Crustal structure beneath the eastern foot of the Japan Trench outer rise by airgun-OBS survey

*Shuhei Otomo[1], Ryosuke Azuma[1], Ryota Hino[1], Gou Fujie[2], Shuichi Kodaira[2]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku Univ., 2. Japan Agency for Marine-Earth Science and Technology

Several studies on the seismic structure of the oceanic crust reported presence of evident reflectors in the oceanic lower crust or in the uppermost mantle although the seismic structure of the deeper part of the oceanic crust is thought to be relatively homogeneous. The presence of such reflective structure would be related to the processes of formation and/or growth of the oceanic crust. For an example, the reflectors identified at the uppermost mantle of the Pacific Plate off the Kuril Trench was interpreted as Riedel shears which were formed during the plate motion [Kodaira et al., NGEO, 2014]. To study the development process of the Pacific Plate, we investigate the crustal structure of the old Pacific Plate in the northwestern Pacific before it suffers from bending deformation at the trench by analyzing an airgun-ocean bottom seismometer (OBS) survey conducted in the eastern foot of the Japan Trench outer rise.

We used OBS data collected by the wide-angle seismic survey made in 2010. 23 OBSs were deployed along an NS-running survey line (239 km, in total) at a 6 km spacing. Airgun was fired at every 0.2 km. On the record sections obtained at the OBSs located southern part of the line, the first arrivals with an apparent velocity of ~6.5 km/s, possibly waves refracted in the oceanic layer 3, are found to be associated with clear shadow zones, in which amplitudes of arrivals were remarkably weak. The shadow zones of the first arrival are interpreted to be caused by a negative velocity gradient in the deeper part of the oceanic layer 3. The shadow zones are more distinct on the records obtained at southern OBSs than those at northern OBSs, suggesting lateral variation of the structure near the bottom of the layer 3.

A traveltime analysis using a 2-D ray tracing method was made to construct a 2-D P-wave velocity model explaining the characteristics of OBS data, especially the presence of the shadow zones of the first arrivals. By assuming a low velocity zone (LVZ) in the lower oceanic layer 3 with lateral variation of the thickness, the observed appearance of the OBS records can be well explained [Otomo et al., SSJ, 2016]. On the other hand, we applied a series of waveform analyses to obtain a reflection seismic profile by the OBS data, combining a Seismic Interferometry (SI) technique and a NMO stacking. On the reflection profile based on the OBS records data, continuous and evident signals are imaged at ~ 9.0 s in two-way travel time (TWT) [Otomo et al., JpGU, 2016]. The TWT of the event is not consistent with that of the reflections from Moho discontinuity but is similar to that of the reflections from the top of the LVZ, if such reflection signals are actually observed.

We tried to apply the series of SI-NMO analyses to synthetic OBS seismograms calculated based on the velocity model with the LVZ in the layer 3 required to explain the observed shadow zones of the first arrivals, so than we can make sure if the reflected arrivals from the top of the LVZ can be imaged by the identical analysis applied to the field data. On the reflection profiles by processing the synthetic data, clear reflection events are identified at TWTs of ~9.0 s and ~9.7 s. The shallower reflector coincides with the top of LVZ, whereas the deeper one is the Moho reflection. This test reinforces our interpretation that the reflections from the LVZ were imaged on the profiles derived by the field OBS data. Since the reflection events are more evidently observed in the southern part of the survey line than in the northern

part, the velocity contrast at the top of the LVZ would be larger in the south, where the shadow zones of the first arrivals were more distinct. These features may be consistently explained by assuming strong lateral variation in the LVZ located near the bottom of the oceanic layer 3.