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A comparison between centroid and forward modeling methods in order to estimate curie point depth using spectral analysis of aeromagnetic data for geothermal exploration

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Extended Abstract

Summary

Geothermal energy can be a good replacement for any kind of energy we use today. Estimation of curie point depth (CPD) is one of the first steps in geothermal exploration. Spectral analysis of aeromagnetic data can provide important information about temperature distribution in depth. In this study, we attempt to estimate the CPD using centroid method and forward modeling in northwest of Iran. The reduced-to-pole (RTP) aeromagnetic data were divided into 11 overlapping windows of the size of 100×100 km. In the centroid method, the average depth to the top of the deepest crustal block, Z_t was first computed by linear fitting to the second longest wavelength segment of the power spectrum of aeromagnetic data. Then, depth to the centroid of the deepest crustal block, Z_o was computed by linear fitting to the longest wavelength segment of power spectrum of aeromagnetic data. In forward modeling, the modelled spectra were fitted to the observed spectrum iteratively and the depth to the top and bottom of the block was finally estimated. According to the obtained results, the CPD is shallow in the west part of the area and as a comparison of the results with the locations of hot springs in the area, we conclude that the west part of the area has a good potential for geothermal exploration.

Introduction

Estimation of CPD using spectral analysis of aeromagnetic data is one of the first steps in primary geothermal exploration. The goal of estimation of CPD is to know the thickness of crust and temperature distribution in depth from a set of known aeromagnetic observations measured on the surface. Spectral analysis of aeromagnetic data can also help in the constraining of the temperature within the crust based on identifying and mapping the depth of curie isotherm. Above the curie temperature ($580^{\circ}C$), magnetic minerals lose their ferromagnetism. This means that deeper layers at greater temperatures are essentially non-magnetic. This curie isotherm interface can be detected through a number of spectral magnetic methods. In this paper, geothermal exploration in northwest of Iran is attempted by determining the depth to the magnetic bottom. We estimate the magnetic bottom using two different methods that are centroid method and forward modeling of the spectral analysis of aeromagnetic data. These methods are used to determine CPD or magnetic bottom in northwest of Iran.

Methodology and Approaches

Aeromagnetic data of the area were taken from the Geological Survey of Iran. This data were corrected for the international geomagnetic reference field (IGRF1976). In this study, centroid method and forward modeling of the spectral analysis of the aeromagnetic data were used to determine CPD. To use these methods, the RTP aeromagnetic data were divided into 11 overlapping windows of size of 100×100 km (overlapped 50% with the adjacent windows). The two dimensional (2D) power spectrum of aeromagnetic data for each window was computed by Oasis Montaj software using fast Furrier transform (FFT) method. The biggest advantage of 2D power spectrum is that the depth of sources is easily determined by measuring the slop of power spectrum when the centroid method is used. Determination of CPD using centroid method can be carried out in two steps. Firstly, the centroid depth of the deepest magnetic source is estimated from the slop of the longest wavelength part of the spectrum divided by the wave number and the depth to the top of the magnetic source is similarly derived from the slope of high wave number portion of the power spectrum. Then, the bottom of magnetic source is obtained. Using forward modeling for estimation of CPD or magnetic bottom

has another advantage. That is the depths to the top and bottom of magnetic source can be determined together. Another advantage of forward modeling is that it allows one to fit iteratively the position matching the adjacent part of the slope more precisely and explore the model space. Based on the fitting the modeled spectra with the observed, one may accept or reject the results more confidently in this overall subjective process of fitting specific part of the spectra.

Results and Conclusions

An attempt has been made to calculate the depth to the bottom of magnetic sources from the aeromagnetic data in northwest of Iran using two spectral methods. CPD has been calculated by the centroid method and forward modeling. The results show that the CPD varies from 15 to 23 km in the study area. In forward modeling, the calculated power spectrum is fitted iteratively with the measured power spectrum using MATLAB software. A conclusion is that by using forward modeling, the depths to the top and bottom of magnetic source are estimated together and with this approach, CPD can be estimated better. Because of that, the CPD, estimated by forward modeling, is considered the CPD of study area. According to the obtained results of forward modeling, the CPD is shallow in west part of area. By comparing the results with the locations of hot springs in the area, we conclude that west part of area has a great potential for geothermal exploration. Consequently, it is proposed that the results of this study to be integrated in GIS environment with all available geological, geophysical, geochemical and other information layers. This additional information will facilitate selection of optimum sites for geothermal exploration.