Probing our understanding of the seismic cycle in the Himalayas of Nepal: Investigating mega-quakes with mega-trenches

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Between Assam in the east and Kumaon in the west, the Himalayan range has experienced four catastrophic earthquakes since 1880, including the 1934 Bihar-Nepal earthquake. Results from geodetic and seismic monitoring show that elastic strain is rapidly accumulating along the locked part of the Main Himalayan Thrust (MHT), which is responsible for these events. Large earthquakes are therefore expected to devastate the Himalayan front again. The gap west of Kathmandu and east of Dehradun, India, for instance, which has not ruptured in at least the last 500 years, stands out as a potential site for a future great earthquake. Understanding of the seismic cycle in the Himalayas has greatly improved in the last decade, based in part on over 32 years of collaboration in seismic monitoring between Nepal and France (DASE). This was complemented by several collaborative research projects involving geodetic and geological investigations. Geodetic monitoring from 25 cGPS stations installed in collaboration with Caltech has emerged as one of the most useful complements to seismology. Together, the seismic and geodetic datasets show that the most active fault is the Main Frontal Thrust, which absorbs 15–18 mm/yr of roughly north-south convergence. Seismological, geodetic, geomorphic and paleo-seismological investigations imply that this fault is locked from the surface to beneath the High Himalayan peaks, over a distance of about 100 km, and slips mostly during great earthquakes with $Mw \geq 8$.

The return periods of such earthquakes, or potential surface ruptures associated with the latest events, are uncertain or unknown. Although a paleo-seismological study of the Main Frontal Thrust was started in 2000, the two main trenches dug, within the 1934 maximum shaking area in central eastern Nepal (Mahra Khola) (Lavé and others, 2005), and in the far-western Nepal seismic gap (Mohana River) (Yule and others, 2006), brought evidence for only one, much more ancient earthquake (1100 AD, and 1505 AD, respectively).

To try to settle such issues, in collaboration with IPGP (France) and EOS (Singapore), we continued to look for a potential rupture of the 1934 Bihar-Nepal earthquake. We focussed our search between the Mahara Khola and Dharan, an area entirely within the 1934 isoseismal VIII. Two small trenches were dug in 2007-2008, and a natural river-cut section was refreshed. The Sir Khola river-cut provides exceptional exposure of offset terraces and shallow thrusting. Preliminary ^{14}C dating indicates the occurrence of two events more than 500 years apart, the last one postdating 1800. To confirm such results, we expanded the scale of our efforts and, in November 2009, opened a ≈ 60 m-long, >12 m-deep mega-trench across the 25 m-high cumulative scarp of the MFT near Charnath Khola. This trench, the largest in the Himalayas to date, exposes for the first time at least three thrust breaks of different ages. More than 300 charcoals were collected. We refreshed a nearby river-cut, revealing inverted and faulted Siwalik beds in the MFT hanging wall. Five smaller pits were also dug in terrace surfaces of different elevation to constrain their abandonment by ^{14}C dating. This large-scale paleo-seismological study was complemented by detailed topographic surveys, seismic profiles, and electrical-resistivity tomography. Such an integrated approach should help decide whether the 1934 event was blind or not, and provide a more definitive time sequence of catastrophic events in Nepal.

References

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