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High-resolution MCS survey during KH-10-5 Leg.1 off northwest Sumatra cruise

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A huge ocean-wide tsunami, with average heights of more than 20 meters along the west coast of the northern tip of Sumatra followed the 2004 Sumatra-Andaman earthquake (Mw9.2). Several working hypotheses have been proposed, but the generation mechanism for this tsunami remains unresolved. Most of these hypotheses suggest a possible coseismic slip on splay faults in the outer-arc-high off northwest Sumatra. Among these splay faults, the Middle Thrust (or possibly the Lower Thrust), can best account for features of the Indian Ocean tsunamis observed at regional and ocean-wide distances. To map fault traces and other geological structures that may be contributed by splay fault displacements, we conducted the KY09-09 bathymetry survey offshore northern Sumatra in 2009. The aim of that survey was to identify a fault trace that could be considered a candidate for the Middle Thrust (Hirata et al.,2010).

In early November 2010, we have conducted another high-density survey of the likely source region for the tsunami. This survey consists of a MCS (GI-gun, G=45 cuin and I=105 cuin; true GI-gun mode shooting every 10 sec; a 1,200 m-long, 48 channel solid streamer cable) and a 3.5 kHz Sub-Bottom Profiler (automatic ping intervals depending on water depth). A MNBS bathymetry survey using the SEABEAM 2120, shipboard gravity measurement, and 3-component magnetic measurement have also conducted as well. The survey ship speed was set at averagely 4 knots relative to ground. We designed the acoustic survey lines to cross a series of ridges and troughs parallel to the local trench axis and hence to sample fault traces that are candidates of the Main Thrust, the Lower Thrust, the Middle Thrust, the Upper Thrust in the outer-arc high.

The primary objective of the KH-10-5 cruise are to image detailed deformation structure in the uppermost sediment layers, up to 1 second bsfl in TWT, that are plausibly related to deformation occurred along fault traces. Our final goals are (1) to understand the geological structures in the outer-arc high off northwest Sumatra and their deformation history and (2) to resolve the generation mechanism of the Dec 2004 huge tsunami.

Approximately 480 nautical miles of MCS and SBP data were acquired during the KH-10-5 cruise(Figure 1). During the survey, we produced band-pass filtered, single channel profiles as preliminary results for all the survey lines. We could obtain clear images down to about 1.5 sec (TWT) in the trench fill and a maximum of about 1 sec (TWT) in small troughs in the outer-arc high. In Lines 5 and 6, a kink folding and landward vergent backthrusts were identified near the trench. Many of the small basins on the outer-arc high show deformed sediment layer structures, indicating either folding or faulting. Many SBP profiles also show deformation pattern in the uppermost sediment layers that are consistent with deeper deformation imaged by single-channel data. But some of them seem inconsistent, suggesting a difference in deformation pattern between recent (uppermost) and old (substrata) sedimentation periods. In the region where the Middle thrust is postulated, we found abundant evidences of faulting and folding of the sediment within small basins, along lines 4, 5, 6, 8, 10, 11 and 12. But these results are based on onboard processing and are tentative. We are going to process the MCS data and then interpret detailed geological structure in the near future.

Figure 1
The survey lines (heavy black lines) during the KH10-5 cruise. Main structural features (dashed): WAF, West Andaman Fault; UT, Upper Thrust, ; MT, Middle Thrust; LT, Lower Thrust; M'T, Main Thrust. DF, Deformation Front. UT and LT, are depicted according to Sibuet et al. (2007); MT according to Hirata et al. (2010).

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Keywords: sumatra, seafloor, survey, reflection, subbottom, fault