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Structure and physical properties of the Sumatran subduction zone: Links to segmentation and earthquake rupture

T J Henstock and the Sumatra Segmentation Project Team Team
National Oceanography Centre, University of Southampton, Southampton, United Kingdom (then@noc.soton.ac.uk)

A major UK and international project is investigating the links between the 3D structure and physical properties of the Sumatran subduction zone and rupture during the 2004 and 2005 earthquakes. Slip during these earthquakes shows clear segmentation of the subduction zone, and at least in part replicates previous patterns of rupture. The project focuses on the segment boundaries between the 2004 and 2005 rupture zones, and at the southern end of the 2005 rupture. The project combines surveys at sea (seismic reflection and 3D refraction, heatflow, sidescan sonar and coring) with a land and marine earthquake recording experiment, and refinement of models for earthquake slip distribution. The marine programme collected refraction and deep seismic reflection data during May-July 2008, and will conclude in Jan-March 2009; recording of earthquakes commenced in April 2008 and will continue until February 2009. We will use the data to (a) determine how the structure and seismic velocity of the prism and plate boundary vary between segments, (b) constrain the seismogenic zone using well-located local earthquakes and relate this to the thermal structure, (c) determine how the plate boundary at depth is linked with smaller-scale structures at the seabed, (d) assess the palaeoseismic history of the segments and (e) investigate links between the static structure and properties and the dynamics of the earthquake rupture. Early results from the marine experiment show the complexity of the prism structure and thrust development including changes in the pattern of vergence near the toe of the prism; the plate boundary is consistently imaged from offshore to the forearc high approx. 75km landward of the deformation front. Particularly strong 3D topography on the plate boundary is present at the southern end of the 2005 rupture zone near the Batu Islands that we interpret as due to subduction of structures in the downgoing plate; these structures may be responsible for the unusual rupture history. This is characterised by high moment release in the aftershock distribution. A prominent reflector within the incoming trench wedge offshore Simeulue Island (the 2004/2005 segment boundary) may represent the proto-decollement; initial analysis shows that its depth and seismic properties vary along strike, with further work to quantify this variation and potential relationship to earthquake rupture ongoing.