3D S-wave velocity structure in volcanic region using surface-wave tomography

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EGS (Engineered / Enhanced Geothermal System) is expected to generate significant energy and reduce CO2 emission. Although EGS could be effective in Japan where many volcanoes exist, there are still many problems to solve to run the power plant using EGS. The supercritical fluid which can exist below the brittle-ductile transition (BDT) is essential to develop the EGS. However, structures and physical properties around and below BDT are still unclear. Since the development of EGS needs long time before operation and requires high cost, it is important to evaluate the suitable area for EGS. Therefore, estimating the structure in high spatial resolution from surface to around BDT is important to develop EGS and reduce risks.

In recent years, surface-wave analysis has been widely applied to estimate underground structure from ambient noise. In this analysis, surface-wave phase velocity can be estimated from ambient noise, and S-wave velocity structures can be estimated from surface-wave phase velocity because phase velocity strongly depends on S-wave velocity. Surface-wave analysis using ambient noise does not require active sources. Therefore, this is effective to survey steep area where it is difficult to enter such as geothermal area. In addition, this method is also effective to monitor change in subsurface for a long period because we can obtain seismic ambient noise continuously only using seismometers.

We used continuous seismic data recorded by a high-sensitivity seismograph network (Hi-net) for a year. We computed cross spectra of ambient noise data between the station pairs, and extracted phase velocity dispersion curves using the frequency domain method. Since the frequency domain method can overcome the limitation of interstation distance (far-field approximation) occurred in the time domain method, we can extract phase velocity at short-interstation pairs which reflect local structures. We then estimated the 3D S-wave velocity structure by applying a direct surface-wave inversion method. Our results show the low velocity structures beneath active volcanoes such as Mt. Asama, and Mt. Nasu, that could reflect volcanic fluid. If we apply this method to dense seismometers around the geothermal fields or volcanic area, we could obtain S-wave velocity in higher spatial resolution and use the information to identify suitable reservoir for EGS.

Keywords: Surface-wave tomography, S-wave velocity structure, seismic ambient noise, volcano, geothermal