International Research (Project No.: 29W-03)

Project name: Source and Structural Properties of the 2015 Mw7.8 Nepal earthquake
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Research period: April 01, 2017~ March 31, 2019
Research location: Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China
Disaster Prevention Research Institute, Kyoto University
Number of participants in the collaborative research: (1 DPRI and 1 non-DPRI staff) 2
- Number of graduate students: (2 Masters and 1 Doctoral students) 3
- Participation role of graduate students [Data analysis]

Anticipated impact for research and education

Studies of ruptures of large Himalayan earthquakes and their relationships to the velocity structure is important for understanding the source process of large earthquakes. Also, the connection between earthquake ruptures and geologic structure is important for evaluating the strong shaking for future large earthquakes in the region. This project also trained graduate students in seismic data analysis.

Research report

(1) Purpose

The Himalaya orogenic belt produces frequent large earthquakes that affect population centers along a length of over 2500 km. In the central region, the 2015 Gorkha, Nepal earthquake (Mw 7.8) ruptured a ~120-km by 80-km portion of the Main Himalayan Thrust (MHT). The event produced strong shaking and caused nearly 9000 deaths in the region. The rupture highlights important scientific questions about Himalayan tectonics and seismic hazards. These questions include, 1) How to distinguish between different possible geometries of the MHT which was the source fault for the earthquake. 2) How to better define the geologic structures and related locations of the earthquake rupture segmentation, both across-strike and along-strike in the orogenic belt. The main purpose of this research is to study the pattern of 3D seismic velocities and relate these results to the geologic structures and the rupture features of the 2015 Gorkha earthquake.

(2) Summary of research progress

The joint research project takes advantage of the advanced analyses techniques available at DPRI with the unique near-field broadband array data collected by the Institute of Tibetan Plateau Research, Chinese Academy of Sciences (ITPCAS) and Stanford University. The ITPCAS stations were installed before the earthquake and provide good data from before and after the 2015 earthquake. The Stanford stations were installed after the earthquake and provide dense coverage of the aftershocks. Major research efforts include, 1. Determination of accurate earthquake locations and focal mechanisms for events before and after the 2015 Gorhka mainshock. These analyses included near-field, regional and teleseismic seismic data to obtain high-quality locations, especially improved depth resolution. 2. Estimate of three-dimensional P- and S-wave velocity structures for the source region of the 2015 Gorkha earthquake using a seismic tomography method.

(3) Summary of research findings

From the results of the three-dimensional velocity structures, we can see that the MHT exhibits clear lateral variation along and perpendicular to the strike of this structure. The ramp under the Lesser Himalayas is observed to have a moderate dip on the MHT beneath the mainshock hypocenter area. And, there is a flatter and deeper MHT beneath the eastern end of the aftershock zone. East of the aftershock zone, the seismic wave speed increases at MHT depths, due to subduction of an Indian basement ridge. A similar magnitude wave speed change occurs at the western end of the aftershock zone (Fig. 2). These gross morphological structures of the MHT appear to control the rupture length of the Gorkha earthquake. Following these observations for the 2015 earthquake, we are involved in imaging the entire 2,500-km Himalayan front to determine the morphology of the MHT and identify likely controls on the maximum magnitude of earthquakes that can be accommodated on different segments of this convergence zone.

(4) Publications of research findings

Bai, L., Klemperer, S. L., Mori, J., Karplus, M. S., Ding, L., Liu, H., Li, G., Song, B., Dhakal, S., 2019. Lateral variation of the Main Himalayan Thrust controls the rupture length of the 2015 Gorkha earthquake in Nepal, *Science Advances* 5, eaav0723.

Rahman, M. M., Bai, L., 2018. Probabilistic seismic hazard assessment of Nepal estimated from multiple seismic source models. *Earth and Planetary Physics* 2(4): 327-341. http://doi.org/10.26464/epp2018030.