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Application of Gradient Tensor Decomposition and Standard Euler Deconvolution for Interpretation using Magnetic Data

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ABSRACT

Euler deconvolution of magnetic and gravity anomalies can be used to estimate the coordinates of simple point source and level of a constant background in the deconvolved field by testing series of structural in dices. Euler deconvolution is a semi-automatic interpretation method that is frequently used with field potential data. For a given source type, which is specified by its structural index, it provides an estimate of the source location. The eigenvectors of the symmetric magnetic gradient tensor can be used to estimate the position of the source body as well as its strike direction. For a given measurement point, the eigenvector corresponding to the maximum eigenvalue points approximately towards the center of mass of the causative body. For a collection of measurement points a robust least squares procedure is used to estimate the source point as that point which has the smallest sum of square distances to the lines defined by the eigenvectors and the measuremen positions. The strike direction of the source can be estimated from the direction of the eigenvectors corresponding to the smallest eigenvalue for quasi 2D structures. These methods have been applied to real magnetic data. The agreement between the results obtained by the gradient tensor decomposition method and Euler deconvolution method is good. Moreover, the depths obtained by the proposed methods are found to be in a very good agreement with the depths information. In this paper, we used Geosoft Oasis Montaj 6.4.2 software and MATLAB programming.

KEY WORDS: Standard Euler Deconvolution, Gradient Tensor Decomposition, Magnetic Data, Bijar Area, Iran.

1. INTRODUCTION

1.1. STANDARD EULER DECONVOLUTION

Euler deconvolution of magnetic and gravity anomalies is based on Euler's homogeneity of the anomalous fields. Euler deconvolution is an automatic technique used for locating the source of potential field based on both their amplitudes and gradients. The method was developed by Thompson (1982) to interpret 2D potential field anomalies and extended by Reid et al. (1990) to be used on grid-based data. Magnetic field M and its spatial derivatives satisfy Euler's equation of homogeneity.

$$(x - x_\circ)\frac{\partial M}{\partial x} + (y - y_\circ)\frac{\partial M}{\partial y} + (z - z_\circ)\frac{\partial M}{\partial z} = NB \qquad (1)$$

where $\partial M/\partial x$, $\partial M/\partial y$ and $\partial M/\partial z$ represent first-order derivative of the magnetic field along the x-, y- and z- directions, respectively, N is known as a structural index and related to the geometry of the magnetic source (Table. 1). Taking into account a base level for the regional magnetic field equation (1) can be rearranged and written as

$$x_\circ\frac{\partial M}{\partial x} + y_\circ\frac{\partial M}{\partial y} + z_\circ\frac{\partial M}{\partial z} + NB = x\frac{\partial M}{\partial x} + y\frac{\partial M}{\partial y} + z\frac{\partial M}{\partial z} + NM \;., \qquad (2)$$

Assigning the structural index (N) a system of linear equations can be obtained and solved for estimating the location and depth of the magnetic body. Using a moving window of a fixed size over a grid of data and calculates Euler Deconvolution solutions for each window. There are typically many solutions, virtually one for every window location, which approaches the number of cells in the grid. The Located Euler deconvolution modifies this procedure by first locating only those windows which encompass peak-like structures in the data. A peak-finding routine is first run which locates peaks and estimates a window size using the locations of adjacent inflection points. These locations and window sizes are then used to define the solution using standard Euler deconvolution method (Eslam and Elawadi, 2007). It is clear that Euler's method requires not only the anomaly but also its gradient in three directions.

