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Tsunami Earthquakes and Their Unusual Source Character

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Updip limit of seismicity observed worldwide suggests that there is an upper transition from seismic to aseismic faulting for subduction zones, which prohibits large slip near the trench during earthquakes. Here we show, however, large amount of slip during two tsunami earthquakes are located near trench.

We use a back project method to analyze the July 17, 2006 Java (Mw 7.7) and October 25, 2010 Sumatra (Mw 7.8) earthquakes, using low- (0.03 to 0.05 Hz) and high frequency (1.0 to 10 Hz) Hi-net data. The results show that {under}(1) the ruptures extended all the way to the trench with a relative slow rupture velocity (1.0 to 1.5 km/s), and (2) released large slips at shallow portion of the source regions (Figure 1).{/under} The source durations of 100˜150 s are much longer than usual earthquakes. The large near-trench slips are coincident with the tsunami generation areas, as identified by tsunami waveform inversion and field investigation.

The correlation between seamounts and tsunami earthquakes locations indicates that seamounts, which represent seafloor roughness, could be capable of increasing the locking of the subducting interface for the shallow portion of the thrust zone.

Understanding the updip locking for the shallow region of subduction zones is important for understanding tsunami earthquake mechanisms and their occurrence intervals. It is difficult to infer the updip locking from onshore observations as it may overlook the potential hazard from tsunami earthquakes. We suggest the importance of seafloor roughness and offshore observation for understanding tsunami earthquakes.

Figure 1. (a) 2010 Sumatra earthquake. Top show the seismograms recorded at station HMNH, the stacked amplitude curve and rupture velocity. The red, yellow and green lines present a rupture velocity of 1.0, 2.0, and 3.0 km/s, respectively. Bottom shows the locations, timing and amplitudes of the maximum amplitudes for the high frequency band. Red star shows the epicenter. The gray solid circles indicate the low frequency centroids. (b) Same results for the 2006 Java tsunami earthquake.

Keywords: 2006 Java earthquake, 2010 Mentawai earthquake, tsunami, seamounts, rupture process