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Lithospheric structure in the north-western Pacific region from surface wave tomography

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The north-western Pacific is a dynamic and tectonically diverse region with several subduction zones, arc-arc junctions, back-arc basins and abundant volcanism. Its deep mantle processes with complex tectonic evolution are still largely unknown. A key to the understanding of the dynamics of this area may be found in the seismic velocity structure of the mantle. The main objective of this study is to obtain a detailed three-dimensional model of the upper mantle beneath the north-western Pacific region from surface wave analysis that displays the expression of the tectonic phenomena and related deep processes in S-wave velocity anomalies. The detailed lithospheric structure in the north-western Pacific region is investigated using the method of multimode surface wave tomography of Yoshizawa & Kennett (2004). A strong heterogeneity of the region resulting in large off-great circle propagation and scattering effects is taken into account. The resolution of surface wave imaging with depth is enhanced by the use of the waveform inversion that includes both the fundamental and higher modes of surface waves.

The data are collected from the IRIS (Incorporated Research Institutions for Seismology) network in the north-western Pacific region. Three-component broad-band seismograms of FARM (Fast Archive Recovery Method) data recorded from seismic events with magnitudes greater than 6.0 from 1990 to 2005 are used in this study. The initial data set is composed of 23 stations and 271 events. Locations and origin times of the earthquakes are taken from the IRIS catalogue. The centroid moment-tensor solutions are provided by the Harvard CMT catalogue. All the data are corrected for the instrumental response.

The obtained waveforms are processed by the following three-stage inversion technique. At the first stage, the dispersion information for available source-station paths is extracted from observed waveforms of both Love and Rayleigh waves. The phase velocity dispersion curves are measured for the fundamental mode and first a few higher modes by waveform fitting. Then, the dispersion information from all paths is combined to produce multimode phase velocity maps as a function of frequency. A first approximation is carried out as a linear inversion based on the assumption that each surface wave path follows its great-circle. Subsequently, the 2-D phase velocity maps are updated by including the ray tracing and finite frequency effects. Finally, the local dispersion information is inverted to obtain 1-D S-wave velocity profiles. Three dimensional SH and SV velocity models can be reconstructed from the set of updated multimode phase velocity maps for Love and Rayleigh waves. This method offers the advantage of incorporating various styles of information such as multimode dispersion, off-great circle propagation, and finite frequency effects for surface waves in a common framework.

Multimode tomographic maps are obtained for the north-western Pacific region. The high phase velocity anomalies in the northern part of the region related to the subducting Pacific plate as well as the low velocity anomalies in the mantle wedge are successfully imaged. A high velocity contrast is found for all periods on the boundary between the Eurasian plate and the Amur plate. Such a pattern seems to represent the contact of two lithospheric blocks with different geophysical properties. The tomographic maps of 70-150s period also show a high phase velocity zone beneath the Chukotka peninsula. This anomaly is possibly related to a remnant slab of the Okhotsk plate.