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Spectral Analysis of the Residual Magnetic Anomalies Overpategi and Egbako Area of the of the Mddle Niger Basin, Nigeria

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Abstract

Statistical spectral analysis of theresidual magnetic field was employedto determine the depth to magnetic basement rocks withinPategi and Egbako areas which is part of the lower Middle Niger basin. The study area lies within latitudes 8.30^0 and 9.30^0 North and longitudes 5.30^0 and 6.00^0 East. For the purpose of this analysis, the study area was divided into 15 rectangular sections. The spectral analysis reveals two prominent layers; the first layer depth varies from 0.28km to 0.89km with an average value of 0.59km while the second layer depth varies from 1.55km to 4.70km.The first layer is attributed to lateritic ironstone,Ferruginoussandstone and effect of the surrounding basement rocks while the second is attributed to magnetic rocks intruded into the basement surface, lateral discontinuities in basement susceptibility and intra basement features such as faults and fractures. The second layerrepresents the average thickness of the sedimentary formation overlying the basement complex within the Pategi and Egbako areas of the Middle Niger basin. This depth increases thepossibility of hydrocarbon potential.

Keywords: spectral depth, buried magnetic rocks, magnetic data

INTRODUCTION

The study area is part of the sedimentary Middle Niger basin, is bounded by latitude 8.30^0 to 9.30^0 North and longitude 5.30^0 to 6.0^0 East situated in the west of central Nigeria (Fig 1).The basin is also known as the Nupe Basin and is believed to be a gentle down warped shallowtrough filled with campanian – maestrichtian marine to fluviatile strata. The geology of the basin is well documented by Jones (1948) Adeleye (1971, 1973, 1974, and 1976). Murat (1972) reported that epeirogenesis responsible for the genesis of the basin seems closely connected to the crustal movement of the santonian-orogeny of south western extension of Anambra basin which is in the east, both of which were major depocenters during the second major sedimentary cycle of southern Nigeria in upper cretaceous time, Udensi,et al (2003).

Source of Data for the present study

Two aeromagnetic map sheets numbers 204 and 183 that cover Pategi and Egbako respectively were used. These maps were produced by the Nigeria Geological Survey Agency (NGSA) which undertook the aeromagnetic survey of substantial part of Nigeria between 1974 and 1980. The data was collected at a nominal flight altitude of 152.4 along N-S flight lines spaced approximately 2km apart. The maps are on a scale of 1:100,000 and half degree sheets contoured mostly at 10nT interval. A correction based on the International Geomagnetic Reference Field (IGRE) epochdatedJanuary 1, 1974 was applied to all data.

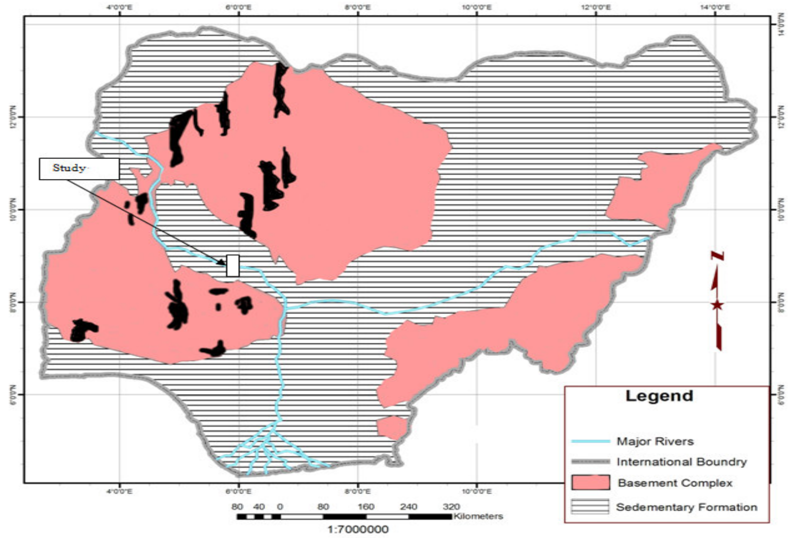

FIG 1. :DETAILELD GEOLOGICAL MAP OF NIGERIA SHOWING THE STUDY AREA (PATEGI AND EGBAKO)

PROCEDUREThe Pategi and Egbako map were digitized manually on a 19 by 19 grid system

The digitized maps were combined into a single “super map” or composite aeromagnetic map. This super map for the study area forms the basis for further analysis and interpretation.

