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3-D P-wave anisotropy tomography of the crust and upper mantle beneath Hokkaido

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The velocity of seismic wave depends on the direction of wave propagation, which is called seismic anisotropy. Seismic anisotropy is induced mainly by the lattice-preferred orientation of anisotropic minerals in the mantle, especially olivine which exhibits strong anisotropy. Olivine can changes its type depending on temperature, pressure, and water content. Isotropic seismic tomography determines velocity anomalies in the crust and mantle, but it cannot directly provide us with information on mantle dynamics. Considering seismic anisotropy in tomography can provide such useful information. P-wave anisotropy tomography has been proposed, which can determine azimuthal and radial anisotropy (e.g., Wang and Zhao, 2013). In this work we focus on 3-D P-wave radial anisotropy.

We estimated 3-D P-wave velocity structure and P-wave anisotropy of the crust and upper mantle under Hokkaido using a large number of arrival-time data from local earthquakes recoded by the dense Kiban seismic network. We used P-wave arrival-time data selected from the JMA Unified Catalog and the data reprocessed by staffs of Research Center for Prediction of Earthquakes and Volcanic Eruptions of Tohoku University. Our study region is between 40N˜46N and 138E˜147E. To determine the velocity structure under the entire Hokkaido, our study region also includes northern Tohoku. We set up a 3-D grid and invert for isotropic velocity and radial anisotropy parameter at each grid node. We also compared our results with those of previous studies. One previous study is Wang and Zhao (2013) on P-wave tomography for 3-D azimuthal and radial anisotropy of Tohoku and Kyusyu subduction zones. The other study is Liu et al. (2013) on P-wave azimuthal-anisotropy tomography under Hokkaido.

In this study, we used 333 seismic stations. The followings are our criteria for the selection of local earthquakes. (1) Earthquake epicenters are located between 40N˜46N and 138E˜147E ; (2) The focal depths are $<$350 km; and (3) the event epicenters are located beneath the land of Hokkaido or the Pacific Ocean within 20 km from the coastline. As a result, our data set contains about 170,000 P-wave arrival times from 2030 local earthquakes.

The grid interval is 0.2 degree in the latitude and longitude directions, and the grid nodes are set up at depths of 8, 25, 40, 65, 90, 120, 150, 180, 200, 250, 300 and 350 km. The starting velocity model for the 3-D tomographic inversion is the 1-D J-B model, whereas we have added +4% high-velocity anomaly to the subducting Pacific slab. The results of this work are summarized as follows.

(1) Prominent low-velocity anomalies are revealed under Mt. Tarumae, Tokachi, and Usu active volcanoes, which may contain high-temperature melts associated with slab dehydration.

(2) Low-velocity anomalies exist in the mantle wedge beneath the volcanic front and back-arc area. The vertical-velocity is greater in the low-V zones, which is similar to that beneath Tohoku and Kyusyu.

(3) The horizontal-velocity is greater in the subducting slab, similar to the radial anisotropy results in Tohoku and Kyusyu.

(4) There is little azimuthal anisotropy in the low-velocity body under Mt. Usu (Liu et al., 2013), but our study shows very strong radial anisotropy. This result suggests the existence of upwelling flow in the mantle wedge beneath Mt. Usu.

References

Liu, X., D. Zhao, S. Li (2013) Seismic heterogeneity and anisotropy of the southern Kuril arc: Insight into megathrust earthquakes. Geophys. J. Int. 194, 1069-1090.

Wang, J., D. Zhao (2013) P-wave tomography for 3-D radial and azimuthal anisotropy of Tohoku and Kyushu subduction zones. Geophys. J. Int. 193, 1166-1181.

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