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An Automatic Method for Anomalies Sources Depth Determination from Magnetic Data (Case Study: Salafchegan Area, Qom, Iran)

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Abstract

In this study, the fast and accurate method of Tilt-Depth is applied to determine the depth of magnetic anomalies. The Tilt-Depth method determines the depth by using the first derivatives of reduction-to-the-pole or reduction-to-the-equator. This method was tested on synthetic data along with 10% noise, and after a theoretical certification was tested on the field data obtained from Salafchegan area located at Qom province. There was a very good agreement between the results from Tilt-Depth method and the obtained drilling data and also Euler deconvolution method.

Keywords: Magnetic anomaly; Depth of anomaly; Tilt angle; Salafchegan area

Introduction

Geophysics data plays significant roles in mineral and hydrocarbon explorations [1]. By introducing and applying the data obtained from GPS, the accuracy of magnetic data has been increasingly enhanced [1]. The increased quality in extraction data and reduced disruptive noises has led to the application of calculation methods to second and third order derivatives [1].

To interpret magnetic data, different methods are used. In addition, within the last decade, robust and quick methods have been used for interpreting geological structures. There are several efficient methods to interpret magnetic anomalies including graphic methods [2] numerical methods such as Werner deconvolution [3,4] and Euler deconvolution [5].

The most natural unforced explanation of the above results is that short-wavelength anomalies are due to crustal effects and the long-wavelength anomalies are due to causes within the core of the earth. The large gap between the short- and long-wavelength groupings supports the hypothesis that the mantle is a forbidden region for magnetic sources. This conclusion is illustrated by calculations based on simple models.

Notably, Euler deconvolution method is more commonly used than other methods. In the present paper, a modern, robust and efficient method is used to determine the depth of magnetic anomalies. Using Tilt-Depth method [6] and the first derivatives of reduction-to-the-pole and assuming having a simple anomaly method, the depth of the magnetic anomalies in the Salafchegan area is studied in this paper. In the end, to confirm the method presented, an example of depth determination map is presented using Euler deconvolution method.

Tilt-Depth Method

This method was proposed in 2007 by Salem et al by using reduction-to-the-pole and also a buried two-dimensional Dyke model.

The Tilt-depth method uses the reduced to the pole (RTP) field and assumes a simple buried vertical 2D contact model.

The horizontal and vertical derivative of the observed magnetic field M is:

$$\frac{\partial M}{\partial h} = 2kfc\frac{z_c}{h^2 + z_c{}^2} \quad (1)$$

$$\frac{\partial M}{\partial z} = 2kfc\frac{h}{h^2 + z_c{}^2} \quad (2)$$

In the above equations, z is the depth of anomaly, h is horizontal distance from the horizontal location of the anomaly; k is the magnetic self-acceptance contrast, parameter c in the equation is equal to 1-cos2i-cos2i sin2A1 which A is the angle between positive axis h and the magnetic north also *i* is the magnetic tilt angle, tan1=tani/cosA and finally d is inclination (slope) amount. The trigonometric angles in the above equation are calculated in terms of degree or radian.

It must be noted theta the tile angle include horizontal and vertical derivations, the tilt derivatives of the reduction-to-the-pole does not contain some information on the buried inducted anomaly magnetism, so structural information and the depth in tilt derivative has no effect [1]. By substituting the above derivatives in tilt angle (θ) and by assuming reduction-to-the-pole of magnetic data, we have:

$$\theta = \tan^{-1}\left(\frac{\partial M / \partial z}{\partial M / \partial h}\right) \quad (3)$$

Which $\frac{\partial M}{\partial z}$ is equal to h and $\frac{\partial M}{\partial h}$ is equal to z_c. So we have

$$\theta = \tan^{-1}\left(\frac{h}{z_c}\right) \quad (4)$$

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In the equation 4, when the tilt amount gets equal to zero (h=0), and when the tilt content is equal to ± 45 degree, h = ± z. In other words, considering h = ± θzc and θ = ± 45 in the equations 3 and 4, it is possible to calculate the depth and the position of the anomaly through the tilt derivatives map by measuring accurately the distance between contours.

Synthetic Model

To investigate the efficiency of the above mentioned method, a vertical prism with dimensions 40×40 are considered (Figure 1). The model is located 10 km from the depth of earth (Figure 1). Also, 10% of noise with a Gaussian distribution is added to the synthetic data.

