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Geometry and fault behaviour of the seismogenic coupling zone in central and southern Sumatra: constraints from teleseismic waveform inversion

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South and central Sumatra were affected by great subduction zone earthquakes in 1797 and 1833, with estimated moment magnitudes of 8.7-8.9 and 8.9-9.1, respectively. The area is expected to fail again in a great megathrust earthquakes in the near future. The source area of the 1833 event was located roughly between the towns Padang and Bengkulu. The 1797 event ruptured the segment to the north. In south and central Sumatra, between January of 2001 and November of 2008, 14 earthquakes with magnitudes between 6.4 and 8.4 provided waveform data of high quality that could be used to study the geometry and fault behaviour. I derived the moment tensor and hence fault mechanism, the centroid depth, and source time function using waveforms recorded at distances of 30 to 90°. In general, earthquakes did not extend into the trench but display a well defined seismic front, with a 100-130 km wide area without major seismicity occurring between the trench axis and Mentawai Islands. Waveform inversion indicates that earthquakes under the Mentawai islands occur at a depth of roughly 24 km and the megathrust fault zone dips at 12-13°. Events occurring further landwards generally show larger dips of the fault plain and occur at greater depth, indicating that the dip of the megathrust fault increases approaching Sumatra. However, fault dip and coupling behaviour changes along the coast line. Off Bengkulu (approx. 4°S to 6°S) the fault dips over approximately 180-200 km at 12-14° and dip seems to increase where the forearc Moho intersects the downgoing plate. In central Sumatra (northward of 4°S) the fault dips at approx. 12° for 120-140 km and the dip increases to 18-19° landwards of the Mentawai islands. In addition, earthquakes tend to nucleate updip of the intersection of the forearc Moho with the mantle wedge in southern Sumatra (<33 km depth), while in central Sumatra the Mw=7.9 earthquake of September 12, 2007 clearly nucleated well below the forearc Moho at 46 km depth. Consequently, while the mantle wedge in southern Sumatra might be weak (serpentinized) and did not promote seismogenic failure mantle has to be strong halfway between Padang and Bengkulu, suggesting lateral changes in coupling and properties of the forearc mantle. This fact has important implications for the risk assessment. Thus, slip along the northern portion of the 1833 rupture area and in the 1797 rupture area may extend further landward and may cause larger damage in Sumatra than slip along the southern portion of the 1833 earthquake.