Estimation of subsurface structure using microtremor H/V spectral ratio around Unzen volcano

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The Shimabara peninsula where Unzen volcano was erupted, located on the west edge of the Beppu-Shimabara grabenwhich crosses the center part in Kyushu island from east to west. Seventy percent of the peninsula is composed by volcanic product fromthe volcano. Using strong motion H/V spectral ratio, the Central Disaster Prevention Council (2008) pointed out that the long-period strong ground motions in the Shimabara peninsula are amplified so much like the Quaternary plains though the sedimentary layer of Quaternary Era is not thick in the peninsula. Especially, in the Yadake region (center part of the peninsula), the long-period ground motions amplify to the same extent as Tokyo area in the Kanto plains. In order to estimate a ground structure in the Shimabara peninsula by using microtremor H/V (horizontal-to-vertical) spectral ratio as an evaluation method of the ground structure, we carried out microtremor observations at 60 points in the whole area of Shimabara peninsula.

The microtremor observations using a three-components wideband portable seismometer of characteristic period 120 second were carried out at each observation site. The data of microtremor were recorded by a portable data-logger with 100Hz sampling.Power spectrum of UD, NS, and EW were calculated and smoothed by using the ensemble average of thirty times, and power ratio of H/V spectra was estimated.

By using data from 60 observation sites, we traced a contour map of primary natural peak period (the longest peak period that exists from 1 to 10 seconds). Peak period of 5-6 s in H/V spectra was obtained at a lot of observation sites at east side of the Shimabara peninsula, where volcanic sediments are thickly distributed. It is thought that the thick volcanic sediment layer is a cause of such longer peak period in H/V spectra.

In the central western area of the Shimabara Peninsula, there are no remarkable peaks in the observed H/V spectra. According to explosion seismic research (Explosion seismic research group of Unzen Volcano, 1995), this area corresponds to rock layer having Vp=3.5km/s, which distributed in shallow to ground surface as a solid lava layer. This structure is reflected in shape of H/V spectra; the value of H/V spectra in this area is nearly constant in the frequency of microtremor.

Next, we are going to estimate subsurface structures in the peninsula using the observed H/V spectra. Using P wave velocity that had been obtained by the explosion seismic research, S wave velocity and density were calculated by relation estimated by Ludwig et al. (1970). During a trial-and-error estimation process, S wave velocity, P wave velocity and density were fixed, and we adjusted the thickness of the sedimentary layers to find a reasonable fit of primary natural peak period of the calculated H/V spectra and the observed H/V spectra to determine the ground structure. Then, the depth to Vs=600m/s layer is estimated as 1.2km at the boring site USDP2 in east side of Shimabara peninsula. Our result is consisting with boring-core sampling data from the borehole.

The horizontal component of long-period microtremor, locally exceed in Yadake site of the center part of Shimabara peninsula. If the ground structure is determined by using the same parameter as surrounding sites, the depth to the basement in the site should be estimated as about 1000 m. However, nearby tectonic map and the result of explosion seismic research do not showsuch a steep basin structure under the site. Thus, we changed S wave velocity of shallow part of the underground structure,and we found that the very low-velocity layer exists beneath surrounding of Yadake site. Because the rich hot-spring resourcesexist in around the site, it is thought enough that existence of the low-velocity layer, which causes the increase of thelong-period strong ground motions.