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Structure of the PHS in the southernmost area of the Southern Japanese Alps using dense seismic array records

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The southernmost area of the southern Japanese Alps is located within a focal region of the anticipated Tokai earthquake and at the western edge of the Izu collision zone. The structure of the subducting Philippine Sea Plate (PHS) in this area, however, remains enigmatic. To investigate the structure of the subducting PHS as well as the physical property of the oceanic crust, we deployed a temporary, dense array consisting of 34 portable seismic stations extending 50 km in the southernmost area of the southern Japanese Alps. The seismic line started from Umegashima, Aoi-ku, Shizuoka city, and ended at Haruno-cho, Tenryu-ku, Hamamatsu city in Shizuoka prefecture. We applied receiver function and seismic tomography to the observed data, and discussed lateral variations of the plate interface and physical properties of the subducting oceanic crust in the studied area.

The analysis in this study is as follows.

1. We estimated velocity discontinuities by applying receiver function analysis to the seismic waveforms recorded by both the present array and five Hi-net stations near the array for teleseismic events with epicentral distance from 30 to 90 degrees.

2. We estimated seismic velocity structures by applying the double-difference tomography method (Zhang and Thurber, 2003) to the arrival time data. We used seismic waveforms of 354 local earthquakes retrieved at both the seismic array deployed by the present study and permanent seismic stations (45 stations) around the array.

3. To investigate seismicity in the studied area, we relocated the earthquakes from January 2004 to October 2014 applying the double-difference relocation (Waldhauser and Ellsworth, 2000) using the final velocity model estimated by seismic tomography.

We interpret the configuration of the PHS in the receiver function image. As overall character, the plate interface beneath the seismic array gradually becomes shallow toward the northeastern side. The plate interface interpreted in the present study well matches with those proposed by Matsu'ura et al. (1991), Kato et al. (2010), and Ito et al. (2013) at the both edges of the section. For example, Hirose et al. (2008) delineated the smooth plate interface of the PHS. However, the interpretation in this study suggests that the plate interface of the subducting PHS is not simply smooth, but has a convex, complex structure in the studied region. Interestingly, this complex configuration well correlates with the spatial distributions of intraslab earthquakes. A likely explanation is bucking deformation of the PHS due to the effect of collision and subduction. Subduction of a sea mountain beneath the seismic line as seen in the southwest part of the studied area (e.g., Kodaira et al., 2004) is another possible explanation. The reason is under discussion.

From the center to the southwestern side of our seismic section, oceanic crust is characterized by relatively low Vs with a high Vp/Vs ratio. The oceanic crust in this area does not host any significant seismicity. In contrast, at the northeastern side of our seismic section, a low Vp/Vs ratio seems to be present within the oceanic crust, and hosts active seismicity therein. A plausible explanation of the low Vp/Vs ratio within the oceanic crust is that intra-oceanic island arc crust is subducting beneath the northeast side of our seismic section. We suggest that different amount of water trapped within the subducting oceanic crust beneath the studied area may control lateral variations of activity level of non-volcanic tremors or deep low-frequency earthquakes at down-dip extension.

Keywords: southernmost area of the southern Japanese Alps, Philippine Sea Plate, receiver function, seismic tomography, intra-oceanic island arc crust, deep low-frequency earthquakes