Temperature Gradient Estimation from Magnetotelluric (MT) Data

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Abstract

The magnetotellurics (MT) is the primary geophysical exploration technique used to delineate key components of a geothermal system, in particular the conductive zones associated with geothermal cap rocks. The strong dependence of resistivity on temperature in geological materials allows to extract subsurface thermal information from MT data. We simply assume that the Arhennius formula may represent the temperature - resistivity relationship of the subsurface. An estimate of temperature gradient can be obtained from the resistivity gradient. Available temperature data from the nearby well can be used to calibrate the results.

Keyword: magnetotellurics, geothermal, resistivity

Introduction

Low resistivity anomalies from MT data are not necessarily correlated with conductive cap rocks of a geothermal prospect. Therefore, we need a other parameter(s) allowing to associate low resistivity anomalies with high temperature anomalies.

Research Method

The temperature - resistivity relationship can be reformulated to obtain the linear relationship between resistivity gradient and temperature gradient. In MT sounding curve, the apparent resistivity as a function of period represents the variation of the resistivity with depth. More particularly, the decrease in apparent resistivity with the period indicates the increase in temperature with depth.

The apparent resistivity gradient over the period is calculated from MT data. Furthermore, the gradient needs to be normalized to the minimum apparent resistivity value of the sounding curve since the high-temperature is mostly associated with the conductive medium.

To obtain a more representative result, the resistivity gradient with respect to depth can be obtained from the results of modeling MT data, especially in 1D. The results of the calculation of the resistivity gradient can be calibrated with the temperature data from the nearby borehole (if available).

Result and Discussion

The MT survey was conducted in Wae Sano geothermal prospect, located in Flores island, East Nusa Tenggara, Indonesia. The apparent resistivity gradient with periods is presented as map in Figure 1 (left). More precise delineation of the prospect area are obtained from the resistivity gradient with depth (Figure 1, right). In the latter, the Bostick transform was performed to to obtain the approximate resistivity variation with depth.

Conclusion

Apparent resistivity gradient and resistivity gradient maps derived from MT data Low resistivity anomalies from MT data show better prospect delineation than that from apparent resistivity map. The gradient calculation can be performed relatively quick, allowing to analyse the MT data to modify the survey design during the survey. Therefore, the efficiency and effectiveness of the MT survey can be improved significantly.



