Resistivity characteristics of various core samples from Aso volcano and its discussion.

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The electrical and electromagnetic surveys are the geophysical exploration methods that use the electrical properties of the stratum to visualize the underground resistivity structure. Moreover, in order to estimate the underground geological structure and hydraulic structure, which is the original intention of the electrical and electromagnetic methods, it is necessary to properly interpret the obtained resistivity structure. Therefore, we must understand what parameter(s) controls rock resistivity. The resistivity characteristics of rocks can be examined by laboratory experiments, where the factors affecting the resistivity can be arbitrarily set. In this study, we conducted laboratory experiments of electrical resistivity using core samples taken from a vertical borehole drilled in the Aso volcanic region from 2017 to 2018, and evaluated the resistivity of five rock types and the its influence factors.

We prepared multiple specimens from a core sample with a length of ~20 cm and measured their resistivity, to improve the data reliability. The shape of specimens was a cylinder with a diameter of ~6 cm and a length of ~3 cm. Upper and lower surfaces of the specimens were made smoothly and parallelly. The rock types of core samples are sandstone, microcrystalline andesite, porous andesite, conglomerate and tuffaceous conglomerate. We obtained two specimens of sandstone, three specimens of microcrystalline andesite, and four specimens of other rocks. The effective porosity is 56% for sandstone, 4% for microcrystalline andesite, and ranges in 21-25% for porous andesite, 24-29% for conglomerate, and 17-19% for tuffaceous conglomerate, respectively. The electrical resistivity was measured by a 4-electrode method using the AC impedance method. By measuring the electrical resistivity of rocks under various conditions of pore water resistivity and water saturation degree under atmospheric pressure and room temperature, the effects of porosity, water saturation degree, and pore water resistivity on rock resistivity were examined. The solution used to saturate the specimens were pure water and KCl solutions (5,000 and 20,000 PPM, respectively). A rock specimen immersed in a water filled beaker was fully saturated after ~72 hours vacuuming, and we assumed that the resistivity of the pore water in the specimen corresponded to the measured resistivity of the water used for immersing.

From the measurement results, it could be clearly seen that there was a negative correlation between the porosity and the resistivity of the saturated rocks, and it was confirmed that their relationships were almost linear in the log-log plot. In addition, even when the KCl concentrations at pores were changed, the relationship between the resistivity and porosity also followed the linear pattern in the log-log plot. And these data showing the correlation between resistivity and porosity were consistent with Lin et al. (2003). Moreover, we confirmed that rock resistivity gradually increased with the decrease of saturation in the higher saturation range, while increased rapidly in the lower saturation range. The relationships between the volumetric water content and the resistivity of the rock also showed the linear relationship for all rock types measured in a log-log plot. We also confirmed a close relationship between the volumetric water content and the resistivity for all the rock types. It was found that the resistivity of rocks tend to increase as the resistivity of pore water increases. Despite these general agreements with the Archie’s law, we also found other characteristic patterns. For example, the increase rate of rock resistivity in case of higher pore water resistivity was smaller than that in case of lower pore water resistivity. In addition, when the rocks were immersed in pore water with higher resistivity, the rock resistivity does not satisfy the Archie’ s equation.

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