Depth to the magnetic layers was determined using statistical spectraldepth analysis of the residual magnetic field. Results of depths obtained from spectral analysis were used to produce contour maps for the study area.

Surface plots were also produced this will indicate areas of relative surface depression and uplifts. Each map was digitized on a 1.5 by 1.5km^2 grid system .This spacing imposes a Nyquist frequency of 1/3km^{-1},thus the narrowest magnetic feature that can be defined by the digitized data has a width of 3km. Previous studies with crustal magnetic anomalies (Hall, 1968 and, Udensi,2001) shows that this spacing is adequate for the portrayal of interpretation of magnetic anomalies arising from regional crustalstructure range much wider than 6km and therefore lie below the frequency range for which computational errors arising from aliasing do not occur.. A computer package “SURFER” was used to contour the data at an interval of 10nT to produce the composite aeromagnetic map (super map) of the study area.

STRUCTURAL TREND

The composite aeromagnetic map (Fig. 2) contoured at an interval of 10nT exhibits the NW-SE

Trend throughout the study area.Udensi (2001) and other previous researchers identified such trends as in the present study.

Several magnetic closures exists in the study area, the closures of magnetic lows are indicated with letter L, while magnetic highs are indicated with letter H. In the composite aeromagnetic map (Fig.2), no major discontinuity was observed except two short discontinuities which close observation reveals that one is below latitude 8.90^{0}and runs NE –SW and another below latitude 9.00^0 that runs E-W cutting the map into two .They are indicated by XX^1 and YY^1, these indicate that a short fault zone exists within the basement underlain by the area.

REGIONAL – RESIDUAL SEPARATION

The least square method was then applied to separate the residual anomalies from the regional background. Because of the simple nature of the geology of the area and its limited spatial extent the least Square Method becomes very handy and adequate. We then assume that the regional field is a first degree polynomial surface. The entire regional field was therefore calculated as a two dimensional first degree polynomial surface. The residual magnetic values was obtained by subtracting regional field from the total magnetic value at the grid cross points. The residual map is presented as fig 3 and shows that the magnetic residual values ranges from -40nT to 50nT .

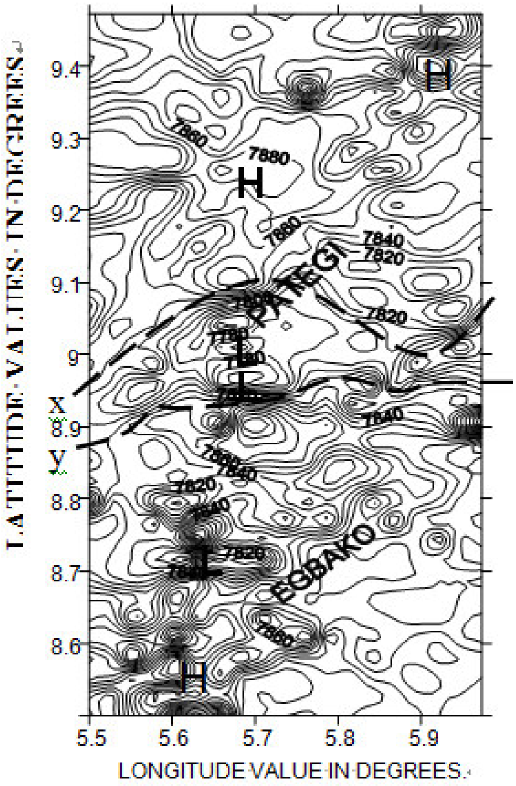

Fig 2 AEROMAGNETIC MAP OF PATEGI AND EGBAKO AREA CONTOURED AT AN INTERVAL OF 10nT SHOWING MAGNETIC LOWS (L) AND HIGHS (H)

