Time variation of the deep reflection extracted from array analysis of ACROSS continuous data

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Toward Tokai monitoring plan to monitor the temporal changes of the reflected phases from the top of Philippine Sea Plate, we carried out an experiment using ACROSS system from Dec. 2004 to Sep.2005 in the Tokai region, central Japan. In this research, we applied semblance analysis to the array data of ACROSS transfer function to detect the reflected phases. Then we investigated a correlation of the travel-time variation of the transfer function with the events such as short-term slow slip and low-frequency tremor in Tokai region (Hirose et al., 2006).

The ACROSS source was continuously operated in Toki City, Gifu Prefecture by Tono Geoscience Center. The frequency-modulated signal from 10 to 20 Hz was precisely repeated with an interval of 50 seconds. We deployed a short-span seismometer array at the distance of 55 km from the source. The cross-shaped array was composed of 12 seismometers having the aperture of 2 km in NS and 1 km in EW directions. In order to enhance S/N ratio, we stacked the signal components for nine months. A transfer function was obtained by dividing the spectrum of the stacked signal by the source spectrum. An inverse Fourier transform was applied to yield the transfer function in the time domain.

We searched the combination of the slowness, the direction angle and the incident angle that give the highest semblance value (Neidell and Taner, 1971). Because of the trade-off between the slowness and the incident angle, the P-wave velocity of 4.0 km/s and the direction angle from the source to the array of N135E were fixed. We searched the incident angle that gives the highest semblance value.

The effect of local heterogeneity was corrected using the record of natural earthquakes. After applying phase shifts using the parameters that give the maximum semblance value for the direct P-phase, the perturbation of P-phase arrival timewas estimated using cross-correlation. The semblance value of the direct P-phase was improved after correcting the perturbation. We found some coherent later-phases. The incident angle of the later-phases is smaller than that of direct P-phase. It suggests that they propagated through deeper part in the crust. From the result of the estimated travel-time using numerical models (Tsuruga et al, 2005), we concluded that the phases from 13 to 14 s include the reflected waves from the top of Philippine Sea Plate and Moho discontinuity.

To investigate a temporal variation in travel-time of these coherent phases extracted from the array analysis, we used Hi-net data installed in a borehole. We stacked the data for three months with shifting time-window for 1 month and calculated the cross-correlation between a reference transfer function and other transfer functions. Travel-time difference of the direct P-phase and later phases showed temporal changes of about 1 ms and about 5 ms at the maximum, respectively during the observation period. Travel-time variation may be caused by a change in the physical properties in the shallow surface, such as rainfall and temperature changes. These later-phases are less influenced than the direct P-phase because the later-phases propagate through deeper part in the crust, Therefore, we concluded that the travel-time variation in later-phases around 13-14 s may indicate changes of the plate boundary or in the deeper crust.

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