Estimation of sedimentary thickness in eastern Anambra basin by qualitative and quantitative interpretation of Aeromagnetic data

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ABSTRACT

Aeromagnetic data over Eastern Anambra basin was assembled, filtered and interpreted to determine the sedimentary thickness details in the study area. Data digitizing was performed to reduced flight noise and for data enhancement and processing. The enhancement of magnetic anomalies associated with fault and other structural discontinuities was achieved by the application of band pass filter. The residual was obtained by separation of regional field from magnetic field by method of linear regression analysis. Qualitative interpretation was done by visual inspection of the anomaly contour map while quantitative interpretation was estimated using Peters' half slope method. Interpretation of the results show that the floor of the basin is characterized by block faults whose widths lie between 15 and 45km, trends in Northeast-Southwest and East-West direction with average sedimentary thickness of 4.56km.

Keywords: Aeromagnetic data; Sedimentary thickness; Peters' half slope
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INTRODUCTION

Magnetic and gravity survey data have been used to provide information on the nature and form of the crystalline basement. Estimation of magnetic basement depth beneath sedimentary cover has been known as one of the key functions of aeromagnetic survey and its interpretation. Sedimentary rocks, in general, have low magnetic properties compared with igneous and metamorphic rock that tend to have a much greater magnetic content. Thus, most aeromagnetic surveys are useful to map structure of the basement and intruded igneous bodies from basemen complex, Essam *et al.,* [1]. Airborne geophysical survey reflects the variations in the distribution and type of magnetic Mineral below the earth surface, Onyedim *et al,* [2]. Many works have been carried out in other parts of Nigeria on analysis of aeromagnetic data; these include that of Onwuemesi [3] who applied 1D spectral analysis to aeromagnetic anomalies in the Anabra basin, Anakwuba *et al.,* [4] used spectral methods to interpret aeromagnetic anomalies over Maiduguri-Dikwa depression of Chad basin. Chinwuko *et al.,* [5]. also applied spectral analysis to evaluate aeromagnetic anomalies over parts of Upper Benue Trough Southern Chad basin, Nigeria, Onyewuchi *et al,* [6] determine magnetic basement depth, delineate basement topography, determine trends of deformation and determine whether Okposi brine Lake is structurally controlled. The study involves qualitative and quantitative interpretation of aeromagnetic data of Eastern part of Anambra basin. This method has an advantage over other geophysical methods because it has the ability to filter all the noise away from the data, information is not lost during the process, and in many cases, operations are easier to perform in the transform domain Telford *et al.,* [7]. Digitization of the aeromagnetic maps, separation of magnetic data and production of magnetic anomaly map, production of the first vertical derivative of the total field and analysis of magnetic anomaly data amongst others were carried out. The aim of the study is to determine depth to basement (sedimentary thickness) by quantitative interpretation of aeromagnetic data.

