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Euler deconvolution of 3D gravity data interpretation: New approach

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ABSTRACT

Euler deconvolution method is used for rapid interpretation of potential field (magnetic and gravity) data. It is particularly good at delineating contacts and rapid depth estimation. This technique is belong to automatic depth estimates methods and, is designed to provide computer-assisted analysis on large volumes of magnetic and gravity data.The depths to magnetic or gravity sources are a very useful product from any magnetic or gravity interpretation. In this paper three-dimensional models has been considered first and the gravity attraction of this models is extracted by using graprism(gravity software).So these values have been used as code input of three-dimensional Euler deconvolution. All values of possible depths (z location),coordinates of anomaly sorces x location and y location has been extracted per all values of SI and W size by using written codes and its best values have the most frequency by drawing Z , x ,and y values histogram.

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INTRODUCTION

In this paper three-dimensional model has been considered first and the gravity attraction of these models are extracted by using GRAPRISM (software).So these values have been used as code input of three-dimensional Euler deconvolution. All values of possible depths has been extracted per all values of SI and W size by using written codes and we use new approach for finding best values of depth.

1)3D gravity modeling:

1.1. Introduction:

Gravity, the attraction force between masses, is one of the basic forces of the physical world. The objective of geophysical gravity method is to obtain indirect information about the subsurface structures from the gravity measurements made on Earth's surface. Absolute gravity measurements try to accurately measure the gravitational acceleration, g, which can be approximated as g=GM/R2, where G=6.67.10-11 m3/kg/s2 is the gravitational constant, M=5.997.1024 kg and R=6378 km are the (total) mass and the radius of (spherical) Earth.

Geophysical measurement are usually made to obtain the relative gravity, that is to say the difference in g with respect to a reference point, where the (geodetic) altitude (R) is known accurately. The gravity instrument tries to determine changes in the gravitational acceleration (g=9.80665 m/s2) with an accuracy of about 0.1 mgal, which equals to 10-6 m/s2.The most important petrophysical parameter that affects the formation of a gravity anomaly is the density, ρ, which determines the mass (or weight) per volume (kg/m3). The density of a certain mineral is a characteristic parameter, which depends on its atomic structure and composition. The density of rocks depends on the proportions of its minerals. Factors that affect the overall density of rocks are the inner structure, porosity, water saturation, temperature, and pressure to name but a few. In general, ultra-mafic (volcanic) rocks have higher density than sedimentary rocks and most plutonic and metamorphic rocks. The distribution of the density variations in general, or the density, position, orientation and dimensions of isolated targets define the spatial characteristics of the gravity anomaly.

Although the gravity data cannot be interpreted uniquely, the information about the density and its distribution can then be used in geological and structural interpretation. The GRAPRISM program computes the anomalous gravity field caused by an isolate, dipping prism-like body. The parameters of the prism model are shown below in Figure 1,2,3. Since only the relative gravity effect is computed, the density of the target is actually the density contrast with respect to the host medium. Only a single body and a single profile can be

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used. The forward computation is based on the solution and the original algorithm of (Hjelt ,1972).The GRAPRISM program is intended primarily for educational purposes.

2) Euler deconvolution:

2-1) Introduction:

Euler deconvolution method is used for rapid interpretation of potential field (magnetic and gravity) data. It is particularly good at delineating contacts and rapid depth estimation. This technique is belong to automatic depth estimates methods and, is designed to provide computer-assisted analysis on large volumes of magnetic and gravity data(Dawi, *et al*, 2004), (Kirkham and Hildenbrand, 2002) Euler's equation has been used by a number of authors for analyzing both magnetic anomalies (Thompson, 1982), (Barongo, 1984; Reid *et al*, 1990) and gravity anomalies (Marson and Klingele, 1993). Euler's homogeneity relationship offers a quasi-automated method to derive the plan location and depth estimation of buried Ferro-metallic objects from magnetic data. Euler's homogeneity equation relates the magnetic field and its gradient components to the location of the source with the degree of homogeneity expressed as a structural index, (Thompson, 1982). Thompson Developed the technique and applied it to profile data. developed the technique more widely used version for grid-based data. Also recent improvements on the technique had occurred which included the estimation of the structural index (Barbosa and Medeiros, 1999). (Hansen, and Suciu, 2002) Developed a multiple-source generalization of Euler deconvolution, which is capable of handling complex systems that the single-source algorithm can only deal with approximately. (Dawi, *et al*, 2004; Kirkham and Hildenbrand,2002)

The advantages of this technique over more conventional depth interpretation methods (i, e. characteristic curves, inverse curve matching, etc...), are that no particular geological model is assumed, and that the deconvolution can be directly applied and interpreted even when particular model, such as prism or dyke can not properly represent the geology.

2-2) Theory of Euler Equation:

Euler's homogeneity relationship for magnetic data can be written in the form:

$$(x-x_0)\frac{\delta T}{\delta x}+(y-y_0)\frac{\delta T}{\delta y}(z-z_0)\frac{\delta T}{\delta z}=N(B-T)$$

where(x_0, y_0, z_0) is the position of the magnetic source whose total field (T) is detected at (x, y, z,).

