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.

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

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Structural Properties of the 2015 Mw7.8 Nepal Earthquake

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The Himalaya orogenic belt is the largest continental collision zone on Earth and presents extreme seismic hazards to growing population centers in Nepal, India and China. Seismologists believe that earthquake rupture zones start and end at locations where there are changes in material properties and/or fault plane changes geometry. The 2015 Nepal earthquake is the most significant sequence along the Himalaya since modern digital earthquake recordings have become available and provides important new data.
In this study, we relocate aftershock hypocenters and conduct 3D P- and S-wave tomography of the source region. This study will benefit from the waveforms recorded by near-field temporary arrays of nearly 100 broadband and short-period seismic stations deployed by the Chinese Academy of Sciences, Stanford University, and Tokyo University. This study extends our previous work (Bai et al., 2016; Pei et al., 2016) which relocated aftershocks within one month and conducted two-dimensional P-wave tomography of the source area. It is our goal to deepen the understanding of the velocity heterogeneity of the earthquake source zones and the geometry of the MHT, along with the Moho and other crustal discontinuities.

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Keywords: the 2015 Mw7.8 Nepal earthquake , Earthquake relocation, Velocity structure

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The ISC products and services related to Tibetan Plateau region

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Several seismological agencies are tasked with the rapid determination of parameters of recent earthquakes such as the 2015 Gorkha Mw 7.8 earthquake in Nepal. The main mission of the International Seismological Centre (ISC) is to provide the definitive information on past earthquakes with the reviewed ISC Bulletin usually becoming available approximately two years after event occurrence. Nevertheless, the historical information relevant to recent earthquakes such as Gorkha is immediately available through a variety of products and services made available to researchers by the ISC.

The ISC Bulletin is the most long-term source of earthquake information that, among other applications, can be used for retrospective seismicity analysis in the area of a recent large earthquake. The data from the EHB bulletin –a groomed subset of the ISC Bulletin –also provides a high-precision view of seismicity in the region. The ISC also updates and maintains the IASPEI Reference Event List (GT) useful for a variety of calibration tasks. The ISC-GEM Catalogue is a highly homogeneous ISC dataset primarily designed for global and regional studies of seismic hazard and risk. The ISC Event Bibliography is an interactive facility that enables searches for references to scientific articles devoted to specific natural and anthropogenic seismic events that occurred within a region and time period of interest.

In this presentation we show examples of how various ISC datasets can be useful to studies of recent earthquakes and structure beneath the Tibetan Plateau region.

Keywords: Tibet, earthquake, catalogue

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The very low frequency earthquakes (VLFEs) relation with the 2008’s great Wenchuan earthquake