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1.1 THE LOCATION AND GEOLOGY OF THE AREA
The study area is shown in Fig. 1, it is located in the Eastern Anambra Basin Nigeria within latitude 6°00N' to 6°30'N and longitude 7°30'E to 8°00'E. The geological map of the study area (Fig.1) clearly shows that the study area is entirely underlain by sedimentary rocks which belong to the Asu river group of Albian age, Petters, [8]. This group comprises of bluish black shale with minor sandstone units. The shales are fissile and highly fractured. Akande and Mucke [4] reported the presence basinal brine in the Asu River Group. Around Abakaliki, the shales are associated with pyroclastic rocks. This group overlies the basement complex.
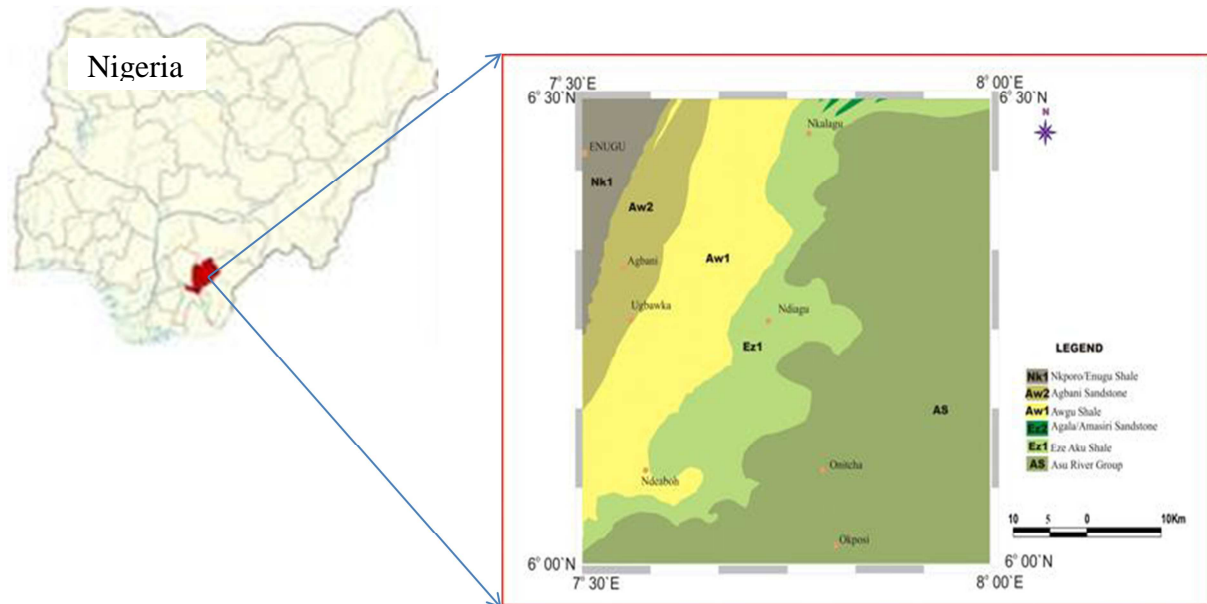

Figure 1: Geologic Map of the study area (adapted from Nigerian Geological Survey map, sheet 302)

MATERIALS AND METHODS

2.1 AEROMAGNETIC DATA
The aeromagnetic data used were filtered using a low pass filter. The nature of filtering applied to the aeromagnetic data in this study in the Fourier domain was chosen to eliminate certain wavelengths and to pass longer wavelengths. These filters are considered most useful for defining the edges of bodies and for amplifying fault trends. Geosoft Oasis Montaj 6.4.2.HJ version and Surfer 10 used in the interpretations of the aeromagnetic map. Regional - residual separation was carried out using polynomial fitting. The magnetic anomalies associated with faults and other structural discontinuity was achieved by the application of band pass filter (Fig 2). This is a purely analytical method in which matching of the regional by a polynomial surface of low order exposes the residual features as random errors. For the magnetic data, the regional gradients were removed by fitting a plane surface to the data by using multi- regression least squares analysis. The regional trend is represented by a straight line, or more generally by a smooth polynomial curve. The fitting of polynomials to observed geophysical data is used to compute the mathematical surface giving the closest fit to the data that can be obtained within a specified degree of details. This surface is considered to approximate the effect of deep seated or regional structures if it of low degree. Average depth values to buried magnetic rocks using the power spectrum of total intensity field were achieved using Peters half slope method. The method allows an estimate of the depth of an ensemble of magnetized blocks of varying depth, width, thickness and magnetization. The slopes of the segments yield estimates of average depths to magnetic sources of anomalies.

