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Interpretation of Magnetic Anomaly data over East Basuria region using an Enhanced Local Wavenumber (ELW) Technique

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Summary

The present study deals with the total magnetic field anomaly data that can be interpreted to compute the depth and horizontal location and geometry of causative magnetized sources using enhanced local wavenumber (ELW) method. Enhanced local wave number is based on the use of the traditional local wave number field and it`s phase-rotated version, the rotated version, the vertical local-wave number field. These combinations allow us to determine the horizontal location and depth of two dimensional magnetic bodies. Using the estimated source location parameter, a value for structural index, characterizing the source geometry is determined using the relation between structural index and Enhanced local wave number. Therefore, the source geometry is estimated by computing the structural index from previously estimated depth and horizontal location. The ELW method has been applied to the total magnetic field anomaly over a part of East Basuria region,Jharia coalfield,India.The results simplifies the presence of faulted basement which have finite vertical offset.

Keywords*: Local wave number, source geometry, structural index, magnetic interpretation*

Introduction

A local phase has been derived from complex analytical signal (Nabighian, 1972) and defined as

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

where $\delta M/\delta x$ *and* $\delta M/\delta z$ are the derivatives of total magnetic field in the x and z directions. Local wave numbers can be defined in terms of horizontal and vertical derivatives by taking the rate of change of local phase with respect to the x and z directions as:

$$k_x = \frac{\partial\theta}{\partial x} = \frac{1}{|A|^2}\left(\frac{\partial^2 M}{\partial x\,\partial z}\frac{\partial M}{\partial x} - \frac{\partial^2 M}{\partial x^2}\frac{\partial M}{\partial z}\right)\dots \quad (2)$$

and

$$k_z = \frac{\partial\theta}{\partial z} = \frac{-1}{|A|^2}\left(\frac{\partial^2 M}{\partial x\,\partial z}\frac{\partial M}{\partial z} - \frac{\partial^2 M}{\partial z^2}\frac{\partial M}{\partial x}\right)\dots \quad (3)$$

where $|A|^2$ is the amplitude of the analytical signal is defined as :

$$|A| = \sqrt{\left(\frac{\partial M}{\partial x}\right)^2 + \left(\frac{\partial M}{\partial z}\right)^2} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (2)$$

The k_x and k_z over simple sources (such as contacts,thin dikes and horizontal cylinders), with horizontal location x_0 and z_0 is given by :

$$k_x = \frac{-(\eta+1)(z-z_0)}{(x-x_0)^2 + (z-z_0)^2} \quad \dots \quad \dots \quad \dots \quad \dots (5)$$

and

$$k_z = \frac{(\eta+1)(x-x_0)}{(x-x_0)^2 + (z-z_0)^2} \quad \dots \quad \dots \quad \dots \quad \dots (6)$$

where N is a parameter characterizing the source geometry and also known as structural index in the Euler deconvolution method and derived values of N shown in Table 1 are from

Table 1: Structural index values (N) for magnetic field data (2)

Source Geometry	Structural index (N)
Sphere	3
Horizontal cylinder	2
Fault for small throw	1
Fault/step for finite offset	0.5
Fault for large throw	0

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By dividing eq 5 by 6 we get

$$k_x x + k_z z = k_x x_0 + k_x z_0 \quad \text{.....(7)}$$

This equation is a simple linear equation without involving N and can be solved for the source position(x_0, z_0) using conventional methods of matrix inversion. If the total field anomaly is measured on ground surface, then z will be zero.

The above equation independent of the structural index, is valid for a contact , a dyke and a horizontal cylinder. From hindsight ,we may generalize that the above equation is valid for any type of source geometry and measured field satisfying the two dimensional Laplace equation.

Geological Background

East basuria is located in the northern part of Jharia coalfield at a distance of about 6 km from the Dhanbad city, Jharkhand, India. The present study are lies between the coordinates 23°47'34" N to 23°47'53" N latitude and 86°21'59" E to 86°22'16" E longitude. All the working coal seams lie in the Barakar formation of Lower Gondwana group rocks of Early Permian age. The rocks of Barakar formation comprises predominantly of sandstone of variable grain size, intercalation of sandstone and shale, grey and carbonaceous shales and coal seams. The general strike of the formation is E-W and dip of the coal seam varies from 10°-15° towards south direction. The location map of East basuria colliery along with generalized geological map of Jharia coalfield is shown in Fig.1.

