Application and challenges of three-dimensional inversion of magnetotelluric data for geothermal exploration

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Application of the magnetotelluric (MT) method for the exploration of geothermal resources was started in early 1980s in Japan. The obtained underground resistivity model as well as the quality of the observed MT data were not always at a satisfactory level for geothermal geologists and developers for the interpretation of geothermal reservoirs. In early 1990s, two-dimensional (2-D) MT inversion methods were developed and applied to MT data in geothermal fields, and more reliable resistivity models began to be obtained. In addition, owing to the innovations in the MT field equipment (e.g., 24-bit A/D, GPS time synchronization, low-electricity consumption, and light weight instrument), the efficiency of the measurement in the field was greatly improved and the quality of the measured data were also improved.

As the 2-D inversion techniques became used widely, MT geophysicists began to recognize that there is a limit in applying the 2-D interpretation to geothermal areas, where the geological structure is usually three-dimensional. In the 2000s, three-dimensional (3-D) inversion programs were developed and applied to MT data, producing more reliable resistivity models that may indicate possible geothermal reservoir structure. In the 2010s, 3-D MT survey has been commonly carried out for geothermal exploration in the world and its effectiveness and reliability have been recognized among geothermal developers. In some cases, however, they express too strong expectations for 3D MT results, which might be beyond the capability of current MT techniques.

At present, several 3-D inversion programs are used worldwide both commercial and academic studies. In this paper, challenges of 3-D MT inversion are discussed based on the examples obtained by a 3-D program that the author has been involved in the development and other case studies recently published by other experts.

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