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Structural heterogeneities around the rupture boundaries of the 2011 Tohoku earthquake

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Japan faces major subduction zones along its entire eastern coast line, and has experienced repeating devastating earthquakes. In order to understand the earthquake cycles including stages of strain energy accumulation and of its release, it is essential to answer the following questions; where the limit of rupture propagation is located and how the rupture stopped.
In March, 2011, the M9 Tohoku earthquake occurred off the northeastern part of Japan. A number of studies about the location of its source region have been conducted. Results of these studies share a common feature: the source region extends ∼200 km from the trench axis in the down-dip direction, and ∼400 km in the along-strike direction. At the southern limit of the source region, the largest aftershock of a size of M7.8 occurred 30 minutes after the main shock.
We had noticed seismicity boundaries around the northern limit of the source area. We conducted a series of marine active-source seismic surveys across the seismicity boundaries using ocean bottom seismometers in 1996, 2001 and 2002. The amplitude of reflections from the plate interface show good anti-correlations with the seismicity: large amplitude reflections are observed in the low-seismicity regions. We discussed that such large amplitude can be ascribed to the existence of a fluid-rich low-Vp layer along the plate interface so that the inter-plate mechanical coupling is weak.
Around the southern boundary of the source region, M7-class earthquakes repeatedly occurred at a constant interval of 20 years. We conducted a marine active-source seismic survey in 2004, and a passive seismic observation in 2005. We identified a subducted seamount at a 10 km depth and a trace of seamount subduction along the plate interface. The seismicity in the region corresponds to such structural heterogeneity. A couple of studies show that the rupture propagation during the largest aftershock of the Tohoku earthquake was limited by the existence of the subducting seamount.
We identified, around both northern and southern limits of the source region of the 2011 Tohoku earthquake, some structural heterogeneities along the plate interface that correlate well with the seismicity. Such structural heterogeneities may control the limit of rupture propagation. We continue our investigations by conducting seismic observations and surveys around the rupture boundaries in order to better define those boundaries and to understand mechanisms to stop the rupture propagation.