Submarine tectonic landforms and their development process on the landward side of the Sunda trench

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The Sumatra earthquake (Ms 9.0) of December 26, 2004, occurred on the Sunda subduction zone. This gigantic earthquake accompanied a big tsunami, which caused severe disaster in coastal areas surrounding the Indian Ocean. Since most of such disastrous earthquakes have occurred at subduction zones, it is important to clarify the structure and development processes of active submarine faults in subduction zones in order to understand the mechanism, and to reveal the past occurrence, of gigantic earthquakes produced from subduction zones.

The Sunda trench is an active plate boundary, where the Indo-Australian plate is subducting beneath the Eurasian plate. This plate boundary west of the Sunda Strait has a large right-slip component due to oblique subduction. The rate of right slip is 36-49 mm/yr. The right-slip component is accommodated mainly by the Sumatra Fault Zone and the Mentawai Fault Zone. These two fault zones extend southeastward via the Sunda Strait into the forearc basin off Java. In this study, attempts have been made to clarify the distribution and development processes of tectonic landforms in the vicinity of the southeastern termination of this oblique subduction zone. The following results were obtained:

1. Tectonic landforms developing in the study area were mapped by using bathymetric data and single-channel seismic reflection profiles, which were obtained by YK02-07 and YK01-02 cruses of JAMSTEC in 2002 and 2001, respectively. It was found that of the Sumatra and the Mentawai faults converge southeastward with the closest distance of 2-3 km from each other at 105 degree 30 minutes E, 7 degree 23 minutes S, and to the farther southeast they spray into several branches. It was also found that there are characteristic fault topography with a linear valley and two marginal swells on both sides of it. Such fault topography is referred to in this study as 'central-valley type'. In many cases, mud volcanoes develop on or close to faults of central-valley type.
2. A numerical model was constructed for the purpose of analyzing the development of tectonic landforms and growth structures that are associated with faulting. The model take into account mass transfer with material creep, deposition from above, difference in erodibility between bedrocks and unconsolidated sediments, compaction, and surface deformation associated with faulting. Using this model, we can simulate the development of growth structures under more complex situations than conventional geometrical analyses of growth structures.
3. This mode was applied to active tectonic landforms and accompanying growth structures in the study area, in order to estimate the geometry of and the sense of slip on active faults. It was revealed that fault topography with a central valley and its marginal swells is caused by shallow-seated (shallower than 1000-1500 m) tensile displacement on a high-angle, deep-seated strike-slip fault. We suggest that the tensile crack is filled with fluidized crastic materials that were produced by liquefaction in the thick pile of unconsolidated sediments in the forearc basin. Although a much larger component of strike slip may exist on the fault, it is not able to evaluate in this study.
4. By applying the model to a multi-channel seismic profile obtained by Schlueter et al. (2002), we estimated the rate of tensile displacement on, and the dip angle of, the Mentawai fault off the Sunda Strait; it was found that the displacement rate is as high as 2.25 mm/yr, and the dip angle is nearly vertical. By applying the model to single-channel seismic profiles obtained by JAMSTEC, we estimated tensile and reverse displacements on the active faults in the north of the study area. It was found that the rate of tensile slip is 0.3-0.75 mm/yr whereas the rate of thrust slip is 0.5-0.6 mm/yr.