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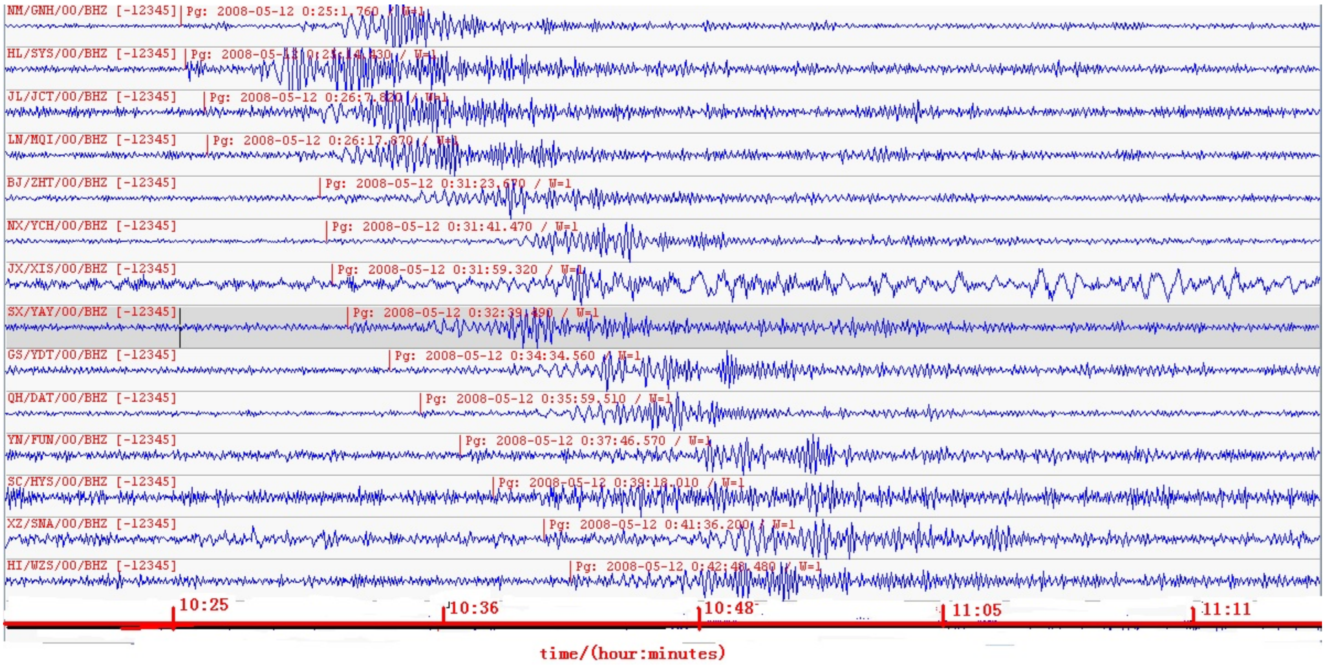
This study reports discovery of very low frequency earthquakes (VLFEs) that occurred 4 h before the 2008 Ml=8.0 Wenchuan earthquake. The VLF events swarm is of 35 events, recorded by China seismic monitoring network between 10:00 to 12:00 on 12 May 2008. The VLFEs are characterized by waveform durations of 1000-2000 s, magnitudes of Mw2-4 and focal depths 25-40 km deeper than those of natural earthquakes in the same regions. The VLFs last arrived phase is reflected wave and clearly to be identified in VLFs waveform, as fig.1. The VLF waveforms is from more than one events with its Pg arrival times.

The VLFEs swarm can be one of important precursor evidence before the large earthquake.

Keywords: very low-frequency earthquakes(VLF), Low-frequency events, the 2008’ Wenchuan 8.0 earthquake



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Density and magnetic intensity of the crust and uppermost mantle across the northern margin of the Tibetan Plateau

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Recently, we have processed the gravitational and geomagnetic data from a geophysical survey along a profile (Baicheng to Da Qaidam) which crosses the northern and eastern Tarim Basin, the Altyn Tagh Mountains, and the Qaidam Basin, respectively. Based on the P- and S-wave velocities (Zhao et al., 2006), both the density and magnetic intensity of the crust and uppermost mantle were determined by using a joint inversion of gravity versus geomagnetism. Our new results at the northern margin of the Tibetan Plateau reflect different crustal structures beneath Tarim basin and Qaidam basin, and these two basins may be produced by different terranes. In addition, strong deformation has occurred in the basement and interior of the Qaidam Basin during the tectonic evolution.

Keywords: Density, Geomagnetic intensity, Tibetan Plateau, Tarim Basin, Altyn Mountains, Qaidam Basin

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Crustal deformation of the northeastern margin of Tibetan Plateau: a combination of the ductile flow and fault-controlled strain

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Through the application of harmonic analysis to a new dense teleseismic data set in the northeastern margin of Tibetan Plateau, we are able to determine the orientation of anisotropy in the upper and lower crust. Upper crustal anisotropy was measured at 18 stations with the fast direction from N32°E to N169°E, which is mainly controlled by local strain. However, in the lower crust, mid/lower crustal flow is probably the main origin of anisotropy, which was measured at 11 stations trending N34°E to N158°E. The crustal deformation model of the northeastern margin of Tibetan Plateau can be interpreted as a combination of the fault-controlled strain field and mid/lower crustal flow.

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Keywords: Tibetan Plateau, Crustal anisotropy, Crutal flow

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