2.2 PETER'S HALF SLOPE METHOD
Peters, [9] was probably the first to relate depth of magnetic source to the horizontal extent of the portion of sloping flanks of his profile curves. Graphical techniques make use of the sloping flanks of profile as illustrated in (Fig. 3) to estimate depth (Nettleton, [10]; Telford *et.al.*[7]). Peter's half slope method estimated depth by finding the horizontal distance between lines that pass through the maximum and minimum of an anomaly and have a slope equal to one half of the maximum horizontal gradient of the anomaly. It can work on the cylinder and sphere models. In practice, it is applied widely to a 2D tabular body (dike) that has vertical sides, great depth extent and is with uniform and vertical magnetization. The depth to the top of the body is proportional to the horizontal distance. The proportionality factor varies from 1/1.2 for very thin bodies to ½ for very thick bodies. The Bean ratio method,

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Bean [12] has improved the Peters' half slope method by introducing a regional slope and thus removing the effect of a local regional field. The slope method is a manual method because it works on a single anomaly each time. The approach is to determine two points; points at which lines with half the maximum slope are tangent to the magnetic profile.
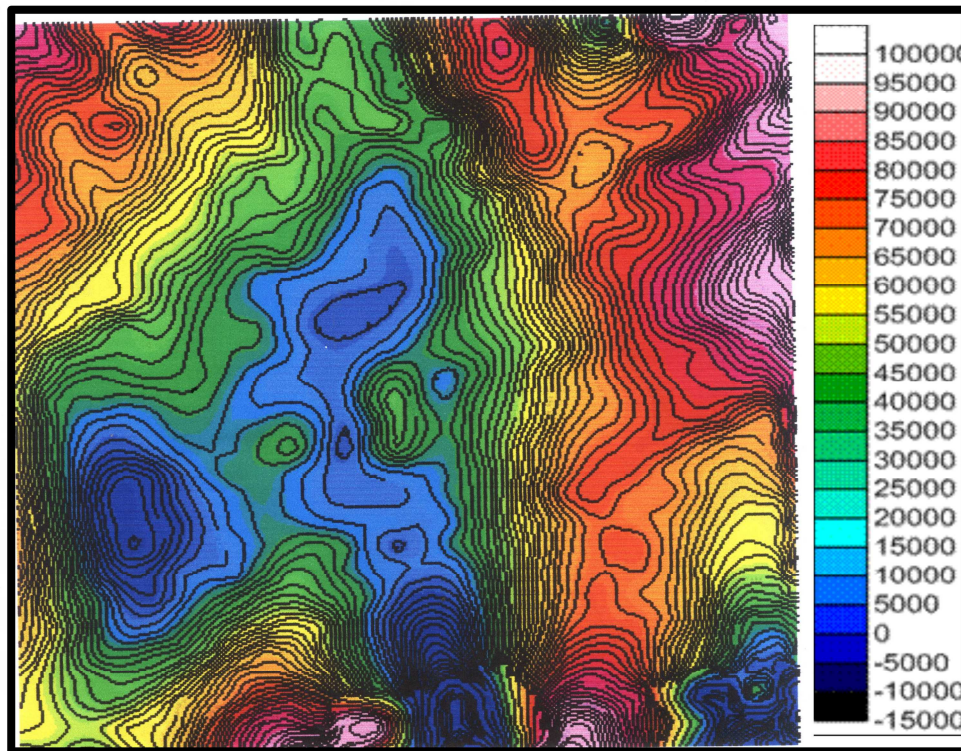

Figure 2: Band pass filtered map

The depth (Z) to the top of the magnetized body; Z = (dcosα)/n

Where d is the horizontal distance between half-slope tangents, 1.2 < n < 2, but usually n = 1.6 and α is the angle subtended by the normal to the strike of the magnetic anomaly and true north.
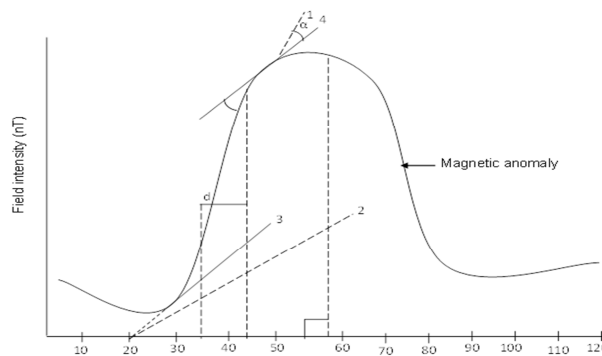