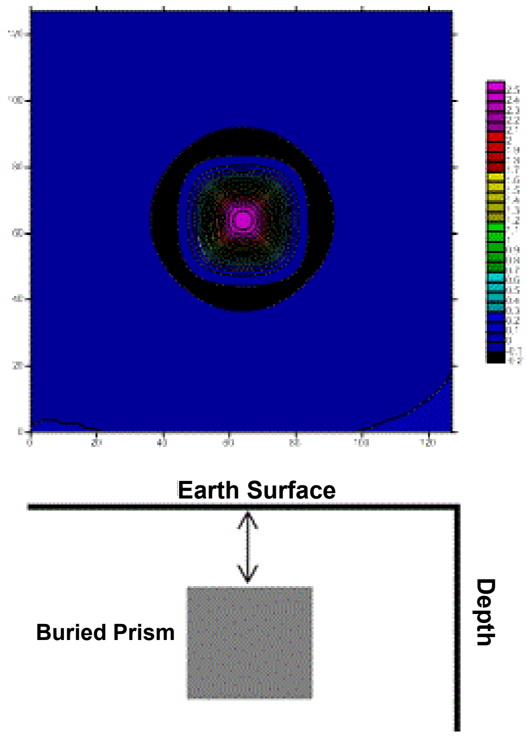

Figure 1: The magnetic anomaly mapping produced by the artificial model of a vertical prism along with 10% noise with Gaussian distribution. (in terms of Nanotesla).

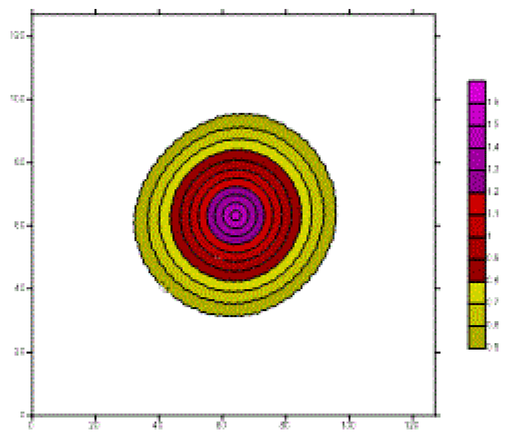

Figure 2: The tilt anomaly mapping obtained from the reduction-to-the-pole data. (in terms of kilometer).

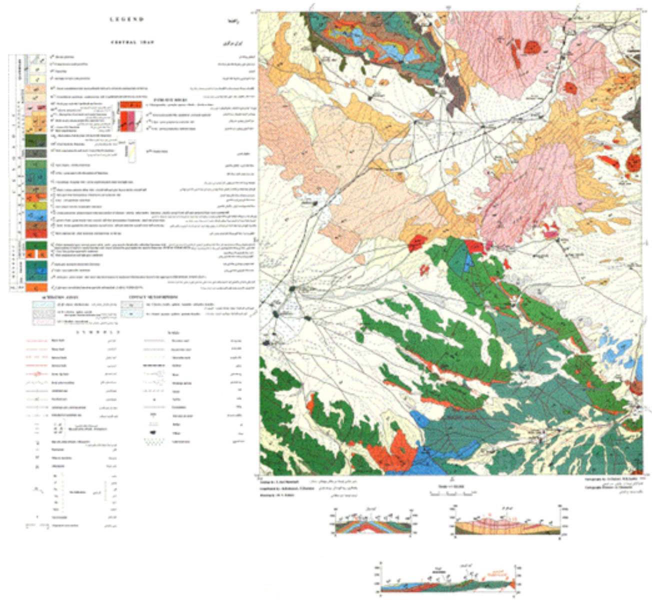

Figure 3: The geological mapping of the area studied.