B is the regional magnetic field. *N* is the measure of the fall-off rate of the magnetic field and may be interpreted as the structural index (SI). The structural index (SI) defines the type of target used in the Euler deconvolution procedure. Structural indexes can be used for many various geological situations. A sill edge, dike, or fault with a limited throw is best displayed with an index of 1.0, while a fault with large throw is best displayed with a zero index /Reid *et al*. 1990/. Although the structural index approach to source description does not include irregular boundaries, irregular sill-like bodies can be well delineated by the Euler method with an index of 1.0, while irregular contacts are well shown with a zero index (Reid *et al*. 1990).Table 1-1 displays some examples of magnetic targets relevant to geological interpretation and their corresponding structural indices.

Table 1-1: Magnetic targets and the corresponding structural indices.

Magnetic target	Structural index (SI)
Sphere	3
Cylinder	2
Pipe	2
Sheet	1
Sill	1
Step	0.5
Contact	0

3) New approach:

In Euler deconvolution method that is used to estimate the depth and the form of anomaly, gravity and magnetic resources, the value of two factors of Structural Index (SI) and the width of Moving window size (Wsize) is not clear to the commentator and he may use primary information of geology, rule thumb or his experience for determining these values in some cases. In this paper in spite of previous works that were mentioned in the introduction, two loops are included in codes written in Matlab language. In the first loop all values of Structural Index (SI) of sets of o -3 values with the increase rate of ./5 is included and in the second loop all values of Moving window size (Wsize) – odd values of 3-19 with the increase rate of 2 is included. All

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the possible depths ,x location and y location is extracted. By drawing the histogram of all Z ,x and y values we will see that accepted values will have the most frequency regarding the depth of model. The result holds true for both models and we can even say that it estimates the depth with an inaccuracy of less than 10 %. We suppose that acquired data from is away from noises or errors.

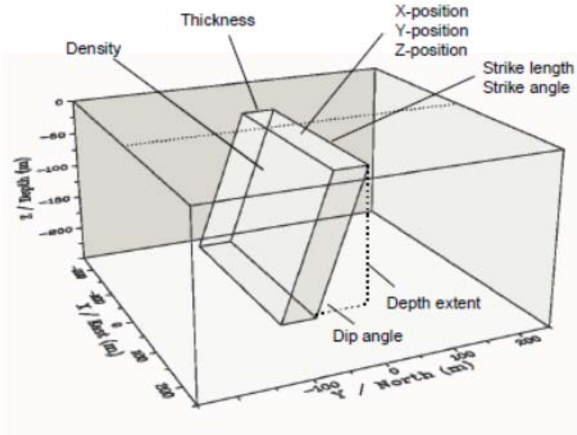

Fig. 1: The parameters of a dipping prism model.

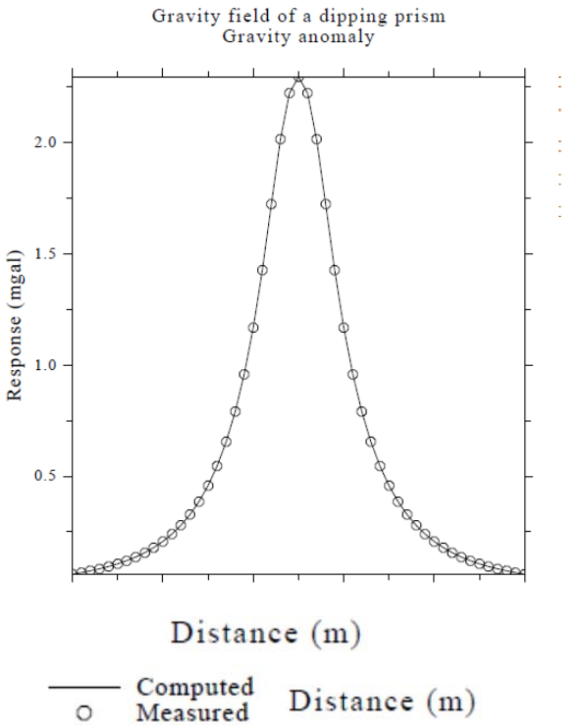

Fig. 2: Gravity field of a dipping prism Gravity anomaly.

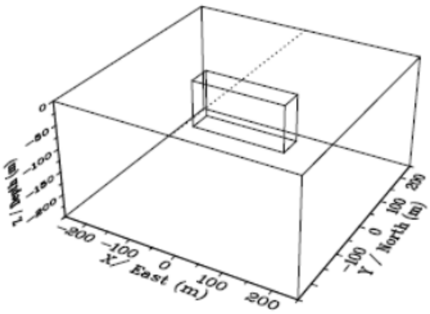

Fig. 3: Model parameters.

