The mantle discontinuity depths beneath the Philippine Sea as inferred from data from ocean bottom and borehole seismographs

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We analyzed broadband waveforms recorded by the broadband ocean bottom seismograph array and the ocean bottom borehole geophysical observatories in the Philippine Sea to investigate the mantle transition zone structure beneath the Philippine Sea. This is the first attempt to study the mantle discontinuities beneath the Philippine Sea using the broadband ocean bottom instruments. As a part of the Ocean Hemisphere network Project (OHP), fifteen Long-term Broadband Ocean Bottom Seismographs (LT-BBOBS) were deployed from November 1999 to July 2000 along a profile from the Saipan Island to the Amami island across the mid Philippine Sea. All of the stations were equipped with semi-broadband sensor (WB2023LP,PMD and 24-bit data loggers. The sensor has a flat velocity response from 0.03 Hz to 30 Hz, which provides high fidelity for the long-period P wave trains analyzed in the present study. We analyzed seismograms from recovered and selected 7 stations with low S/N ratios. The ocean bottom borehole geophysical observatory in the Philippine Sea was installed in 2001 in the west Philippine basin, west of the Kyushu-Palau Ridge, and named as WP1. The WP1 station is equipped with the CMG1T broadband sensor and the 24-bit data logger.

We determined the depths of the 410 km and 660 km discontinuities (called the '410' and '660' hereafter) and thickness of the mantle transition zone under the Philippine Sea region by the Velocity Spectrum Stacking Method (Gurolla et al., 1994, Saita et al., 2002), where we can take into consideration the three-dimensional velocity variation in determining the discontinuity depths. By stacking the data from all the LT-BBOBS stations, the '410' is estimated to be shallower than the global average by 17 km and the '660' is deeper than the average by 37 km,resulting in the transition zone thicker than the average by 54 km. The western part of the Philippine Sea has the '660' at a depth of 703 km, which is deepest in the studied area. Existing tomographic models have high velocity anomalies there, which is interpreted as the cold stagnant Izu-Bonin slab, suggesting that the deep '660' is related to temperature anomalies associated with the stagnant Izu-Bonin slab. The Mariana trough has also the deep '660' at a depth of 691 km in spite that the Mariana slab seems to be subducted vertically into the lower mantle and no high-velocity anomalies are present in the tomographic models. This cannot be explained only by the cold temperature and compositional factors, e.g., influence of water dehydrated from the Mariana slab may contribute to the transition zone thickness. The '660' in the west Philippine basin are estimated to be 670 km from the WP1 data, which is close to the global average and is consistent with no high velocity found by the tomography. The '410' is estimated to be as shallow as 370 km below WP1, which may require a cause other than temperature anomalies.