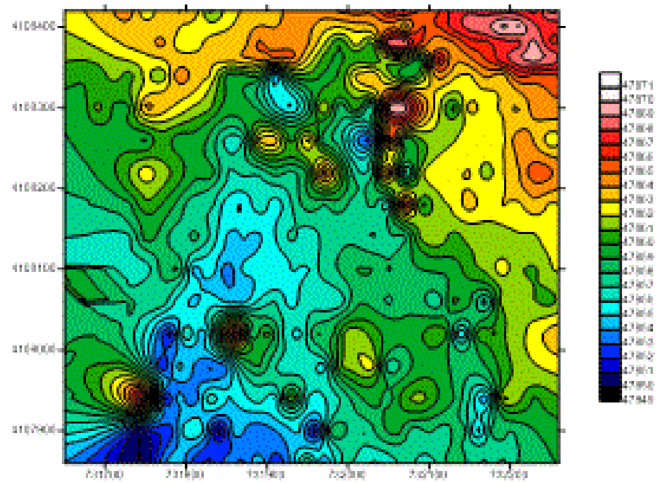

Figure 4: The magnetic field intensity mapping in the Salafchegan area. (in terms of Nano Tesla)

The anomaly map and reduction-to-the-pole data tilt map are shown in Figures 1 and 2, respectively. To determine the depth using Tilt-Depth a computer program is written in MATLAB language.

Field Study

The magnetic interpretations in mineral explorations can play roles in two forms: one is studying and exploring mines and other is being used as complementary tool to determine the scope and evaluation of mine reserve. Salafchegan area lies in geographical location, longitudes 44 degree and 50 minutes to 50 degree East and latitudes 38 degree and 30 minutes to 38 degree and 15 minutes north and covers the square southeast plate of Qom 1250000.

The closest population centers to this area include Qom, Arak, Ashtian, Mahalat and Delijan which are linked together by national ways Isfahan-Qom and Arak-Qom. This area is located at the central

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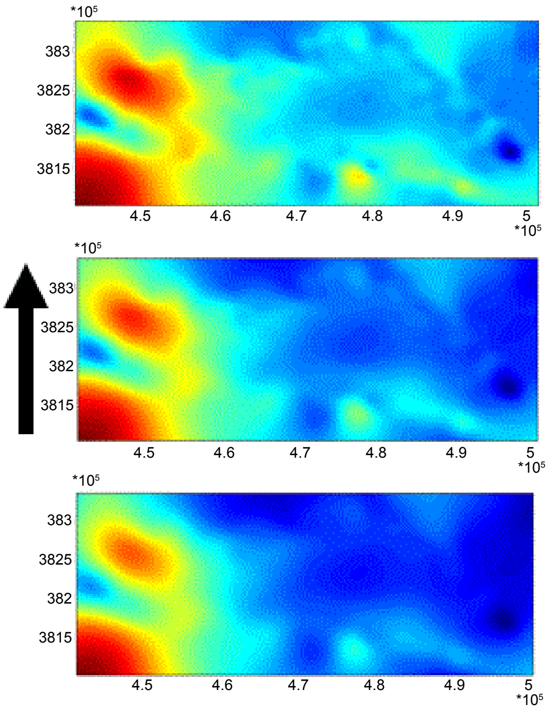

Figure 5: Upward continuation mapping. (50 m, 100 m, and 150 m).

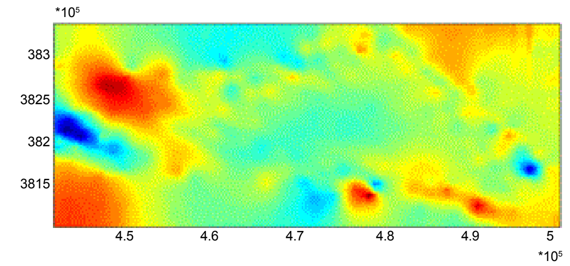

Figure 6: The reduction-to-the-pole mapping of the magnetic data in the region studied.

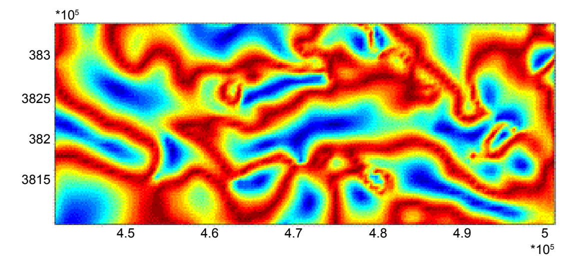

Figure 7: The magnetic data tilt mapping in the Area studied.

Iran zone and under the Uromieh-Dokhtar zone. Geologically, Salafchegan region covers volcanic and sedimentary units of Eocene, Oligocene and Miocene. These units include Trachyandesite, andesite, tuff, marl and sand silt limestone. At the next stage, intrusive Miocene-Pliocene semi-deep stones by the forms such as dyke, silt and semi-deep masses have penetrated into older units [11-13]. The most significant faults of this section have a strike-slip mechanism and have cut Eocene-Oligocene deposits in the direction of eastern north to western south. The faults are mainly of a left-lateral slip direction and have displaced Eocene-Oligocene sediments (Figures 3 and 7-10).