Figure 3: Peters' half slope method of determining the depth to the top of a magnetized body

RESULTS AND DISCUSSION

From the aeromagnetic map digitized along flight lines at 2km intervals, the total field aeromagnetic data of the study area (Fig. 4) was produced as a contour map. The total field of the aeromagnetic data revealed that the underlying basement has magnetic intensity estimated at 7920 gammas. Areas with high magnetic intensity anomalies are seen on the western flank on the study area. The residual contour map (Fig. 5) shows that the positive magnetic anomaly has a relief of 40nT. The magnetic intensity increases eastward. The maximum and minimum values of the residual aeromagnetic anomaly are 40nT and –120nT and the contour interval increases by 20nT. The most dominant trend is in the northeast-southwest direction followed by east-west direction. There is a lateral shift,

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which offset the anomaly contour. This lateral shift may suggest faulting. The floor of the basin is characterized by block faults whose widths lie between 15 and 45km. It is these multiple and intermittent block faults that gave rise to the elongated lobes of magnetic anomalies for the basin (Fig. 5).
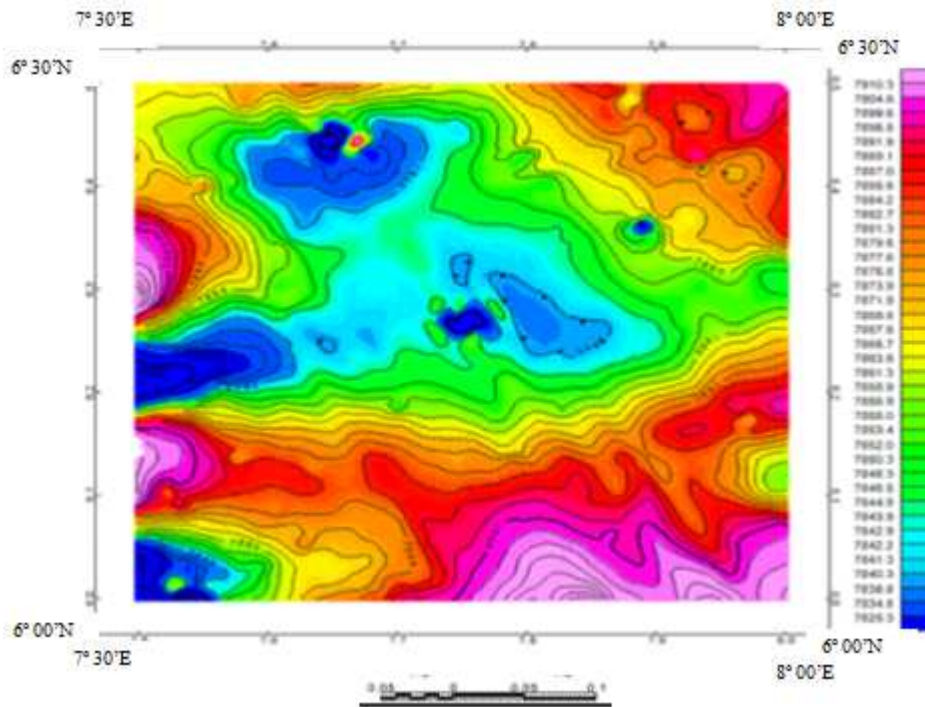

