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The Contribution of Hydrothermal Fluid and Hydrothermal Alteration to the Bulk Resistivity: a case study of USDP-1 site

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Volcanic edifices have hydrothermal systems in the shallow subsurface. Hydrothermal systems discharge volcanic gases from spring, fumarole, and groundwater flow outward. Resistivity survey, as well as geochemical survey, can be a helpful method to estimate the transportation of volcanic gases, because interstitial water resistivity steeply decreases when volcanic gases dissolve into water. However, obtained bulk resistivity is the combination of pore water resistivity and intrinsic matrix resistivity. Therefore, the estimation of the transportation of volcanic gases by means of electromagnetic method requires the separation of bulk resistivity into pore water resistivity and intrinsic matrix resistivity. The separation methods have been developed on the basis of the Parallel Resistances Model by laboratory experiments; however, to date, no application of these methods to the field observations at volcanoes have been conducted. The objective of this study is to apply the separation method to a volcano by the use of drillcore samples and to examine the contribution of bulk resistivity to the hydrothermal fluid and rock alteration separately. As a case study, this study was conducted at the USDP-1 borehole site located in the northeastern flank of Unzen Volcano, SW Japan. The bulk resistivities beneath USDP-1 borehole were successfully separated into pore water resistivity and intrinsic matrix resistivity as follows: The 40ohm-m section of high-temperature and relatively-permeable part can be separated into 3 ohm-m of pore water and 1100 ohm-m of matrix, and 200 ohm-m section of the temperature-decreasing and impermeable part can be separated into 30-50 ohm-m of pore water and 300-840 ohm-m of matrix. These results could explain consistently the vertical profiles of temperature and core permeability. Thus, the pore water resistivity could be quantitatively estimated. Further, relatively high values of intrinsic matrix resistivity suggested that few electrically-conductive clay minerals were produced, probably as a result of the low temperatures of the hydrothermal fluids at the this study site. This method described here will be applicable to apply to many other volcanoes for which electromagnetic data and core samples are available, and separated informations of pore water resistivity and intrinsic matrix resistivity at a volcano will be of great help for the estimation of not only the transport of volcanic gases, but also the degree of hydrothermal alteration.

Keywords: Unzen Volcano, Parallel Resistances Model, pore water resistivity, intrinsic matrix resistivity, hydrothermal alteration