Heterogeneous structure in and around the slow-earthquake source region beneath the eastern Kii Peninsula, SW Japan

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The Nankai trough region, where the Philippine Sea Plate (PHS) subducts beneath the SW Japan arc, is a well-known seismogenic zone of interplate earthquakes. Recently, various slip types, including episodic tremors and very low-frequency earthquakes, have been recognized at or near the up-dip and down-dip limits of seismogenic zone (e.g., Obara, 2002; Ito and Obara, 2006). Obara(2002) suggested fluids as a source for tremor. Previous studies indicate the fluid pressure on a plate interface is one of the key factors to understand the fault slip process (e.g., Saffer and Tobin, 2011). Seismic reflection characteristics and seismic velocity variations can provide important information on the fluid-related heterogeneity of structure around plate interface. In 2006, active-source seismic experiment was conducted to obtain the subduction structure beneath the eastern part of the Kii Peninsula (Iwasaki et al., 2008). Iwasaki et al. (2008) revealed the geometry of the subducting PHS. However, little is known about the deeper part of the plate boundary, especially Vp/Vs structure in and around the source region of the slow-earthquake. Passive seismic data is useful to obtain a deep image including the S-wave velocity. Therefore, we conducted passive seismic experiment in the eastern part of the Kii Peninsula. Ninety portable seismographs were installed on a 90-km-long line nearly parallel to the direction of the subduction of the PHS with approximately 1 km spacing. Each seismograph consisted of a 1.0-Hz 3-component seismometer and an offline recorder. Waveforms were continuously recorded during the period from May 26, 2015 to December 8, 2015. The continuously recorded data obtained by the offline recorders were processed in the laboratory subsequent to the observations. First, they were divided into event files, each of which had waveform data that started from an origin time determined by the Japan Meteorological Agency. In order to obtain a high-resolution velocity model, a well-controlled hypocenter is essential. Due to this, we combined the seismic array data recorded by the offline recorders with the telemetered seismic data. We used 116 telemetered seismic stations in the present study. P- and S-wave arrivals for the 275 local earthquakes were picked, yielding 17,957 P-wave and 15,442 S-wave arrival times that were used in our analysis. To investigate the earthquake locations and three dimensional Vp and Vp/Vs structures, the double-difference tomography method (Zhang and Thurber, 2003) was applied to the P- and S-wave arrival time data obtained from 275 local earthquakes. The initial 1-D velocity model used in the present study was obtained by resampling the 1-D velocity model calculated by the joint hypocenter determination technique (Kissling et al., 1994). The final 3-D velocity structures are resolved down to 50 km depth. Hypocenter distribution associated with the underthrusting of the PHS is located beneath the subducting oceanic Moho. Most low-frequency earthquakes (LFEs) are located within subducting oceanic crust. Reported strong reflector interpreted to be the top of the PHS (Iwasaki et al., 2008) well corresponds to the top of the LFE zone. LFEs are also located in and around the low Vp and high Vp/Vs zone. The low Vp and high Vp/Vs zone generally suggests the existence of fluid (e.g., Zhao et al., 1996). The obtained fluid-related heterogeneous structure is clearly correlated with the source region of the LFE. These results indicate the occurrence of the LFEs may be associated with fluids. Previous research has indicated that zones of high pore-fluid pressure are marked by high reflectivity and/or high Vp/Vs (e.g., Kodaira et al., 2004). These studies suggest that fluids dehydrated from the PHS may control the degree of plate coupling.

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