V_{SV} and V_{SH} structure beneath Kirishima volcanoes inferred from seismic interferometry

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Shinmoe-dake, one of Kirishima volcanoes, experienced magmatic eruptions in 2011. The analysis of crustal deformation shows that the pressure source locates 5 km to the northwest of the Shinmoe-dake summit at a depth of 8 km, which implies the existence of a magma reservoir. We are trying to resolve a better image by a seismological technique toward ensuring its existence and deriving precise crustal structure and revealing a magma pathway.

The technique we employed is a seismic wave interferometry, which extracts the seismic wave propagation between two seismic stations by taking a cross-correlation of random wavefields, such as the ambient seismic noise or the seismic coda wave. The cross-correlations of random wavefields recorded at two stations can be represented as if the source is at one station and the recorder is at the other. This technique is suitable for exploring local structure since the extracted wave is sensitive to the internal structure between the two stations.

We inferred the crustal phase velocity anomaly using three-component records of the ambient seismic noise recorded by a seismic array between April 2011 and December 2013. Rayleigh and Love waves are extracted by taking cross-correlations (Rayleigh waves from cross-correlation functions of pairs of vertical components, and Love waves from transverse and radial components). We derived reference dispersion curves of Rayleigh and Love waves, respectively, using all pairs of stations, then measured a phase velocity anomaly of each pair against the reference in various frequency bands (0.1-0.2 Hz, 0.2-0.4 Hz, 0.3-0.6 Hz, and 0.4-0.8 Hz). Finally, three-dimensional V_{SV} and V_{SH} structures were obtained from a collection of local one-dimensional velocity profiles derived by inverting phase velocities of Rayleigh and Love waves, respectively, at each grid point.

The obtained three-dimensional V_{SV} and V_{SH} structures show high-velocity anomalies beneath the volcanoes at depths of shallower than 4 km b.s.l., reflecting the elevation of basement corresponding to the topography. A low-velocity anomaly was found at about 5 km off to the northeast of the volcanoes at 5 km b.s.l., which extends into the region right beneath the volcanoes at deeper depths toward 10 km b.s.l. in V_{SV} structure. The low-velocity anomaly was not detected in V_{SH} structure, implying the possibility of a radial anisotropy. The crustal deformation source of the eruptions in 2011 locates at uppermost and northwesternmost of the low-velocity region, indicating that the low-velocity region is a magma chamber of the volcanoes. Moreover, low-frequency earthquakes occur beneath the southeasternmost of the low-velocity region. We can, therefore, present a model of a magma pathway that magma rising up from the deeper region right beneath the volcanoes is once stored at a magma reservoir and further ascend toward the surface from the uppermost and northwesternmost of the magma reservoir.

Keywords: Kirishima volcanoes, seismic interferometry, ambient seismic noise