Detailed imaging of the subduction front in the locked and 2010 Mentawai tsunami earthquake rupture zones from full waveform inversion of seismic reflection data

Gabriel Huot[1], Yanfang Qin[1], *Satish Singh[1]

1. Institut de Physique du Globe de Paris

The Sumatran subduction zone is one of the most seismically active zones on earth. Since 2004, three great earthquakes (Mw > 8.0) occurred (2004, 2005, 2007), rupturing the forearc region along the megathrust. The 2004 earthquakes also ruptured the frontal section of the megathrust, supposed to be aseismic, generating a destructive tsunami. While the 2005 and 2007 great earthquakes did not generate a powerful tsunami, the 2010 Mw 7.8 earthquakes did by unexpectedly rupturing the updip part of the Mentawai segment, which has already ruptured in 2007 in the forearc region. The northern part of the Mentawai segment, between the 2007/2010 and 2005 rupture zones is still locked and might generate a great earthquake, and possibly a destructive tsunami. Therefore, the understanding of rupturing processes and differences between the different segments of the Sumatran subduction zone are critical to assess rupture potential.

We combined downward continuation, traveltime tomography and full waveform inversion on this 15-km-long streamer and low frequency seismic data to characterize the nature of the accretionary wedge and the plate interface. The downward continuation of the streamer data to the seafloor enhanced the refraction arrivals to be observed from near-zero offset up to far offset. Then, the travel time tomography was used to determine the background velocity from the upper sediments down the top of the oceanic crust. Starting from these velocities, we perform an elastic full waveform inversion to determine the detailed velocity structure of the sub-surface. In both regions, the combination of pre-stack depth migrated seismic images and high resolution velocity results show a low velocity subduction channel with high porosity at the plate interface that connects active frontal thrusts at the toe of accretionary wedge, suggesting that the frontal section of the prism is seismogenic. Computation of the porosity of the sediments determined fluid content along these channels and faults. Active seaward and landward-vergent faults at the front of the subduction could generate a powerful tsunami by moving the seafloor at high depth.

Keywords: Sumatra subduction zone, Tsunami earthquake, Full waveform inversion