Spatial distribution of the interplate reflectivity around the slow slip source off the northeastern Japan forearc by an airgun-ocean bottom seismometer survey

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Various kinds of slips have been observed along the plate boundary (PB) in the Japan Trench subduction zone. The Tohoku-oki earthquake has largely ruptured the shallowest part of the plate boundary fault in the Japan trench subduction zone. Prior to the Tohoku-oki earthquake, slow slip events (SSEs) happened in 2008 and 2011 at 37.7–38.7 N in the shallow slip area of the 2011 Tohoku-oki earthquake (Ito et al., 2013). In the Nankai trough subduction zone, faults hosting SSEs are often characterized by low seismic velocity anomalies indicating the existence of the high pore pressure fluid (e.g., Shelly et al., 2006). Although it is expected that the distribution of the interplate low velocity material can be identified by strong seismic reflectivity of the interface, a detail structure in the SSE source area remains unknown.
To clarify seismic structure around the 2011 SSE source area, which will improve understanding of the mechanism of SSE generation, we made an airgun-OBS (Ocean Bottom Seismometer) survey in 2014. Two survey lines, which ran on the land slope and were slightly oblique to the trench axis, covered the SSE source area in their southern sections. We estimated a P-wave velocity (Vp) model by a first arrival traveltime tomography (Fujie et al., 2013). Then, to examine a variation of the interplate reflection intensity which is sensitive to the presence of the interplate low velocity material, we estimated a ratio between amplitudes of the reflection signals from the plate boundary to those of direct water waves, after identifying the interplate reflections based on a reflection traveltime mapping analysis (Fujie et al., 2006).
The estimated Vp models along the survey lines showed that, above the plate boundary, the high Vp island arc upper crust (˜ 5 km/s) and the Cretaceous backstop (˜ 4 km/s) distributed to the south of 39 N, corresponding to the spatial extent of the 2011 SSE. In the northern part of the survey line, outside of the SSE zone, the low Vp unconsolidated sediment (< ˜ 3 km/s) corresponding to the deformed prism was identified.
The estimated amplitude ratios varied bounded on 39 N. For the both survey lines, the ratios of ˜0.01, meaning strong reflection sufficiently clear to pick, distributed to the south of 39 N. On the other hand, to the north of 39 N, the ratios increased to 2–3 times for the trenchward line besides the interplate reflection was scarcely observed for the landward line.
In general, the strong interplate reflection is observed in case that a large variation in Vp exists across the plate boundary. Because a small Vp difference across the reflective boundary in the Vp model expects a less efficiency of the interplate reflection, some interplate low Vp materials (e.g., subducted sediments and/or pore fluid) is necessary to cause a large Vp contrast. On the other hand, the spatial extent of the strong reflectivity is not always consistent with the variation of the small Vp difference across the plate boundary. Therefore, the observed interplate reflectivity may indicate a structural anomaly localizing around the plate boundary. After all, the strong reflectivity happens simultaneously to the 2011 SSE fault. Therefore, the observed structural anomaly would participate with the occurrence of the SSE.

Keywords: interplate reflectivity, crustal structure, slow earthquake

