Source fault geometry of the 2015 Gorkha earthquake (Mw 7.9), Nepal, derived from a dense aftershock observation

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The megathrust of the Himalayan foothills produced the Mw 7.9 Gorkha earthquake, on 25 April 2015, in Nepal. This earthquake occurred in the India-Eurasia Plate Collision Zone. Several geological cross sections through the central Himalaya have been proposed. However, the megathrust geometry beneath the Himalayan foothills is still debated (e.g., Lave and Avouac, 2000; Bollinger et al., 2004; Hubbard et al., 2016). The geometry of the source fault provides basic information for understanding the active tectonics of the area and for forecasting seismic hazards. To obtain the seismic image of source fault, we conducted a dense seismic array observation across the central focal area of the 2015 Gorkha earthquake. Thirty-five portable seismographs were deployed along a 90-km-long line between Shabru Besi and Hetauda in the north-south direction with 3-10 km spacing. Each seismograph consisted of a 4.5 Hz 3-component seismometer and a digital data recorder (GSX-3). Waveforms were continuously recorded at a sampling rate of 250 Hz for a total of two months in two separate deployments between August 15 and November 28, 2015. The continuously recorded data obtained by the GSX recorders were processed in the laboratory subsequent to the observations. STA/LTA trigger algorithm was applied to detect the seismic event. A total 716 of earthquake events were detected and their hypocenters were determined using a 1-D velocity structure (Pandey et al., 1995). In order to obtain a high-resolution velocity model, a well-controlled hypocenter is essential. Due to this, we selected 609 events, whose hypocentral errors were less than 0.5 km. To investigate the aftershock distribution and the velocity structure, the double-difference tomography method (Zhang and Thurber, 2003) was applied to the 9,551 P- and 5,769 S-wave arrival time data obtained from 609 local earthquakes. The initial 1-D velocity model used in the tomographic study was obtained by the joint hypocenter determination technique (Kissling et al., 1994). The final velocity structure is resolved down to about 15 km depth. The aftershock distribution portrays a gently northward-dipping zone at 5-15 km depth. In several earthquake record sections, later arrival phases, probably reflected waves from the deeper part of the crust, can be recognized. We estimated the geometry of the reflectors which can well explain the observed reflection travel-times, using a 3D finite difference travel-time algorithm (Hole and Zelt, 1995). We identified two reflectors between 60 to 80 km north from the Main Frontal Thrust (MFT). Shallower reflector corresponds to the plate boundary and lower reflector is in the Indian slab. The aftershock distribution is located above reflector. Estimated source fault geometry from earthquake reflection is divided into two parts by 80 km from the MFT; southern part is dipping north by 5 degrees and northern part dips 13 degrees. Our estimated source fault is shallower in depth and lower in dip angle than previous geological estimates (e.g., Bollinger et al., 2004). In the immediate vicinity of the estimated source fault, we find a high-Vp zone in the area 80-90 km north of MFT, which coincides with the large co-seismic slip zone (>6m) as deduced from InSAR and GPS data (e.g., Elliott et al., 2016). A low-Vp zone corresponds to the southern edge of the large co-seismic slip zone. These results suggest that heterogeneous structure around the plate boundary control frictional properties of the fault.

Keywords: The 2015 Gorkha earthquake, Earthquake source fault, Dense seismic array observation, Aftershock distribution, Velocity structure