Figure 4: The total field aeromagnetic data of the study area (contoured at 5 gammas interval)
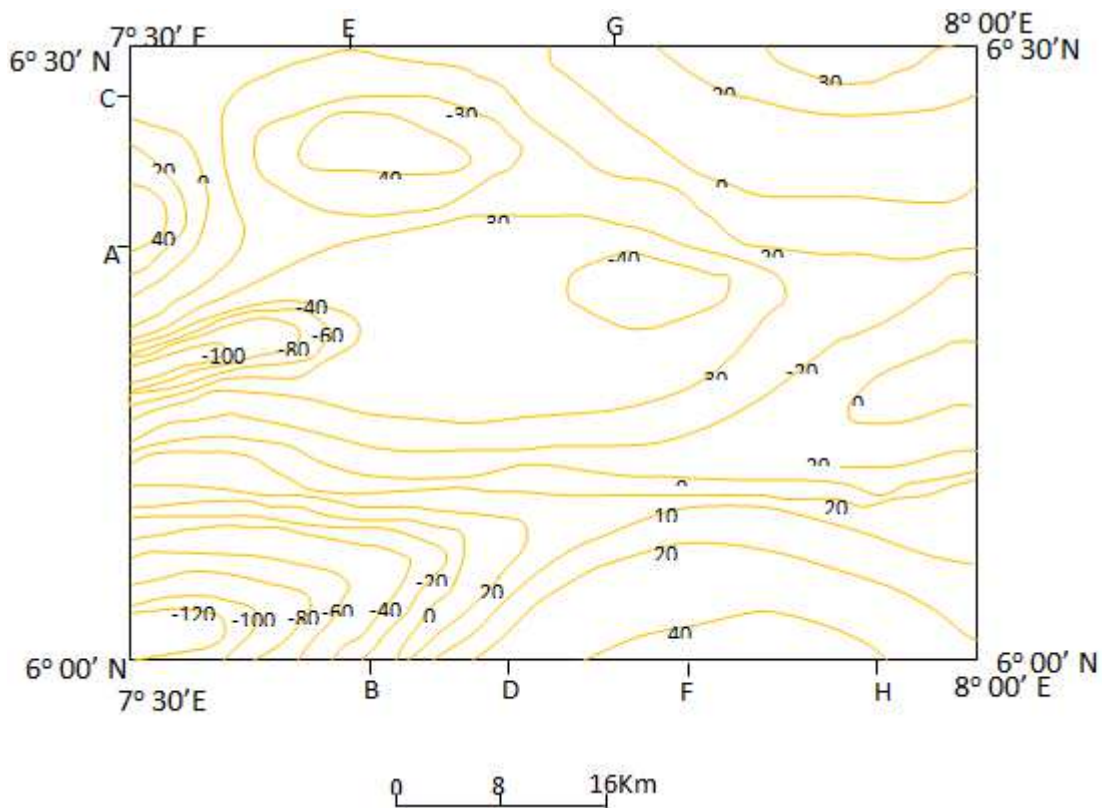

Fig. 5: Residual contour map of the study area. Contour interval ~20nT

The residual contour map above was profiled AB, CD, EF and GH along the most prominent anomaly zones within the study area as shown on the profile map (Fig. 5) for the purpose of magnetic basement depth estimation. The

