Upper mantle and crustal seismic structure beneath the northwestern Pacific basin using OBSs and borehole broadband seismometer

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A detailed structure of an oceanic plate is important information to consider a dynamics of oceanic plate. In August 2000, the borehole broadband seismometer, WP-2 was installed in the northwestern Pacific basin. Geomagnetic studies in this area indicate the crust was formed 129 Ma. The seismic experiments with ocean bottom seismometers (OBSs), the WP-2 and airguns were performed around the WP-2 in July 2001, July 2002 and July 2005. To detect a seismic anisotropy in the uppermost mantle, the experiments had four profiles with different directions. Broadband seismic records for 436 days in total were retrieved from the WP-2. Reflecting low noise environment, many teleseismic events were recorded. The purposes of the present study are to obtain a detail seismic structure of crust and uppermost mantle including a seismic anisotropy from the seismic surveys and to estimate a upper mantle structure including depths of discontinuities using the WP-2 records.

Shallow seismic velocity models just below OBS were derived from using tau-p method and records of a hydrophone streamer. The obtained seismic models were confirmed using the ODP logging data. Deep structures were estimated by forward modeling using a two dimensional ray tracing method. The estimated crustal structures beneath each line are almost identical. In a sediment layer, P-wave structure is 1.6km/s, S-wave is about 0.2km/s, the thickness of this layer is approximately 0.4km. The layer 2 is divided into two layers which have different vertical velocity gradients (layer 2A and layer 2B). The P- and S-wave velocities at the top of the layer 2A are 4.6km/s and 2.7km/s, respectively. The layer 2B has P- and S-wave velocities of 5.3km/s and 3.1km/s at the top of the layer, respectively. Total thickness of the layer 2 is about 1.4 km. The data from the WP-2 were useful to estimate the detailed structure of the layer 2. The uppermost Layer 3 has P- and S-wave velocities of 6.8km/s and 3.8km/s, respectively. The layer 3 is about 5km thick. To explain large amplitudes of Pn phase, a crust-mantle transition layer is required at the bottom of the crust. The Pn velocities are different in each profile. Average velocities of Pn and Sn are 8.2 km/s and 4.7 km/s, respectively. The velocity variations are about 5% for P-wave and about 3.5% for S-wave. From this result, a seismic anisotropy of the uppermost mantle is suggested, and the fast direction seems to be perpendicular to the magnetic lineations. Therefore the anisotropy below the WP-2 is suggested to originate in a preferred orientation of olivine crystals in the uppermost mantle.

The upper mantle velocity structure is inferred from travel times of earthquakes recorded by the WP-2 and the previous studies of the northwestern Pacific basin. To explain late first arrivals from the earthquakes with epicentral distances smaller than 2200 km, a low velocity zone below a depth of 30 km and a rapid increase of velocity at a depth of 210 km are needed. To perform receiver function analysis, we selected 16 events with a magnitude greater than 6, that have epicentral distance ranging from 30 degrees to 90 degrees, and have high signal-to-noise (S/N) ratio from the WP-2 data. A bandpass filter of 8-360 seconds was applied for the receiver function analysis. A velocity model named the WP-2 model which is modified Iasp91 model where crustal layers are replaced by the results of the airgun experiment was constructed. After the theoretical Ps-P times are calculated using the WP-2 model, travel times for large amplitudes of the receiver function corresponding to 410 km and 660 km discontinuities were read. Averaging the read times, conversion depths of 416 km and 666 km were obtained.