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ELECTROMAGNETIC METHODS FOR GEOTHERMAL EXPLORATION

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KEY WORDS

magnetotelluric (MT), controlled-source magnetotelluric (CSMT), source effect, geothermal, electrical conductivity

PROJECT BACKGROUND AND STATUS

In the fall of 1993, Trans-Pacific Geothermal Inc. (TPGI) consulted with LBNL in evaluating the CSMT data collected near Vale, Oregon. LBNL interpreted the data provided by TPGI using a state-of-the-art, two-dimensional MT inversion code (INV2D) developed at LBNL. The inversion code is capable of handling the topography, which is of great importance when dealing with data from rough terrains. The results were very successful. There was one concern however. At low frequencies the impedance data appeared to have been affected by the source effect. So we could not be certain of the interpreted result at depths.

TPGI is now engaged in a few ambitious field exploration projects in Central America (Tsvi Meidav and Bill Teplow, personal communication, 1995). The first field site to be investigated is the El Hoyo-Monte Galan field in Nicaragua. The depth of investigation at this site ranges from 4000 to 5000 ft and the major field technique considered is the CSMT method. To support TPGI's effort in the exploration, and possibly in the reservoir characterization stage later, LBNL proposed to investigate the source effect in the CSMT method and design and direct survey specifications using CSMT methods at the El Hoyo-Monte Galan field. Upon completion of the survey according to the specification, LBNL will make corrections for the source effect and interpret the data using the inversion code INV2D mentioned above.

PROJECT OBJECTIVES

Technical Objectives

- Evaluate current magnetotelluric (MT) methods for: (a) use in exploration of geothermal fields, and (b) characterization and monitoring of production processes in regional scale.
- Demonstrate the utility of the controlled-source megnetotelluric (CSMT) method when used in conjunction with the MT method, and identify source effects and make corrections to CSMT data.

Expected Outcomes

- Provide improved means for interpreting MT and CSMT data.
- Help establish guidelines for efficient and economic CSMT survey design.
- Improved general reservoir characterization.

APPROACH

There is an essential difference between MT and CSMT methods in terms of the nature of the source field. The MT source is natural and the resulting electromagnetic field is a plane wave with zero horizontal wavenumber for all frequencies. The CSMT source field is man-made consisting of a wideband wavenumber spectrum. Wideband wavenumber effects in CSMT result in deviation from plane wave impedance responses in regions near the source.

We approximate the controlled source fields by terms at a few appropriately-chosen horizontal wavenumbers. The objective is to develop a simple correction of near-source effects.

RESEARCH RESULTS

The finite wavenumber approach leads to an asymptotic expression between the impedance and the various field components. Initial results using a few chosen wavenumbers to approximate fields by finite sources have been very promising.

FUTURE PLANS

We are now investigating which part of the wavenumber spectrum can best approximate the correct impedance. This will be a function of frequency and source-receiver geometry. Of particular interest is the use of high horizontal wavenumbers for this approximation. With this method, one may be able to achieve better asymptotic relationship between fields and impedances.

INDUSTRY INTEREST AND TECHNOLOGY TRANSFER

CSMT methods have been widely used in geothermal exploration in hostile environments. Presently, this project is a joint TPGI and LBNL effort (In the future, other companies might also participate.) TPGI will provide field support, CSMT data, and other relevant geophysical and geological information. Meetings are held periodically to discuss research directions and priorities.

REFERENCES

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