Detailed resistivity structure by high-density AMT surveys in the geothermal area: A case study near Unzen volcanoes, Japan

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SUMMARY

In geothermal areas, hydrothermal alteration zones including impermeable clay can play a role of caprock, retaining geothermal reservoirs underneath. The alteration layers have electrically high conductivity due to clay; therefore, the magnetotelluric (MT) method can clearly image the distribution of alteration zones. Faults, along which geothermal fluids are considered to circulate the fracture zones, are also recognized as conductive bodies due to the presence of fluids and clays. Thus, resistivity structures in a geothermal field revealed by MT survey are effective to discuss the geothermal fluid circulation, However, the spatial resolution of resistivity structure is often not enough to reveal the detailed geological features due to sparse spacing of the MT sites. In this study, a high-density audio-frequency MT survey was carried out at 83 sites in the Unzen hot spring area with a dense spacing of about 50 to 150 meters to estimate the detailed three-dimensional (3-D) resistivity structure near the surface (shallower than 1 km). As a result of 3-D inversion, conductive bodies were found near the surface. Some of them are exposed, and coincide with surface hot springs and fumaroles. These conductive bodies represent the hydrothermal alteration layers. Around a known active fault located the north of the hot springs, a sharp resistivity boundary is found; conductive bodies were only found in the southern side with hot springs. This feature suggests a rapid change of subsurface thermal structure, controlling the hydrothermal alterations. Based on the resistivity structure, we infer a possible hydrothermal circulation in this area: a recharge of meteoric water along the fault which would be supplied to the geothermal reservoir located at the southern side of the fault. We concluded that high-density AMT surveys is effective to reveal shallow subsurface geothermal systems.

Keywords: hydrothermal alteration zones, active fault, higi-density AMT survey