Seismic velocity monitoring using ambient noise observed by DONET seismometers in the Nankai Trough, Japan

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Subduction zones, where a tectonic plate subducting beneath the other plate, megathrust or interplate earthquakes could be generated repeatedly. Because of the nature of interplate earthquakes, the process of plate subduction governs the distribution, mechanics, and style of slip along the interplate fault. At the Nankai Trough subduction zone, located beneath the Pacific Ocean off the southeast coast of Japan, we have installed a seismic observation system, named DONET (Dense Oceanfloor Network system for Earthquake and Tsunamis), which is composed of twenty seafloor broadband seismometers and a borehole vertical seismic array to monitor the seismic activity and the process of earthquake generation including the stress accumulation.
To elucidate earthquake generation and preparation process, it is necessary to investigate how the stress could be accumulated not only in deeper part but also in the shallow sediments, what the role of interstitial fluid could be in the stress accumulation processes, etc. There are some conventional methods to measure these physical properties, such as borehole strainmeter, borehole breakouts or borehole dynamic tests. However, these methods have some difficulties from the viewpoints of technical and/or cost. For example, borehole breakouts and dynamic tests can be conducted only while drilling and/or immediately after that. Therefore we need to have some other methods to see the state and variation of the stress in the subseafloor.
In this study, we applied seismic interferometry technique to ambient noise records observed by horizontal components of DONET seafloor seismometers to obtain time dependent S-wave velocity and its anisotropy as a proxy of stress state below each DONET observatory. We first calculated cross-diploe 4-C pseudo shot records from every 1 hour ambient noise records observed by horizontal components of DONET seismometers. More than 8700 traces for each 4-C component were obtained from 1 year continuous data. Obtained 4-C shot records are then stacked every 48 hours. Clear phases, which should be caused by S-wave anisotropy, are visible in off-diagonal components. We then evaluated time variation of S-wave velocity below each observatory by using phase variation of reflected waves from the bottom of the shallow sediment layer. Alford rotation method was also applied to the 4-C shot records to obtain S-wave anisotropy parameters, directions of fast S-wave and time lag between fast and slow S-wave velocities below each observatory. Although, further analysis and discussion, such as error analysis and more quantitative discussion of the relationship between S-wave anisotropy and stress, we expected that our method can be a simple tool to monitor stress state in the Nankai Trough seismogenic zone.

Keywords: Nankai Trough, velocity monitoring, ambient noise