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Table 1: Euler magnetic structural indices

Source type	Magnetic SI
Sphere or compact body at a distance	3
Line source(pipline, narrow kimberlite pipe)	2
Thin sheet edge (sill, dike)	1
Contact of considerable depth extent	0

1.2. GRADIENT TENSOR DECOMPOSITION

The Magnetic Gradient Tensor is a multi-component Magnetic system computed from the second derivatives of the earth's magnetic potential in the three Cartesian directions (Zhdanov et al., 2004). Magnetic Gradient Tensor data can be measured either using airborne, land or marine platforms. In recent years, the applications of magnetic gradient tensor data in hydrocarbon exploration, mineral exploration and structural geology have increased considerably (Fedi, et al., 2005). Pedersen and Rasmussen (1990) studied gradient tensors of gravity and magnetic fields and introduced scalar invariants to indicate their dimensionality. They also showed that the maximum eigenvalue and corresponding eigenvector of the Magnetic Gradient Tensor is related to the center of mass for a simple point source. The methods are applied to magnetic data from Bijar Area in Iran.

2. Field Data

The study area is located in west of Iran. Geological scheme of the study area is shown in Figure 1. The Bouguer gravity was calculated using a density at3.17g/cm^3 (Figure 2). Depths of anomalies measured are shown in Figure 3 and Figure 4.

