Probing shallow region structure of Atotsugawa fault fracture zone with cosmic-ray muon detector in borehole

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This presentation will give a brief overview of technique of underground density structure measurement and observation system using cosmic-ray muon detector from a borehole. Thereafter, results of measurement campaign and parameter estimation in 2016 at Atotsugawa fault fracture zone in Gifu prefecture, Japan will be presented.

Fault zone parameters such as strike, dip, density and width of fractured zone are important to predict seismic intensity and disaster scale of earthquake. However, it is necessary to do spatially wide and dense investigation to probe these parameters by previous methods. We have developed new method to measure wide area density structure including a fault from one observation site using cosmic-ray muon radiography technique.

The muon radiography technique uses high penetration power of cosmic-ray muons. Cosmic-ray muons can penetrate several kilometers of rocks and they attenuate in their paths. Average density on their paths is measured with the amount of muon attenuation. The muon attenuation depends on the density of the penetrated material without dependence on other parameters such as chemical and structure heterogeneity. Therefore, this method provides reliable measurement of shallow region of crustal structure without effect of heterogeneity. This technique can be applied to huge object like a volcano and a fault. However, cosmic-ray muons come only from the sky, and this method could not measure underground object other than uplifting object.

In order to overcome the challenge and measure under ground fault structure, we developed compact muon detector system to install it in a borehole that has 15 cm diameter. The detector has limited angular resolution due to its small size. Zenith angle is limited to one direction by statistically. In azimuthal angle, it resolves in eight directions. Underground density structure is measured by moving the detector along with depth direction. Wide area (several hundred meters) density structure including a fault is measured from one borehole.

We did measurement campaign at Atotsugawa fault zone in Gifu prefecture, Japan in 2016. The measurement was up to 100 m depth. As a result, low-density region was detected in the direction, which is consistent with the result of trenching survey. Moreover, fault zone parameters were estimated with the result of density structure.

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