Crustal structure in the outer-rise off the Japan Trench

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The bending of the incoming oceanic plate is an important process changing the internal structure before the plate gets subducted. In order to understand the relation between the plate deformation and structure changes in detail, it is necessary to clarify how the crustal structural in the outer-rise region changes towards the trench axial region. Recently, several seismic surveys around the Japan-Kuril trench outer-rise region indicated a possibility that some structural change may have occurred in the oceanic plate before starting the bending-related deformation because structures by their surveys showed different structure from that in the NW Pacific Basin.
We investigated the crustal structure of the old Pacific Plate in the eastern foot of the Japan Trench outer-rise, northwestern Pacific, where the oceanic crust is supposed to be less influenced by the bending-related deformation. In this study, we applied a traveltime inversion to the refraction and wide-angle reflection seismic data obtained by an airgun-ocean bottom seismometer (OBS) survey to estimate a P-wave velocity (Vp) structure model. We also produce a seismic reflection image using dense and wide-offset seismic data by applying a seismic interferometry (SI) to the airgun-OBS data.
The estimated Vp model showed a horizontally layered structure, composed of the oceanic layer 2 from 6 to 8 km in depth, the oceanic layer 3 from 8 to 13 km, and the uppermost oceanic mantle deeper than 13 km. Evident velocity reversal was identified ion the depth range from 9 km to 13 km, corresponding to the lower part of the oceanic layer 3. The Vp in the layer 3 was 6.8 –7.1 km/s at 9 km in depth but decreases to 6.5 –6.9 km/s at 12 km depth. But the degree of the velocity reduction is variable along the line because the Vp at the lower crust shows lateral increase by ˜ 0.3 km/s towards the north.
The record sections obtained by SI showed three distinct phases with different arrival times and apparent velocities. Based on a comparison of traveltime curves calculated traveltimes from the Vp model, these phases were interpreted as the reflection waves from the basement of the sediment layer, the refraction waves from the oceanic crust, and the reflection waves from the oceanic Moho, respectively. The seismic section processed by a pre-stack time migration provided clear reflector images at TWTs of 7.8 s and 10.2 s, respectively interpreted as the oceanic basement, top of the igneous oceanic crust, and the oceanic Moho. The oceanic Moho was much clearer than that imaged by the conventional multi-channel seismic reflection survey. The reflectivity of the oceanic Moho was continuous in the southern part of the survey line but decreased at the northern part of the survey line, indicating significant lateral variation of the deeper part of the oceanic crust.
The velocity reversal structure in the oceanic layer 3 had a negative velocity gradient of about 0.01 s^{-1} and was also observed by other refraction surveys conducted around the survey lines of our study (e.g. Fujie et al., 2013). However, such the velocity reversal was not observed in the northwestern Pacific Basin distant from the outer-rise region. Therefore, we suggest that the velocity reversal in the lower oceanic crust could be formed in the outer-rise.
The basement high located at the northern end of the survey line is associated with positive Vp anomaly in the oceanic layer 3 and also with the significant decrease of the reflection intensity of the Moho. Positive gravity anomaly around this structure anomaly (Nakanishi, 2017) and similarity to the Vp structure of the old seamount (e.g. Nishizawa et al., 2009), the basement high could be product of an off-ridge volcanism. Petit-spot activity formed in the outer-rise area (e.g. Hirano et al., 2006) can be one of the candidates.

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