3-D upper mantle structure beneath the Sea of Japan with inter-station surface-wave analysis using multiple seismic arrays

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The Sea of Japan is one of the typical back-arc basins in the western Pacific, comprising three major basins (Japan, Yamato and Tsushima Basins) and Yamato and North Yamato Rises in its center. In addition to such characteristic sea-floor topography, the crustal thickness beneath this marginal sea is variable, reflecting the complex tectonic history of the back-arc spreading, which had occurred from 30 to 10 Ma. Thus, the seismic structure in the crust and upper mantle beneath the Sea of Japan is likely to reflect its complex tectonic history including back-arc spreading and the subsequent formation of the Japanese islands.

The 3-D upper mantle structure around the Japanese islands has been investigated by Yoshizawa et al. (2010, PEPI), based on inter-station dispersion measurements of surface waves primarily using permanent broad-band seismic stations deployed throughout Japan (F-net) and some stations of the Global Seismic Network in east Asia. However, this earlier model had insufficient lateral resolution for most areas in the Sea of Japan, due to the limited ray path coverage. In this study, in addition to the permanent seismic networks in Japan and east Asia, we employ temporary broadband seismic arrays in Northeast China (NECESSArray) with 120 stations from 2009 to 2011, and in Far-east region of Russia with 8 stations since 2005. By combining all these multiple seismic arrays, we are able to collect a large number of inter-station paths across the Sea of Japan, which can be of help in enhancing the horizontal resolution of surface-wave tomography model.

For the inter-station phase speed measurements of this study, we used a fully non-linear waveform fitting technique developed by Hamada & Yoshizawa (2015, GJI). Through the waveform analysis of the combined data sets in the period range between 25 and 130 seconds, we collected about 12000 new measurements of phase speeds using events with moment magnitude greater than 6.0 from 2002 to 2016. With the additional data sets from arrays in Northeast China and Far-East Russia, we are now able to resolve the smaller scale heterogeneity of about 1.5 degrees or less in the Sea of Japan. The updated 3-D upper mantle structure show significant fast shear wave speed anomalies in the top 55-65 km, representing the oceanic-type lithosphere, while the conspicuous slow anomalies are found beneath 70 km depth in most areas under the Sea of Japan. The lithospheric thickness varies slightly from place to place, suggesting relatively thicker lithosphere in the eastern margin of the Japan Basin as well as Yamato Basin. Slow anomalies in the asthenosphere are more enhanced under the Japan Basin, compared with the other basins. This slow anomaly tends to be more enhanced in the western part of the Japan Basin

near the continental margin, which may be mixed with the strong local slow anomaly right beneath the Changbaishan Volcano in the border between China and North Korea, mainly due to the smearing effects caused by biased azimuthal coverage of surface wave paths in this region.

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