論文の内容の要旨

Fluid distribution along the Nankai-trough megathrust fault off the Kii Peninsula inferred from receiver function analysis; from seismogenic to transition zones
（レシーバ関数から推定される
紀伊半島沖南海トラフ巨大地震断層近傍の流体分布
―巨大地震発生域からゆっくり滑り域まで―）

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Exploring fluid distribution around megathrust faults on subducting oceanic plates is intriguing because fluid is considered to reduce the strength of megathrust faults to cause various types of fault slip including regular earthquakes. To date, many studies have revealed hydrous state of the subducting oceanic crust beneath onshore region by conducting receiver function (RF) analysis; the method has high sensitivity to the contrast of the elastic properties, especially to S-wave velocity. However, the RF analysis has rarely been applied to data recorded by ocean-bottom seismometers (OBSs).

The difficulty of RF analysis using OBS data is attributed to P-wave multiple reflections within the sea water column, or water reverberations, which appear prominently on vertical component records. That is because the water reverberations alter vertical component records from source wavelets. We developed a method to remove the water reverberations from OBS vertical component records, where we treated water reverberations as a frequency filter, i.e., a water-layer filter (WLF). By assuming vertical incidence of P-wave, we can describe the WLF with only two parameters, reflection coefficient on the sea floor and two-way traveltime within the water layer. We determined these parameters by non-linear inversion analysis, making use of the advantages of OBS array.

We created RF image of subsurface structure around the Kii Peninsula at the southwestern Japan, by applying the above WLF method to OBSs which had been deployed off the Kii Peninsula. Resultant image elucidated the 3-D geometry of the subducting Philippine Sea plate, where the top of subducting plate and the oceanic Moho exhibited negative and positive RF peaks, respectively. The negative RF peaks along the plate interface extended to seaward, suggesting the existence of low-velocity zone (LVZ) even beneath the offshore region.

Beneath the Kii Peninsula, the magnitudes of RF amplitudes along the oceanic Moho and the plate interface gradually decreased as the slab subducts deeper. We interpreted this amplitude reduction was caused by two factors related to the metamorphic phase changes of the oceanic crust: (1) the velocity increase of the oceanic crust and (2) fracturing of the plate boundary seal caused by the densification of the oceanic crust. According to this interpretation, non-volcanic tremors beneath the Kii Peninsula are characterized by permeable plate interface. This feature contrasts to long-term slow slip events, which are believed to occur along sealed plate interface.

The thickness of the LVZ would not be evaluated correctly by the above imaging method due to the simplistic reference velocity model. Furthermore, in the case of OBS data with low-frequency band, P-to-S conversion phases may be contaminated by sediment reverberations, which makes interpretation of RF amplitudes difficult. To investigate more detailed feature of the LVZ located at the top of the plate interface, we conducted RF inversion including high frequency contents using several OBSs with good data quality. We first estimated physical properties of the sediment layer beneath the seafloor by stacking analysis and then constrain deeper structure by performing waveform inversion analysis. As a result, we revealed the existence of a thin LVZ (~2 km thick) at the depth of the plate interface. We interpreted this as a fluid-rich layer.

Such inversion analysis provides well-constrained thickness and velocities around the plate interface, which we could not obtain form the results of the imaging method. Although the number of sites where we conducted the inversion analysis is limited so far, further expanding the analysis to the other stations in our future work would reveal the spatial variation of the velocities and thickness of the LVZ. This, in turn, will lead to better understanding of the fluid distribution and its influence on future megathrust earthquakes.