Availability of magnetoelluric resistivety survey to explore deep geothermal resources

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A supercritical geothermal resource, which exists at a deeper part than a brittle-ductile transition, can be one of the dominant renewable energy sources in a volcanic zone. In order to find an appropriate field for utilizing this resource, highly accurate geophysical explorations should be required. A resistiveity exploration including the magnetotelluric (MT) method is considered to be a powerful tool for this purpose because resistivity is very sensitive to existence and connectivity of fluids in rocks. We estimated an availability of the MT method to explore such a deep geothermal resource, applying the 3-D resistivity simulation.
We composed 3-D resistivity models to demonstrate geothermal fluids beneath old calderas in NE Japan, which included surrounding seawater and sediments. At first, the conventional MT method examined different bottom depths of the conductive body (=fluids zone). The MT responses from these different cases were compared. All models showed considerable response changes, which were more than 20% compared with the non-conductor model. The existence of the conductor itself can be identified by inversion analysis. However, the change was less than 5%, comparing the response between the models with the 6km and 10 km bottom depths. It might be difficult to identify this difference by any resistivity inversions because the estimated changes were smaller than observational errors.
Next, we calculated the MT responses in the situation that both the electric and magnetic fields were measured in the earth. The different measurement depths were examined. The calculated responses showed the highest change in the case that the measurement depth was deeper than an overlying conductive layer (e.g. sediments). This situation is similar to marine electromagnetic explorations. However, it is technically too difficult to measure the electric field in the earth.
Finally, we calculated the MT like response in the situation that the magnetic field was measured in the earth, while the electric field was on the surface. This trial also showed the highest response change in the case that the magnetic measurement depth exceeded a conductive layer. Thus, the downhole magnetic field measurement can drastically improve the accuracy of the MT method. A development of the magnetometer to be available under the condition in high- temperature and pressure should be required in order to realize this method.

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