Temporal change of subsurface structure near Mt. Aso inferred from seismic interferometry using V-net vertical array data

*Yuta Mizutani[2], Kiwamu Nishida[1], Yosuke Aoki[1]

1. Earthquake Research Institute, University of Tokyo, 2. Univ. of Tokyo

Volcanic activity could be often activated by tectonic stress changes by a large earthquake. For example, Mt. Aso erupted in October 2016 after the 2016 Kumamoto Earthquake. To understand the relation between these events, it is important to monitor the temporal change of the structure of seismic velocity related to the event. In this study, we estimated the temporal change of subsurface structure in the Aso region with seismic interferometry (SI).

Monitoring seismic velocity by SI requires the isotropic source distribution, because the temporal or spatial change of the distribution of the sources biases the measured temporal change of subsurface structure. In order to mitigate the bias, a measurement of the temporal velocity change utilizing coda part of the cross-correlation function (CCF) is feasible. Moreover, the delay time of coda waves is larger than that of the direct waves. This means even a subtle change could be detected from coda waves with high accuracy. Here, we focused on how to localize the temporal subsurface velocity change from the difference between direct waves and coda waves.

In this study, we analyzed the data recorded from January 1, 2015, to October 31, 2016, at 4 V-net stations deployed by National Research Institute for Earth Science and Disaster Resilience (NIED) around Mt. Aso. Each station is composed of a broadband seismometer at the surface and a high-frequency seismometer (1 Hz) at the bottom of a borehole (depth ~200 m). First, the records were bandpass-filtered from 2 to 8 Hz. After one-bit normalization of the records and spectral whitening, a CCF between same components of the bottom and surface sensors was calculated every day. Then, we made a reference CCF by stacking CCFs from October 25, 2016 to October 31, 2016. Second, we measured the delay times between the reference and a CCF in time windows of 2.56 s whose center time was increased from -5 s to 5 s every 0.2 s. Plots of the delay time against lag time show a linear trend. When the temporal change is homogeneous, the slope characterizes the bulk velocity change within a spatial scale of about 2 km. In contrast, the intercept, which represents travel time of direct waves, characterizes the localized velocity change between the station pair (~200 m).

After the 2016 Kumamoto Earthquake, the estimated slope of the EW component showed the velocity reduction of approximately 0.2 % at 3 stations except for Takamori station. At Takamori station, the seismic velocity was little changed in the EW component, but in the NS component, about 0.2 % of the velocity drop was detected. On the local velocity change in the borehole with the depth of about 200 m, nearly 5-8 % velocity drop was observed in the EW component at Hakusui and Ichinomiya stations and the NS component at Takamori station. Otherwise, there was an approximately 20 % drop at Nagakusa station. This could attribute the serious damage of subsurface structure by the earthquake.

At Ichinomiya station, the velocity change with a time scale of a few weeks coincided with that of the precipitation data. This change was well agreed with a simple model of the ground water level inferred from the data. The change could be localized near the borehole, because the detected temporal change was associated with that of water head in a volcanic alluvial fan.

In this study, we detected the temporal velocity change on a scale from several hundred meters to some kilometers using vertical array data. In a future study, we will address CCF analysis with ray paths across Mt. Aso for detecting the temporal change associated with the volcanic event.

Keywords: Seismic interferometry, Temporal change of seismic velocity