Effecitive combination of MT and GDS survey for three-dimensional imaging of geothermal resovoir

*Tada-nori Goto[1], Yuji Yamada[2]

1. Graduate School of Life Science, University of Hyogo, 2. Graduate School of Engineering, Kyoto University

Magnetotelluric (MT) survey is mainly used for acquiring subsurface information, essential for exploration and development of geothermal resources. Since the geothermal alteration zone located above the geothermal reservoir shows a remarkably low resistivity, the subsurface resistivity structure obtained by MT survey is useful for discovery of the geothermal reservoir and evaluation of the subsurface temperature distribution. In recent years, with high-speed computers and sophisticated algorithms, the inversion of MT data for inferring three-dimensional (3-D) resistivity structures has been actively carried out. The 3-D inversion requires a number of MT stations. However, due to the steep topography, it is difficult to set MT stations densely in geothermal areas. This is because MT survey requires a flat area of several tens of meters square. Sparse MT stations result in low spatial resolution, and less effectiveness to geothermal explorations. Furthermore, MT data is strongly affected by near-surface local resistivity anomalies (so called static distortion), which may reduce the reliability of inversion results of MT data.

In this research, we focus on the Geomagnetic Depth Sounding (GDS) survey, carried out in a small space on the geothermal field. The GDS survey can obtain the subsurface resistivity information by measuring horizontal and vertical magnetic field. The GDS survey is also known as the robustness to the small-scale near-surface anomalies. Therefore, we perform the effectiveness of the densely-arrayed GDS survey together with a few MT stations, for overcoming the problem on the low spatial resolution and severe effects of near-surface heterogeneity on the MT data.

We discuss the 3-D inversion accuracy with varying the number of MT/GDS stations. A typical 3-D resistivity model in a geothermal area is assumed first, then the synthetic MT / GDS data is obtained by 3-D forward calculations. This synthetic data is used for the input dataset to a 3-D inversion code. Finally, the obtained inverted result can be compared with the 3-D model original assumed for evaluation of the optimal combination of MT/GDS stations.

In the case of no static distortion in MT data, we found that the subsurface resistivity structure could be properly obtained even with a small number of MT stations and a lot of GDS stations. We also validate the effectiveness of the MT / GDS combined analysis in the case of sever distortion in MT data as follows: i) with adding the static distortion numerically and randomly to the raw synthetic MT data, and ii) with a 3-D model having a number of near-surface resistivity anomalies on the shallow surface. As a result, it was clarified in the case (i) that the effect of the static distortion in MT data was corrected by the spatially dense GDS data. On the other hand, in the case (ii), the inversion results still include the false images due to the near-surface anomalies even if we added the dense GDS data. In the forward calculations, we found that horizontally elongated low resistivity zones near the surface can distort the GDS data, which was the major cause of less effectiveness of MT/GDS combination in the case (ii). We conclude that the combination of MT/GDS survey can effectively refine the spatial resolution and also reduce the static distortion, except for the near-surface low resistive body such as pipelines and power lines.

Keywords: Magnetotellurics, Geothermal field, Geomagnetic Depth Sounding