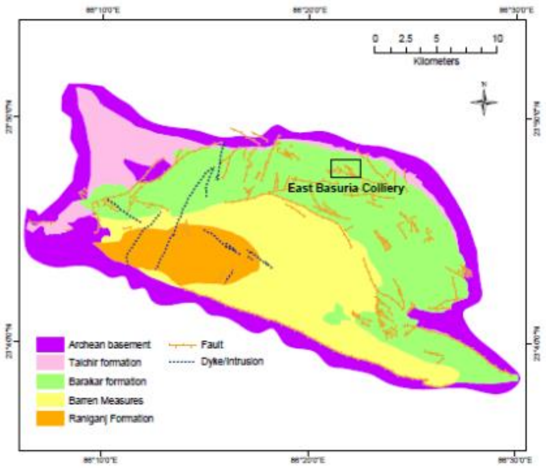

Fig.1 Location map of the study area(East Basuria Colliery) along with generalized geological map of Jharia Coal field

Methodology

A simple procedure is used to automate this method and cancels solution from false anomalies. In this method, the sources are first detected at the location of the local wave number peaks k_x. Then the ELW is applied using a selected field data points around each peak to estimate the source location parameters(x_0,z_0). The choice of the no. of used data points is a function of the width of the peak, the data quality, and the degree of interference of anomalies from nearby sources. For isolated anomalies, a large number of data points can be used to overcome the effect of noise. For multiple neighbouring sources, a smaller number of data points is appropriate to reduce interference effects. The values of source parameters (x_0,z_0) is accepted if the estimated structural index lies close to the range of the 2D magnetic bodies(02)(Thompson,1982; Reid et al., 1990). Noise and errors may shift the indices from the ideal image. Therefore, the acceptance range may slight expanded (i.e from 0.2-2.2).

Results and Discussions

In present study, detailed magnetic survey have been carried out for the better understanding of magnetic field characterstics of East basuria colliery using proton precession magnetometer .Total magnetic field intensity has been measured with the sensitivity of 0.15 nT/Hz and 0.2 nT absolute accuracy. The diurnal correction have been applied on recorded magnetic readings. Then the derived data have been processed to generate the total magnetic field anomaly map of East basuria region. The total magnetic anomaly map of the study area has been shown in Figure2a. Total magnetic field distribution along profile AA/ have been shown in Fig. 2b.

Fig 3 shows local wave number field k_x calculated from eq.2. It should be noted that k_x has instabilities, caused by derivative curves from Fig 3b at the beginning and the end of the profile.

We use only a single window11 point of selected data points closed to k_x and magnetic peak location. Results of ELW method indicate that a source at a horizontal location of 5.609 km, a depth of 5.307 and the standard deviation in structural index by horizontal, K_x=0.216 and K_z = 0.487 denotes the presence of faulted basement with vertical offsets. By substituting these values in Eq.5, the variation of N can be determined at the measuring points. Based on this analysis, the anomalous source corresponding to the structural index of 0.5 is determined as a finite-offset fault or contact with vertical offset.

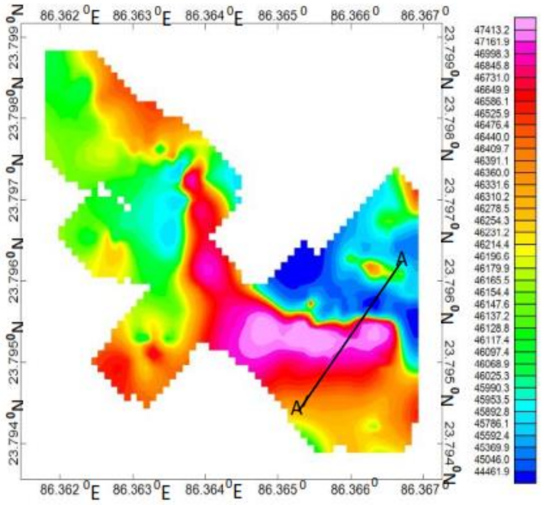

Fig.2a Total magnetic field anomaly over East Basuria colliery

Fig.2b Magnetic anomaly distribution along Profile AA'.

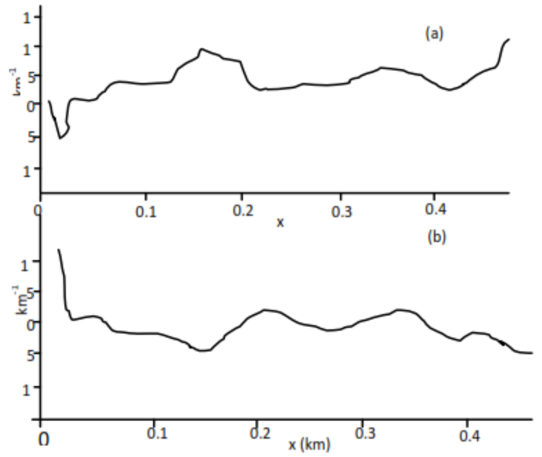

Fig.3 Local wave number field k_x and k_z computed from data Set computed from Fig. 3.

Conclusions

The ELW technique for magnetic data interpretation across 2D source structures that uses simultaneously two complementary first-order local wave number. More importantly,

ELW provides a generalized equation to estimate the horizontal location and depth to source without any assumption on the nature of source geometry, susceptibility contrast, etc. The nature of the sources is subsequently determined using the source position parameters.

The present paper deals with magnetic field data over a part of the Jharia coalfield which is contaminated with noise, which leads to errors in the anomaly values that will be mapped into solutions.

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