Characteristics of slab-derived fluids beneath Kii Peninsula, southwestern Japan inferred from seismic tomography

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1. Introduction

In order to investigate behavior and nature of slab-derived fluids discharged from the Philippine Sea plate subducting beneath Kii Peninsula, southwestern Japan, we carried out linear array seismic observations, receiver function analyses and seismic tomography. We estimated the geometry of the slab and the seismic velocity structure beneath the Kii Peninsula, and discussed the behavior of the fluids with the distribution of low velocity anomalies. We are now understanding relations between the fluids and deep low frequency events and active micro seismicity beneath the northern Wakayama Prefecture.

2. Receiver function analysis

We carried out linear array seismic observations in the Kii Peninsula from 2004 to 2013. We deployed seismometers along profile lines with an average spacing of ˜ 5 km. We applied receiver function analyses and obtained images of S wave velocity discontinuities. We estimated 3D configurations of the continental Moho, the slab top and the oceanic Moho from receiver function images for four profile lines in the NNW-SSE direction which is the dip direction of the Philippine Sea slab and for two profile lines in the NNW-SSE direction that is almost perpendicular to the dip direction.

The continental Moho, the slab top and the oceanic Moho are clearly found in the receiver function images. A new knowledge obtained by the analysis is that the continental Moho dips upward in the southeast direction above the Philippine Sea slab.

3. Seismic tomography

We carried out seismic traveltime tomography with FMTOMO (Rawlinson et al., 2006) in which a robust wavefront tracking (de Kool et al., 2006) is implemented for the theoretical travel time calculation and the ray tracing. We used a velocity model with the 3D geometries of the three discontinuities derived from the receiver function analysis. We also used observed travel times at temporary stations in the dense linear arrays in addition to permanent stations. A dense distribution of the temporary stations contributed to higher resolutions of tomographic images. We used 231,650 P travel times and 210,142 S travel times from 3,445 local events during May 2004 –March 2013. We also applied the four-step approach by Ramachandran and Hyndman (2012) to estimate accurately Vp/Vs ratios.

Results of the tomography show that low velocity anomalies (> 5 % in both P and S wave velocities and high Vp/Vs ratio > 1.8) are located in deep low frequency events areas at 30 –40 km depths on the Philippine Sea slab and that another strong low velocity anomaly (> 10 % in P wave velocity and low Vp/Vs ratio < 1.6) is widely distributed in the lower crust beneath the northern Wakayama Prefecture where small to micro earthquake activity is very high in the upper crust (Figure 1). The first feature can be due to discharged H_2O from hydrous minerals in the oceanic crust at 30 –40 km depths. The second feature can be explained by a mechanism that fluids upwelling from the low velocity anomaly in the lower crust increase the pore pressure in existing cracks in the brittle upper crust. The low Vp/Vs ratio in the low velocity anomaly beneath the northern Wakayama Prefecture might indicate that the low velocity body is deposited silica.

We used waveform data from permanent stations of NIED; JMA; ERI, Univ. of Tokyo; Nagoya Univ. and DPRI, Kyoto Univ.

Keywords: tomography, slab-derived fluids, Kii Peninsula

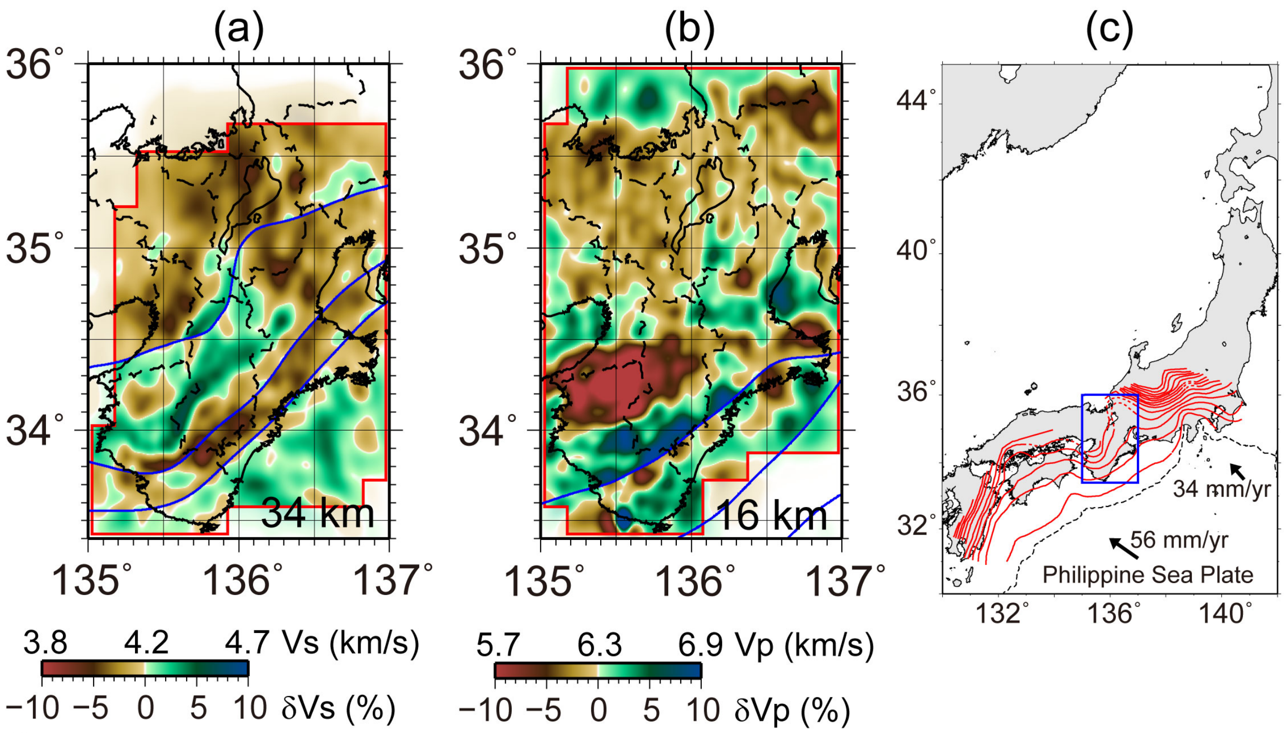

Figure 1
Heterogeneous distribution of seismic wave velocity in and around Kii Peninsula.
(a) Perturbation of S wave velocity at 34 km depth from the reference velocity of 4.23 km/s. The blue lines denote the continental Moho, the slab top and the oceanic Moho from the north to the south. The broken lines indicate prefectures' borders.
(b) Perturbation of P wave velocity at 16 km depth from the reference velocity of 6.28 km/s.
(c) A map showing the location of our study area (blue rectangle). The broken lines indicate Nankai and Sagami troughs. The red lines show contours of the Philippine Sea slab. The arrows indicate velocities of the Philippine Sea plate.