Scattering and attenuation structures beneath volcanoes inferred from envelope widths of natural and artificial earthquakes

*Hiroyuki Kumagai[1], Roberto Torres[2], Yuta Maeda[1]

1. Graduate School of Environmental Studies, Nagoya University, 2. Colombian Geological Survey

It has been thought that volcanoes exhibit the strongest structural heterogeneities on the Earth. However, a recent study indicates that such strong heterogeneities exist only in a thin surface layer down to a depth of 1 km. This estimate was obtained by using the envelope widths of volcano-tectonic (VT) earthquakes at Taal (Philippines) and Nevado del Ruiz (Colombia). To examine whether this heterogeneous feature can be found at other volcanoes, we analyzed the envelope widths of VT earthquakes at Galeras (Colombia) as well as those of artificial earthquakes with dynamite blasts at Kirishima, Unzen, and Iwate (Japan). The envelope width is defined as the ratio of the cumulative amplitude to the peak amplitude for S waves in an envelope waveform band-passed between 5 and 10 Hz. We estimated envelope widths as functions of source-station distances using vertical seismograms at the four volcanoes. Our estimates of envelope widths at these volcanoes showed similar tendencies, in which the envelope widths increase with increasing distance up to around 5 km and then show constant values with scatters. These trends were also similar to those at Taal and Nevado del Ruiz. We performed the Monte Carlo envelope waveform simulations to estimate envelope widths in various one-dimensional (1D) models represented by the scattering mean free path (l_0) and the quality factor for medium attenuation (Q_i) for S waves. Our grid search with respect to l_0, Q_i, and layer depths indicates that highly heterogeneous (l_0 = 250-1000 m) and attenuative (Q_i = 25-50) surface layers exist to depths of around 1 km and are underlain by less heterogenous layers with l_0 larger than 100 km at the four volcanoes. These structures are similar to those estimated at Taal and Nevado del Ruiz. These results suggest that a highly heterogenous layer down to a depth of around 1 km commonly exists at volcanoes. To further investigate three-dimensional distributions of l_0 and Q_i, we mapped the residuals between observed envelope widths and those calculated with 1D models at Kirishima, Unzen, and Iwate, where artificial sources were used. The sources and receivers existed in the surface heterogenous layers at these volcanoes, and thus the energy kernel for diffusive wavefields may be used as space-weighting functions. Our mapping of envelope width residuals displayed positive residual anomalies suggesting stronger localized heterogeneities at Kirishima and Unzen, although no clear anomalies were found at Iwate. The anomalies at Kirishima and Unzen correspond to velocity and *Q* anomalies estimated by previous tomographic studies at these volcanoes. This indicates that the envelope width residuals provide useful information about 3D distributions of heterogeneous regions at volcanoes.