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Exploration of geothermal resources using MT data in Bushi area- Sabalan, northwest of Iran

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Extended Abstract

Summary

The exploration of geothermal resources in the Bushli area of Ardebil Province utilizing magnetotelluric (MT) data is presented in this paper. This study is performed on 60 MT stations in an area surface of 90 square kilometers of Bushli area, located in southeast of Nir district. The data has been processed using algorithms based on robust methods, which are resistant to noise. After that, dimensionality analysis has been applied to the MT data having appropriate limits of frequencies related to all stations. Considering dimensionality analysis results, the regional structures are mostly identified as two-dimensional structures with north - south strike direction. Regional structures have been interpreted following one dimensional (1D) and two dimensional (2D) inverse modeling applied on the data. The results of 1D and 2D inverse modeling integrated with geological data indicate that the upper part of the geothermal reservoir is composed of a low resistivity area at the depth of 500 to 2000 meters. Final results have shown that the location of the geothermal reservoir extends to the southern parts of the study area.

Introduction

MT method is an electromagnetic (EM) method that uses natural EM fields, generated from Earth's magnetosphere for mapping deep subsurface structures. This method plots the electrical conductivity distribution beneath the earth surface by recording vertical and horizontal components of magnetic and electric fields from ground surface. High penetration depth of EM fields in MT method has made it applicable to deep target explorations such as geothermal and hydrocarbon resources. Hence, due to these options, this method has special status among other geophysical methods. Preliminary studies on the geology of Bushli area, which is located in southwest of Nir and Sareyn hot springs, have shown a relatively good potential for geothermal resources in this area that could be a preferred alternative for fossil fuels and future energy supply.

Methodology and Approaches

MT method is widely utilized for surveying geothermal areas. In thermal areas, the electrical resistivity is extremely lower than that of areas with colder subsurface temperature. The selected MT survey lines are located in the area crossing over the hydrothermally altered zones and different geological structures. The data was acquired along 12 survey lines crossing the Bushli hot springs with a total of 60 MT stations in a frequency range of 1000 Hz to 0.001 Hz. Spacing between MT stations was almost considered 500 m constantly, for a better resolution. At first, 60 MT sounding time series data were reviewed. Then, the acquired raw data were analyzed using methods resistant to noise (i.e. robust methods), and also, outlier elimination method in order to achieve high quality apparent resistivity and phase data at each desired frequency. Specialized software was utilized for this purpose such as Mapros for processing and WinGLink for 1-D and 2-D smooth inverse modeling. Mapros has plenty of different robust methods for processing, and the preferred processing procedure, used in this paper, was to use least squares weighted functions. The Rodi and Mackie computer code and Occam smoothing algorithm were also used for 2D inversion and forward modeling, respectively. This algorithm seeks the minimum possible structure model subjected to an appropriate fit for the data, and it uses a code for 2D inversion from Rodi and Mackie (2001) in a way that this algorithm searches simultaneously for the model with the lowest overall RMS misfit and the smallest lateral and vertical conductivity gradients respectively. Apparent resistivity and phase data of TE+TM (joint) mode along each survey line were modeled in this study.

Results and Conclusions

Considering the results obtained from 2D inversion and the geological information, the following conclusions were acquired: the thick surface layer with resistivity of 100-500 ohm-m along the north-south survey lines was also observable along the west-east survey lines. In some stations, a very conductive layer was seen on top of the surface that could be interpreted as the top soil saturated by penetrated water. Below this layer, there was a decline of resistivity with depth observable along the whole survey lines. This conductive layer (<10 ohm-m), showing variable thicknesses along the profile, was most naturally interpreted as the limestone, related to late Permian, of Ruteh formation acting as system reservoir. Below this conductor, a very resistive zone (>250-300 ohm-m) was observed. This resistive and intrusive mass was interpreted as the bed rock zone and a heat source that was mostly formed from granite and granodiorite related to first age of geology with high enthalpy. According to the models and electrical vertical sections and also horizontal resistivity maps at different depths, the geothermal reservoir was designated at a depth of 2500 to 3000 meters. Furthermore, resistivity map showed that the location of the geothermal reservoir continued to the south of the area. This was probably due to the significant properties of eastern parts of the area like the existence of many faults as well as low height of this part of the area compared to neighboring parts that caused the appearance of numerous hot springs in the area.