Tomographic Imaging of Heterogeneous Structure beneath the Kii Peninsula; Role of Mantle Upwelling on Crustal Activity

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The Kii peninsula is located in the forearc region of southwestern Japan, where the Philippine Sea (PHS) plate is subducting along the Nankai Trough beneath the Amurian plate and the Pacific (PA) plate is descending from the east beneath them. Non-volcanic low-frequency earthquakes (LFEs) occur around the plate boundary in this region. The Kii peninsula is known to be an anomalous region in terms of ^{3}He/^{4}He ratios (Sano and Wakita, 1985) suggesting that some mechanisms that bring primordial ^{3}He from the mantle are working there. To understand detailed heterogeneous structure beneath the Kii peninsula, we attempt to determine 3D seismic velocity structure by using the tomographic method of Zhao et al. (1992).

The study region is 33-37N, 133-138E, and a depth range of 0-400km. The number of stations used in this study is -600. We excluded earthquakes whose P and S wave arrivals were not observed at any stations within shorter epicentral distance than those focal depths. Then, an earthquake with largest number of observations in each 0.05degree$*$0.05degree$*$5km box was selected to make the distribution as uniform as possible. The total number of earthquakes thus selected was -12,000. Horizontal and vertical grid nodes were set with a spacing of 0.2degree and 5-50km, respectively. The final results were obtained after the 5^{th} iteration. The root mean squares (RMS) of the arrival time residuals were reduced from 0.16s and 0.31s to 0.11s and 0.23s for P and S waves, respectively.

Obtained results show following features. Beneath eastern Shikoku and Tokai, high-velocity anomaly is imaged just below the seismicity in the PHS slab, while low-velocity anomaly is imaged around and above LFEs. In the southwestern part of the Kii peninsula, seismic velocity under the slab seismicity is not so high. Although seismic velocity around LFEs is also low in this area, high-velocity anomaly is seen above LFEs. Low-velocity anomaly imaged beneath the Wakayama earthquake swarm appears to connect with that around the Moho. The central Kii peninsula shows similar features to Tokai, except for the high-velocity anomaly in the lower crust.

In order to image more detailed structure, we performed tomographic inversion with denser grid spacing. The 3D model obtained by the 1^{st} inversion was adopted as an initial velocity model. Grid nodes with narrower horizontal space (0.1degree) were placed in a region of 33.6-34.6N, 134.8-136.2E, and depths of 10-60km. Only velocity structure within the restricted region was inverted. We reselected an earthquake with the same way from a box of 0.02degree$*$0.02degree$*$2km for this region. The total number of selected earthquakes was -16,000. The final results were obtained after the 5^{th} iteration. RMS of the arrival time residuals was reduced from 0.08s and 0.17s to 0.07s and 0.16s for P and S waves, respectively.

Results of the 2^{nd} inversion show smaller-scale heterogeneous structures. A low-velocity anomaly at the uppermost part of the PHS slab, which is interpreted as hydrated oceanic crust, is imaged seaward of LFEs in the southwestern part of the Kii peninsula, while it is imaged around LFEs in the central part. Velocity distribution along a curved surface 5km below the upper boundary of the PHS slab shows that a low-velocity anomaly is distributed along the coast of the peninsula. This anomaly is disrupted at the southern tip of the peninsula where a slab segmentation extended from the segmental boundary of Nankai and Tonankai earthquakes is suggested (Shiomi and Park, 2008). The imaged velocity structure may be related to this slab segmentation.

Below the PHS slab, a mantle upwelling from the PA slab is suggested by Nakajima and Hasegawa (2007). We will estimate seismic attenuation structure in the upper mantle beneath the Kii peninsula and investigate the cause of low-velocity anomaly below the PHS slab.