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Sunda Subduction Zone: What causes differences in the 2004 and 2005 Sumatra earthquakes ruptures?

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The Sunda subduction zone has been intensively studied over the last several years, following the Great Sumatra Mw 9.1 earthquake of 2004. Later earthquakes of 2005 and 2010 ruptured in the vicinity of the southern termination of the 2004 rupture, confirming the known observation, that the subduction zone earthquakes usually form segmented patches of co-seismic rupture, bounded by permanent barriers. In particular, in the case of the Sumatra 2004 and 2005 earthquakes, the segment boundary is attributed to the subduction of the 96°E fracture zone. A set of collocated reflection and wide-angle seismic profiles are available on both sides of the segment boundary, perpendicular to the trench, located offshore Simeulue Island. In this study we compare the seismic structure of the subduction complex along two profiles, located on the different sides of the segment boundary: one in the area of the 2004 rupture; the other in the rupture area of the 2005 and 2010 earthquakes. The key differences include: (a) change in the oceanic plate crustal thickness, (b) variations in the amount of sediment on the oceanic plate and in the trench, (c) the volume of the accretionary complex. By comparing the crustal structure along the profiles, we speculate that the 96°E fracture zone presents an efficient barrier in the trench parallel sediment transport, and acts as a divider between the oceanic crustal blocks of different structure. We further speculate that the observed variability of the seismogenic behavior (the width of the seismogenic zone) and the tsunami potential of adjacent segments are mostly controlled by the amount of sediments entering the subduction system.