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Three-dimensional S-wave velocity structure beneath the Naruko volcanic area by ambient noise seismic interferometry

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The 2008 Iwate-Miyagi Nairiku earthquake (M7.2) occurred along a fault ranging from the south of Iwate to the north of Miyagi. The focal region of the earthquake is located in the proximity of four volcanoes: Yakeishi-dake, Mt. Kurikoma, Onikobe, and Naruko. To study the positional relationship between the fault and magmatic bodies beneath these volcanoes, several studies have been conducted. Okada et al., (2010) estimated the S-wave velocity structure up to a depth of 40 km from body-wave tomography, and revealed that aftershock regions are distributed escaping the low velocity zones beneath the volcanoes. This study attempts to elucidate the correlation between the shallow structure of the volcanic bodies and aftershock regions in detail, focusing on the Naruko volcano locating in the south of the focal region, by seismic interferometry using cross-correlation analysis from ambient noise. Seismic interferometry is a method based on the fact that a cross-correlation function calculated from particle-motion records at a pair of stations in a wave field is equivalent to a Green's function between the two stations.

In cross-correlation analysis, we used the vertical-component data recorded by an observation network, which is densely installed in the Naruko volcanic region. By spectrum and beamforming analysis, we identified the characteristic of noise dominating in 0.1-10 Hz. The main sources of the noise are due to ocean waves coming from the Pacific Ocean and the Sea of Japan. Targeting the low-frequency range in which surface waves are more dominant than body waves, cross-correlation functions are calculated for each observation day for each pair of stations, and then stacked for 18 months to obtain a Green's function with a high SN ratio. We extract group velocity dispersion curves of Rayleigh waves using the multiple filter technique proposed in Dziewonski et al., (1969). Rayleigh-wave velocity maps from the period of 3 to 10 seconds are then calculated by processing surface-wave tomography based on the method of Barmin et al. (2001). Finally, we estimate the 3-D S-wave velocity structure up to 10 km depth by S-wave velocity inversion.

The structure shows two significant low velocity anomalies in the northwest of Naruko and in the south of Onikobe Caldera between 3 and 4 km depth. These anomalies are presumably magmatic bodies or geothermal water. Compared with the distribution of aftershocks and the fault, we can see that aftershocks do not occur in the low velocity anomaly beneath the Naruko volcano, and aftershock activity stops immediately at the northeast part of the anomaly.

Keywords: seismic interferometry, cross-correlation analysis, ambient noise, tomography