrust (HFT), and are the result of lateral propagation of deformation from two fold segments i.e., JF1 and JF2 respectively in northwest direction along the strike. Ground Penetrating Radar (GPR) profiles and trenching across the HF2 reveal two low-angle thrust fault strands (F1 and F2). Displacements of \(\approx 7.5\) m on F2 and \(\approx 1.5\) m on the associated branching faults (fa, fb and fc) were observed. Total four stratigraphic units: unit A (gravel) – with a lens of medium sand (unit A\(_0\)) is the oldest; overlain by units B – medium to coarse sand; unit C – with fine to medium sand; and unit D – fine to medium sand with scattered gravel were observed in trench. Radiocarbon ages of the charcoal samples from unit B and unit D, optical ages of sediments from units A\(_0\), B and C, GPR data and trench log, suggest two major events along F1 and F2 strands. Event I along F1 occurred during 2600–800 yr BP and Event II around 400 yr BP and before 300 yr BP. Given the uncertainty in dates it is suggested that the latest event occurred during 1500–1600 AD. Considering the oldest unit (unit A) exposed in trench with vertical displacement of 7.5–8 m, age of 2600 years, and net displacement of \(\approx 9\) m during single event along low-angle fault \((\beta = 25^\circ)\), implies slip rate \(= 7.6\) mm/yr, uplift rate \(= 3.2\) mm/yr, shortening rate \(= 6.9\) mm/yr and recurrence interval = 1160 ± 250 yr for large-magnitude event with Mw > 7.0. With the recurrence of 1100 yr, the penultimate event probably occurred at around 1400–1500 yr BP. Given the recent GPS based slip rate of 14 mm/yr in Kangra reentrant (Baneerjee and Burgman, 2002), the present study suggests that about half of this slip is consumed along the HFT and that this fault is more active compared to those in the hinterland.

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**1. Introduction**

The continued convergence between Indian and Eurasian plates has made the Himalayan arc a seismically active region that experienced moderate to large earthquakes. In last 100 years the Himalaya has experienced three major large-magnitude events during 1905 Kangra (Mw 7.8), 1934 Bihar (Mw 8.1) and 1950 Upper Assam (Mw 8.4) earthquakes (Seeber and Armbruster, 1981; Yeats et al., 1997; Ambraseys and Bilham, 2000; Ambraseys and Douglas, 2004) (Fig. 1a). The recent October 8, 2005 Muzaffarabad earthquake (Mw 7.6) occurred along an earlier identified active fault named *Balakot–Bagh fault* causing extensive damage in Pakistan as well as in Indian side (Nakata, et al., 1991; Kaneda et al., 2008). Seismic hazard evaluation in Himalaya is one of the most crucial problems. Historic records and instrumental data available so far is not so comprehensive and also little or no written records are available from much of the Himalayan belt, hence actual appraisal of hazard from this dataset is difficult (Iyengar and Sharma, 1999; Bilham et al., 2001). For proper seismic hazard estimation,