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plots of the contour values against the distance produced the smooth picked graphs (Fig. 6). Slope method has therefore been employed to quantitatively determine the depth to the anomaly sources. The calculations on table 1 have revealed depth estimates averaging 4.56km as the magnetic basement depth. Offoegbu [13] and other works have equally shown that this area have favourable geological features. More attention should be paid to the Ogbaku and Mberubu area because they have more favourable geologic features and sediments. Osazuwa *et al*, [14] estimated the thickness of sediments in the upper Benue Trough to vary between 0.9km and 4.6km. The NE-SW direction of magnetic contour trend observed from the study agrees with that made by Ajakaiye, [15] for the area which was attributed to the events at the possible opening up of South American and African plate or Pan – African Orogeny trends. The summary of the estimated depth for the four profiles taken are shown on table1 using the half slope method. Additional advantages of these graphs (Fig. 5) is that besides using the quick slope method to estimate depth we could also read off other parameters from the graph and apply host of other graphical methods like: Bean, [11], Stanley, [16]. Profiles A to H (Fig. 5) were taken as follows: Profile [AB], 3.63Km East of Enugu; Profile [CD], 4.10Km South of Mberubu; Profile [EF], 7.00Km North-East of Ogbaku. Profile [GH], 3.50Km Ogbaku (Fig. 6).
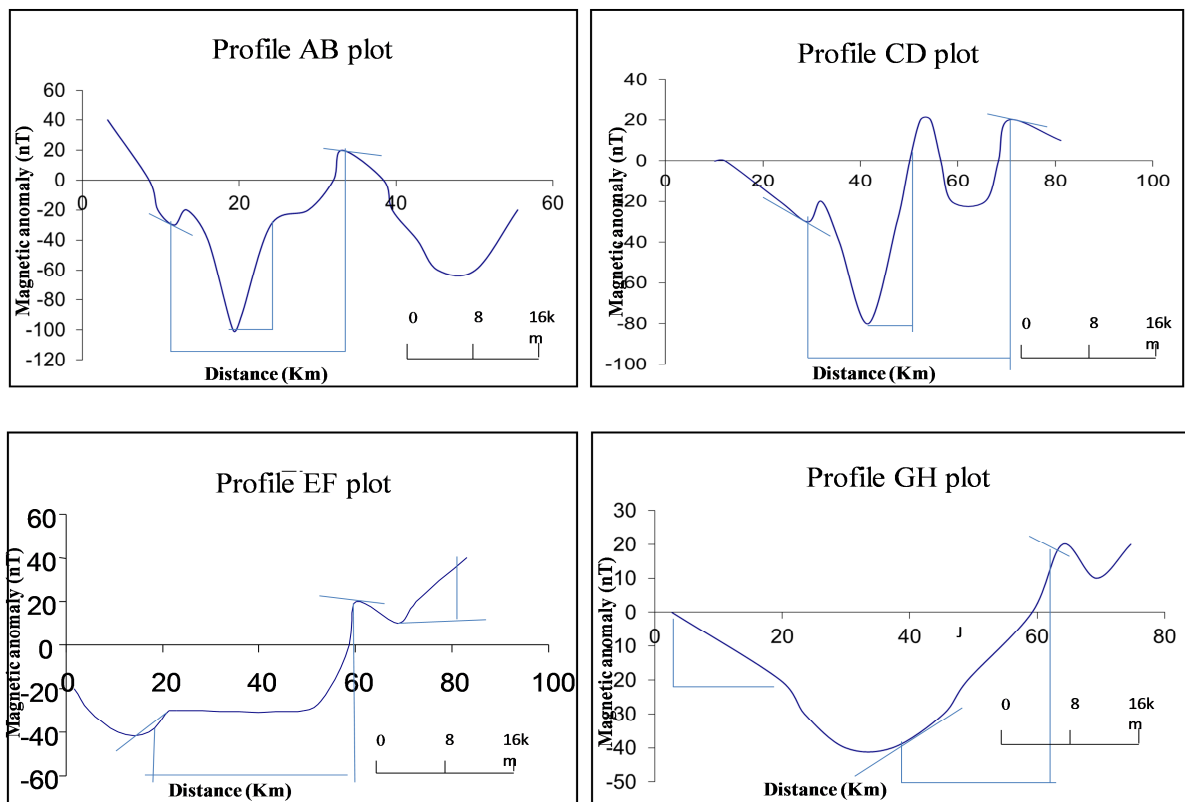

Figure 6: Depth estimations from the sloping flanks of the profile plot

Table1: Summary of depth estimated from the slope method

Profiles	Depth (Km)
AB	3.63
CD	4.10
EF	7.00
GH	3.50
Average	**4.56**

Estimated magnetic basement depth from the slope method = 4.56Km

CONCLUSION

The procedure involved in this study includes separation of the aeromagnetic data, production of the residual anomaly map, and estimation of depths to magnetic sources. The results show a linear depression with thicker sediment accumulation trending NE-SW. The results also reveal that depth to sedimentary thickness is from 3.5 to 7.00 Km which could be associated to near surface magnetic sources that intruded into the magnetic bodies within the sedimentary cover.

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