

Three-dimensional shear wave velocity structure in and around Japan by the surface wave two-station method

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In this study, we first obtained phase velocity models of fundamental-mode Rayleigh and Love waves beneath the Japanese Islands and the Sea of Japan in the period range between 20 and 150 seconds by extending a conventional two-station approach, using a large data set in the Japanese Islands and its surrounding area. We used three-component seismograms from the F-net broad-band seismic network (NIED) inside Japan (73 stations) as well as FDSN stations in East Asia (23 stations). We also used records of the temporal broad-band stations in the Far-east region of Russia deployed under the auspice of the Stagnant Slab Project (8 stations). With the Russian data, we could set up a fair good ray-path coverage over the Sea of Japan for the first time. We used seismic events over the world for 3 years from 2005 to 2007 with moment magnitude greater than 6 and at depth shallower than 100 km. We chose two-station pairs with the following criteria: difference in azimuth from a source to two stations less than 0.5 degrees, and their distance longer than 50 km. The average station interval of F-net is less than 100 km, which is appropriate to estimate local phase speed dispersion in a relatively short period range down to 20 seconds.

We then converted two sets of surface wave phase velocity distributions into 3-D SV and SH wave velocity models independently. The obtained 3-D shear wave velocity models are reliable in the depth range between 40km and 160km beneath the Japanese Islands and the Sea of Japan. In our SV model, slow anomalies (about 4-8%) exist at the depth of 40km in the central Japan (Chubu) and the Hokkaido region, especially in the Hidaka region, which is likely to be related to thick island-arc crust there. We can also identify high velocity anomalies (about 2-8%) in the Japan Trench extend from the west of Tohoku to Kanto as well as Izu-bonin, which corresponds to the subducting Pacific plate. Furthermore, we can confirm nearly horizontal high velocity anomalies beneath the southwestern Japan at the depth between 40 and 100km, which is likely to be related to the subducting Philippine Sea Plate. The majority of the Sea of Japan appears to be oceanic with relatively high velocity at a depth shallower than 100 km. In the west of the Kyusyu Island, we see a low velocity anomaly at a shallow depth between 50 and 130 km. In the back-arc of Kyusyu, upwelling flow in the mantle was inferred from several previous geological and geophysical studies. Although our shear wave velocity models do not have sufficient resolution beneath this region, the imaged low anomaly strongly supports this upwelling flow.

In our SH models, we obtained high resolution in the depth range between 40 and 70 km while the resolution deeper than 70km is not sufficient. This is mainly because horizontal components are usually noisier than the vertical component, and, the fundamental-mode Love wave tends to be overlapped by body waves and/or higher modes in our chosen time window, which often makes it more difficult to estimate Love wave phase velocities than the Rayleigh. Furthermore, mis-alignment of the horizontal components may take place at some stations and off-great-circle propagations of surface waves might be strange than the case of Rayleigh waves.

In the end, we mapped the degree of polarization anisotropy estimated by the SV and SH wave velocity models. we can see a remarkable anomaly of SV faster than SH in the depth range between 40 and 70km beneath the center of the Sea of Japan. It may reflect a remnant of upwelling flow below the former spreading axis.