The Impact of Fault Geometry on Megathrust Ruptures

Judith HUBBARD
Earth Observatory of Singapore, Nanyang Technological University

What controls the size and shape of earthquake ruptures? In strike-slip settings, geometrical barriers such as bends and step-overs have been interpreted to act as persistent barriers to rupture, but for thrust faults the role of subsurface geometry is less well known; often the distribution and size of rupture are attributed to changes in fault zone properties.

The 2015 Mw7.8 Gorkha earthquake in Nepal provides a case study to evaluate the impact of fault geometry. Using published geological maps, we have developed a new structural cross-section and a 3D, geologically informed model of the Main Himalayan Thrust, which sourced the rupture. Comparing our model to a detailed slip inversion shows that the slip patch in the earthquake closely matches an oval-shaped, gently dipping fault surface bounded on all sides by steeper ramps. The Gorkha earthquake rupture seems to have been limited by the geometry of the fault.

Similar geometric structures (gently dipping décollements separated by steeply dipping ramps) can be found in other convergent settings, onshore and offshore. We show examples of such geometries from other parts of the Himalayan fault system, the Longmen Shan in China, and the Nankai Trough. Given that fault geometry was the primary control on the Gorkha earthquake, it is likely that geometry could play an important role in segmenting earthquakes in these regions. Adequately constraining megathrust fault geometries around the world may help us to better assess the sizes and locations of future earthquakes.