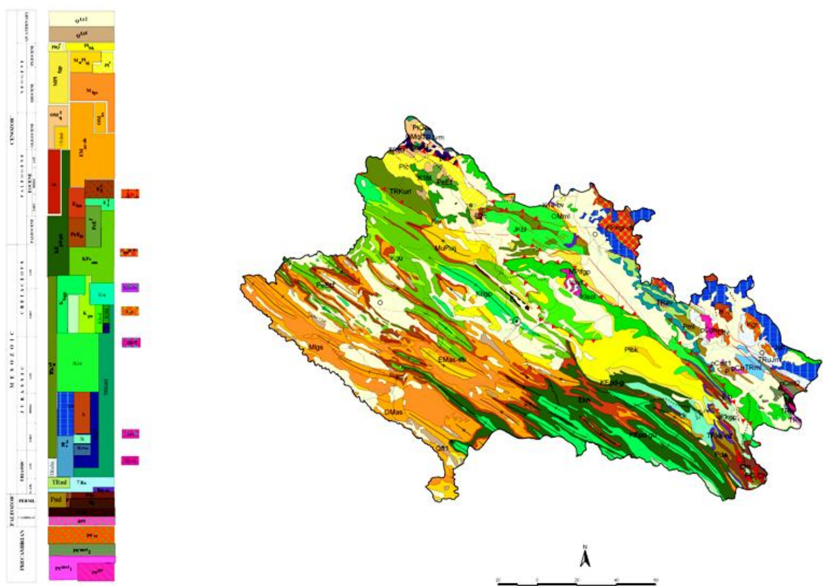

Figure 1: geological map of the study area

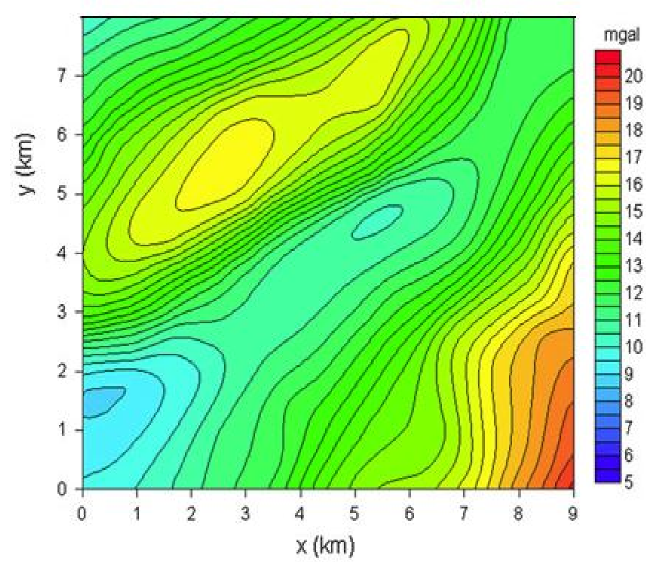

Figure 2: a Bouguer gravity anomaly map of the Bijar area

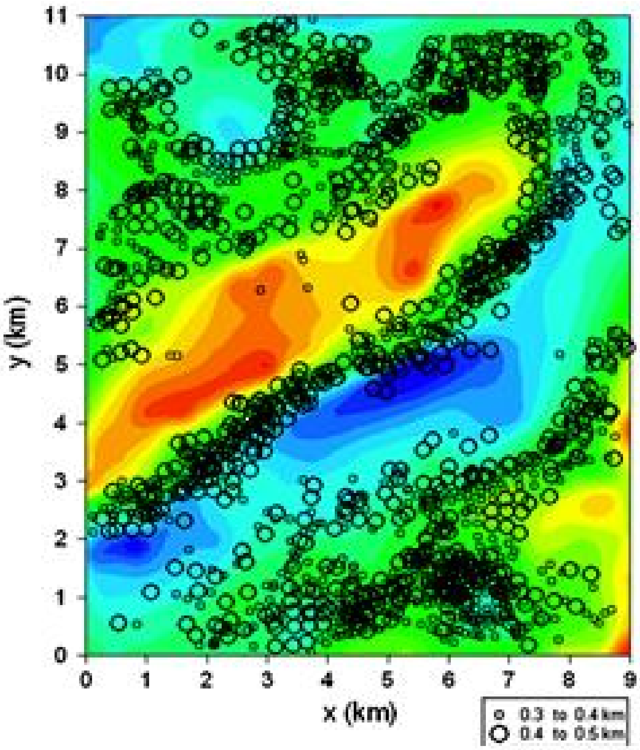

Figure 3: Magnetic Gradient Tensor map of the study area

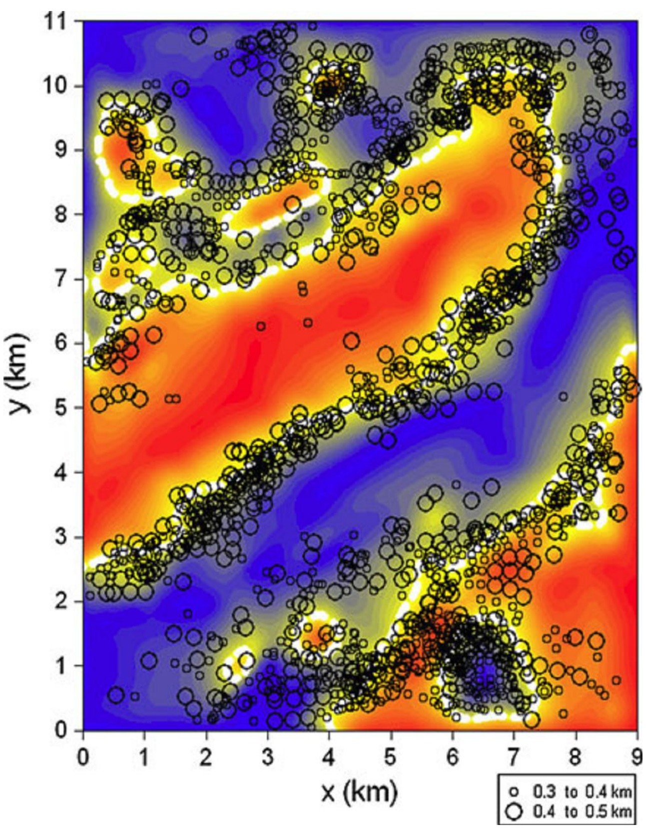

Figure 4: Euler deconvolution map of the study area

CONCLUSION

Euler deconvolution (Thompson, 1982; Reid et al., 1990) has come into wide use as an aid to interpreting profile or gridded magnetic survey data. It provides automatic estimates of source location and depth. Euler deconvolution has been widely used in automatic gravity interpretations because it requires no prior knowledge of the source magnetization direction and assumes no particular interpretation model. The Euler deconvolution method is best suited for anomalies caused by isolated and multiple anomalous sources and Magnetic Gradient Tensor is a robust and fast method. Results of

Euler deconvolution and Magnetic Gradient Tensor are similar. The methods are applied to a dataset of magnetic measurements, located over Bijar area, Iran.

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