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3D tomographic seismic imaging of the southern rupture barrier of the great Sumatra-Andaman 2005 earthquake

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In 2008 a 3D onshore-offshore controlled-source seismic experiment was carried out in an area of 300 km x 400 km, centered on the southern termination of the great Sumatra-Andaman 2005 earthquake rupture. In the first part of cruise SO198 on R/V Sonne ∼10000 airgun shots were fired into an array of 47 Ocean Bottom Seismometers (OBSs). A further ∼50000 shots were fired into an array of 10 long-deployment OBSs. All shots were recorded on ∼15 seismometers on the islands and more than 20 seismometers along the coast of Sumatra.

An initial velocity model has been derived from 70132 first-arrival traveltimes from 45 OBSs, using the First-Arrival Seismic Tomography (FAST) inversion code developed by Zelt and Barton (1998). Root Mean Square traveltime misfit reduces from 1311 ms in the 1D starting model to 81 ms after 20 non-linear iterations. Offsets range between 0 and 265 km, with rays penetrating up to 28 km depth in the final model, hereby imaging the top of the subducting oceanic plate and revealing its complex 3D topography.

Ray coverage is still being extended by including first-arrival traveltime picks from the landstations on the coast of Sumatra and the islands and from the 10 long-term deployment OBSs that will be recovered in January. The robustness and resolution of the final 3D model is examined by exploring different starting models, different inversion parameters and by carrying out checkerboard tests and synthetic tests.

The resulting crustal 3D velocity model will allow us to explore the nature and physical cause of the rupture barrier of the 2005 great earthquake. Comparison with a similar dataset and subsequent 3D velocity model acquired at the boundary between the 2004 and 2005 earthquakes will provide important insights into the segmentation of the Sumatra subduction zone and the dynamics of its great earthquakes.

Zelt, C. A. and P. J. Barton (1998). Three-dimensional seismic refraction tomography: A comparison of two methods applied to data from the Faroe Basin. Journal of Geophysical Research 103: 7187-7210.