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Seismic interferometric imaging from OBS survey data in the plate subduction zone

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In marine seismic surveys, the Multi-channel reflection survey (MCS) and the ocean bottom seismograph (OBS) survey are widely used for exploring the crustal structure. In the MCS survey, detailed subsurface images are obtained from the high resolution reflection data. In the conventional OBS survey, a wide-angle reflection analysis and a tomographic refraction analysis are usually applied for deeper structures. However, it is difficult to get shallow subsurface image from the reflected waves in the OBS data because of the limitation of imaging area, even though by using the high density OBS survey with 1 km interval. In our study, we overcome this problem by applying a seismic interferometry (SI) to the OBS survey data. The SI is one of the redatuming techniques to synthesize virtual source records by crosscorrelating the seismograms. By applying the SI to the OBS common receiver records, the redatumed data are corresponding to the reflection survey data that the shot and receiver points are located at all original shot positions. Then, the redatumed seismic data can be processed to construct the depth profiles based on the reflection seismic survey. The SI imaging with the OBS survey data is a powerful technique to obtain the reflection profiles from just below the sea bottom to the deeper part of the crustal structure without the spatial imaging gaps.

We applied the SI to the high density OBS survey data acquired along a 175 km survey line crossing the Nankai Trough off the Kii peninsula by JAMSTEC in 2004. The OBSs were deployed on the line with 1 km interval in the central portion, and with 5 km or 10 km interval in the other. The air gun was fired at 200 m intervals along the survey line. In the SI stage, 30 sec OBS records including effective multiple reflections were used for the seismogram correlation, then 20 sec reflection records due to 878 virtual sources with 878 virtual receivers were synthesized. In the SI imaging result, subsurface structures from the sea bottom to the deeper part in the plate subduction zone are clearly shown on a whole survey line, forearc basin, the subduction plate boundary, and splay faults branching from the plate boundary. Because the OBS data contains low frequency energy, the SI profile is lower resolution than the profile of the MCS survey. However, our result is very important to show the advantages of SI imaging from the only OBS survey data without spatial imaging gaps. In addition, the deconvolution-based interferometry could provide the result with higher resolution and lower correlation noise in both the synthesized virtual shot records and the stacked section than the correlation-based interferometry. In another test of the OBS density, the subsurface structures were clearly shown in the depth section from the low density OBS data with 10 km intervals, although the reduction of the OBS density degraded the results with the low reflection continuity and the amplitude change especially in a shallower part.

Keywords: seismic interferometry, OBS survey, seismic reflection survey, Nankai trough, plate subduction zone