Most of the deepest lows are caused by thick accumulations of low-density Cenozoic sedimentary rocks that fill tectonic basins adjacent to the faults and in the surrounding areas. Shallower lows occur over certain large serpentinite bodies within the Franciscan assemblage, over felsic plutons in the granitic terranes of California, and over a young

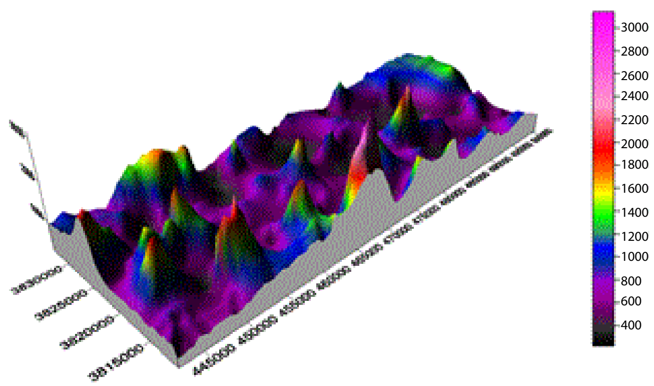

Figure 8: The mapping of Salafchegan arch depth by using Tilt-Depth Method. (in meter)

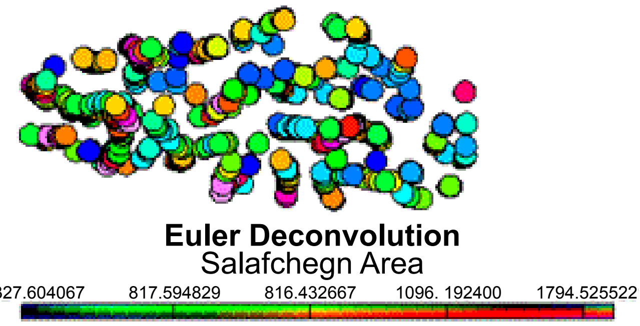

Figure 9: The mapping of Salafchegan arch platter by using Euler deconvolution. (in meter)

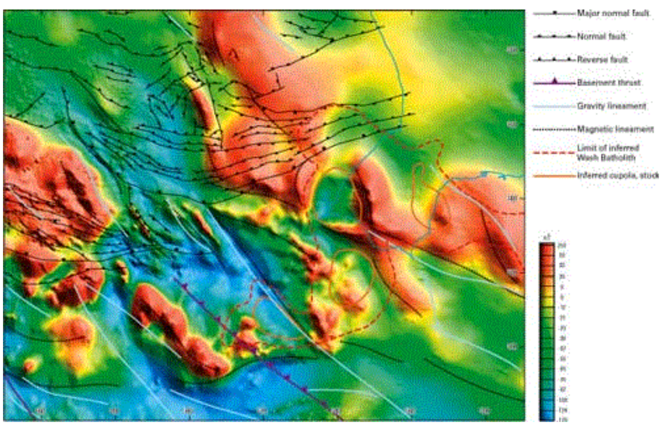

Figure 10: Pole magnetic anomaly map.

concealed granitic pluton associated with the Geysers geothermal area at lat 39° N., long 122°45' W.

Using Arkani algorithm, interpretational data networkare converted into reduction-to-the-pole [7] (Figure 6).

To interpret data, the magnetic tilt angel 53 degree and magnetic deviation angle 4 are considered. The noise effects in data are relatively reduced by using upward continuation method. Figure 4 shows the intensity mapping of the magnetic field interpreted in the area studied and Figure 5 shows upward continuation method [14,15].

Conclusion

In this study, Tilt-Depth method is used to determine the depth of magnetic anomalies. Initially, using the artificial data along with noise, the depth is determined and then the mentioned method is applied to the field data obtained from Salafchegan area. Tilt-Depth method is applicable to the different geological structures and for local and regional data.

Time permitting, the presentation will present similar continental to basin scale examples for Australia, and other regions. The Tilt-depth method is thus shown to work in many geological environments worldwide at both regional and local scales. It is likely to have a major impact in furthering our regional understanding of the structure of continental margins.

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