Towards resistivity structure analysis using the EM-ACROSS method at Inferno Crater Lake, New Zealand

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Abstract

Inferno Crater Lake, located in the Waimangu Geothermal Zone on the North Island of New Zealand, was formed by the eruption of Tarawera Volcano on June 10, 1886. Scott's observations[1, 2] from 1972-1990 showed that the water level fluctuated on a 38-day cycle, and the water temperature fluctuated accordingly. As the water level rises or is high, the seismic noise level increases[3, 4], which has been interpreted as the two-phase region in the subsurface pushing up against the liquid-phase region above[5]. In addition, electrical resistivity surveys using the self-potential method during high and low water periods in both 2006 and 2007 identified a region of 40 times higher resistivity during the high-water period just below Inferno Crater Lake, suggesting the presence of the two-phase layer[6].

Monitoring and observing fluctuations in the gas-liquid two-phase layer is important for volcanic eruption forecasting research. In order to accurately observe the time-varying structure of the hydrothermal system, observations using the EM-ACROSS method are planned around the Inferno Crater Lake. In this study, we developed a forward analysis program for the EM-ACROSS method and investigated the response in the frequency band used for the observation.

We first developed a program to calculate the electromagnetic field produced by finite-length dipole currents. We performed the calculations on a model for which the theoretical solution is known and compared the analytical and numerical solutions to confirm that they were sufficiently close. The tensor transfer function at an arbitrary observation point can be calculated from the observed electric and magnetic fields and the installed dipole moment. We then calculated the tensor transfer function and obtained the frequency response for a model mimicking Inferno Crater Lake. We found that the off-diagonal component of the tensor transfer function at points far from the inline is particularly sensitive to two-phase (high resistivity) layers. We also found that frequencies between 1000 Hz and 300 Hz are not suitable for identifying two-phase layers, and that there is no electromagnetic induction around the lake below 3 Hz, so no information about deeper structures can be obtained. We designed the waveforms used for the actual observations based on these frequency characteristics.

References

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