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Thick = 50.0 Length = 200.0 Height = 100.0
X-pos = 0.0 Y-pos = 0.0 Z-pos = 20.0
Dip = 90.0 Strike = 0.0
Dens. = 2.500 X-start position -250 Y-start position 0
X-end position 250 Y-end position 500

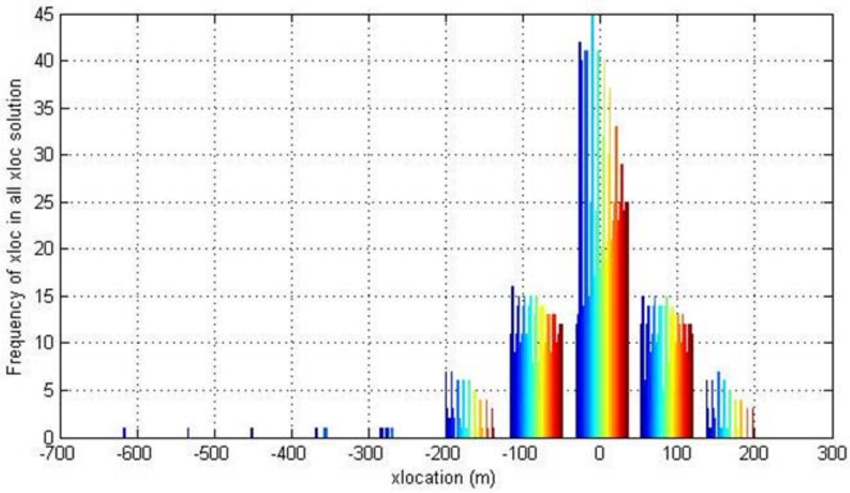

Fig. 4: Histogram of x location values for model.

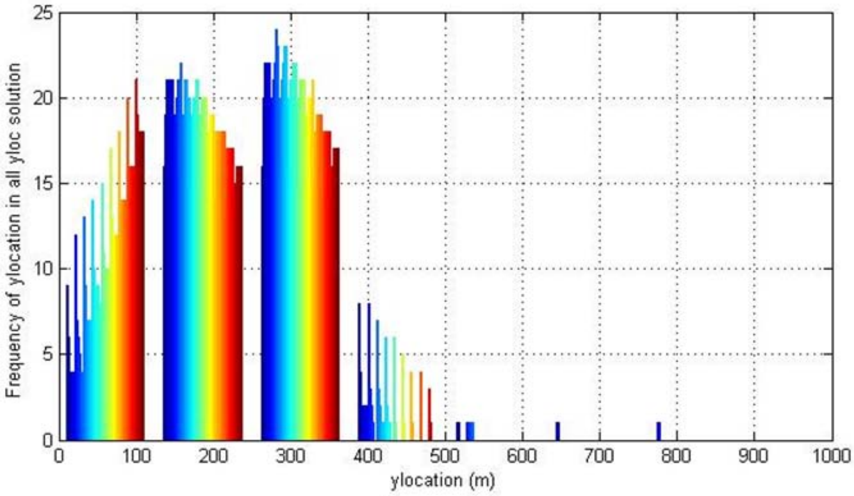

Fig. 5: Histogram of y location values for model.

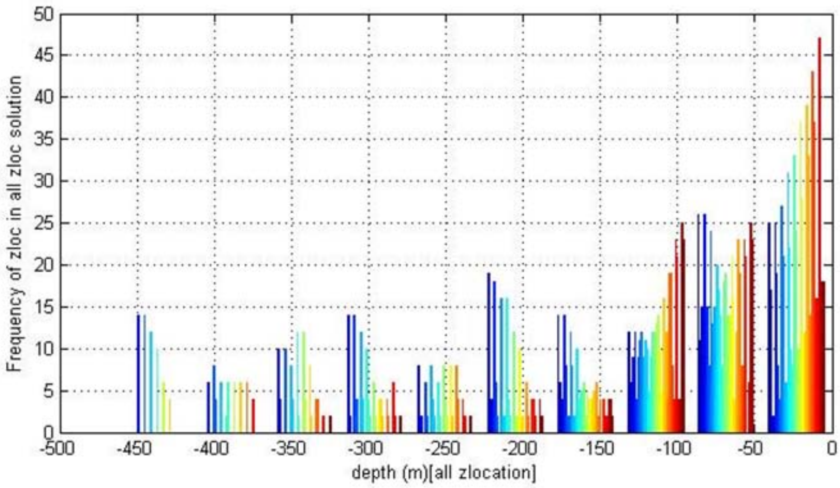

Fig. 6: Histogram of z location values for model.

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Conclusion:

Euler deconvolution method is used for rapid interpretation of potential field (magnetic and gravity) data. It is particularly good at delineating contacts and rapid depth estimation. This technique is belong to automatic depth estimates methods and, is designed to provide computer-assisted analysis on large volumes of magnetic and gravity data. All the possible depths of two-dimensional Euler deconvolution are extracted. By drawing the histogram of all Z values we will see that accepted values will have the most frequency regarding the depth of model. The result holds true for both models and we can even say that it estimates the depth , xloc and yloc with an inaccuracy of less than 10 %.

* The algorithm represented within the previous section has been implemented in MATLAB so as to assess its performance. The MATLAB code is obtainable, upon request, from the authors.

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