Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS01-P02 Room:Convention Hall Time:May 19 18:15-19:30

Structural heterogeneities around the shallow megathrust zone of the 2011 Tohoku earthquake

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The coseismic rupture area of the 2011 Tohoku Earthquake has estimated over the wide region from the coastline to near the Japan Trench. Several kinds of studies, such as tsunami source inversion [e.g., Fujii et al., 2011], coseismic slip inversion [e.g., Ide et al., 2011], submarine topography change [Fujiwara et al., 2011] and seafloor displacement observation [Sato et al., 2011; Ito et al., 2011; Kido et al., 2011], share the common feature that the largest coseismic slip occurred at the shallow plate boundary in close vicinity to the Japan Trench. However, the structural image just beneath the largest coseismic slip area was unclear since the observation areas of previous ocean bottom seismographs (OBSs) in this region were limited and there were few OBSs near the Japan Trench [e.g., Yamamoto et al., 2011]. To understand the relationship between coseismic rupture behavior and structural heterogeneities, it is necessary to know the seismic velocity structure of the subducted slab crust and mantle near the trench axis.

After the occurrence of 2011 earthquake, some National Universities (Hokkaido, Tohoku, Chiba, Tokyo, Kyushu, and Kagoshima), JAMSTEC, and Meteorological Research Institute together have conducted the aftershock observations along the landward slope of Japan Trench to obtain detail hypocenter distribution [Shinohara et al., 2012]. Tohoku University has performed the other OBS observation off Miyagi prefecture from 2010 to 2011. During this observation, a sequence of foreshocks, the mainshock, and aftershocks of the 2011 Tohoku earthquake were recorded [Suzuki et al., 2012]. In addition, JAMSTEC has conducted the aftershock observation at outer slope of Japan Trench, around the epicenter of a Mw 7.6 earthquake that occurred about 40 minutes after the 2011 mainshock, from May to June [Obana et al., 2012].

In this study, we performed the three-dimensional seismic tomography by combining these OBS dataset and land seismic data to obtain the fine hypocenter distribution and velocity structure around the largest coseismic slip zone of 2011 Tohoku earthquake. From the relocation results, we found that some deep intraslab earthquakes occur near the trench and their focal mechanism are normal fault type. Since these earthquakes occurred before the 2011 mainshock showed thrust type [e.g., Gamage et al., 2009], our results suggest the change of stress regime in this region. In the outer-rise area, the hypocenter distribution of the relocated shallow earthquakes has a linear trend along the horst-graben structure. Subducted oceanic crust has some heterogeneous structure around the hypocenter of the 2011 mainshock as follows: (1) relatively low Vs and high Vp/Vs zone at landward side of the mainshock location, (2) high Vs and low-Vp/Vs in the south of mainshock. These structural heterogeneities might represent the heterogeneous distribution of fluid in the oceanic crust and/or existence of subducted seamount. In addition, the velocity of uppermost slab mantle from 143 degree E to the trench axis showed low Vp, Vp/Vs (˜1.70) and high Vs ($>$ 5.0 km/s). This feature might reflect the existence of strongly anisotropy in the slab mantle or indicate the locally orthopyroxene enrichment.

This work is supported in part by the Special Coordination Funds for the Promotion of Science and Technology (MEXT, Japan) titled ”the integrated research for the 2011 off the Pacific coast of Tohoku earthquake”. A part of this study also supported by ”Research concerning Interaction between Tokai, Tonankai and Nankai Earthquakes” funded by MEXT, Japan, and the JAMSTEC’s rapid response research project for the 2011 Tohoku-oki earthquake.

Keywords: Tohoku megathrust earthquake, seismic tomography, ocean bottom seismic observation, oceanic crust