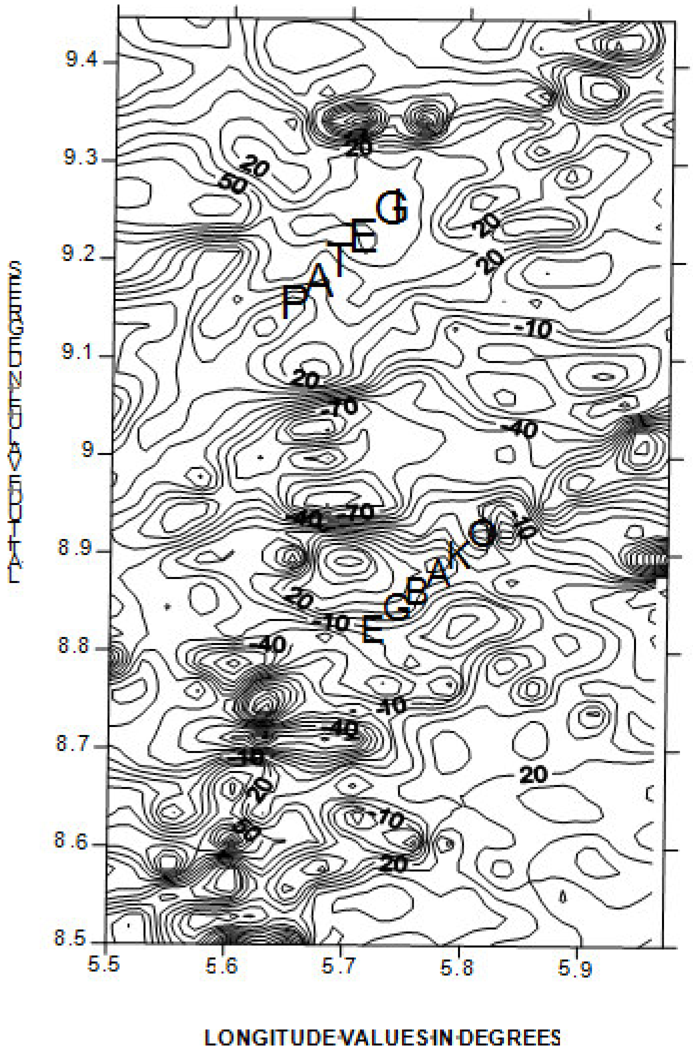

FIG 3: RESIDUAL MAGNETIC MAP OF PATEGI AND EGBAKO AREA CONTOURED AT AN INTERVAL OF 10nT

SPECTRAL ANALYSIS

Limiting depth is the most important parameter derived by direct interpretation and thus may be deduced from magnetic anomalies by making use of their property of decaying rapidly with distance from source, (Keary and Brook 1989). Magnetic anomalies caused by shallow structures are more dominated by high wave number components than those resulting from deeper source. This effect may be quantified by computing the power spectrum of the anomaly since the long power spectrum has a linear gradient whose magnitude is dependent upon the depth of the source, (Spector and Grant 1970).Such techniques of spectral analysis provide rapid depth estimates from regular spaced digital field data, no geomagnetic or diurnal corrections are necessary as these removes only low wave number components and so not affect depth estimates which are controlled by high wave numbers components of the observed field. In particular the statistical approach has been found to yield good estimates of mean depth to the basement underlying a sedimentary basin, (Treadle et al 1971), (Hahn et al 1976)and Udensi (2001).

In this research the characteristic of the residual magnetic field over Pategi and Egbako area of the Middle Niger Basin (Fig 3) were studied using statistical spectral method. This was achieved by first transforming from space to frequency domain and then analyzing the frequency characteristics. The study area was divided into fifteen sections (15) for the purpose of spectral depth determination. The sections and locations of the first and second layer spectral depths are shown as H_1 and H_2 respectively in Table 1. Graphs of the logarithm of the spectral energies against frequencies for sections 1and 2 are presented in Fig 4.The depth to the basement contour map (Fig 5) shows a maximum depth of 4.7km

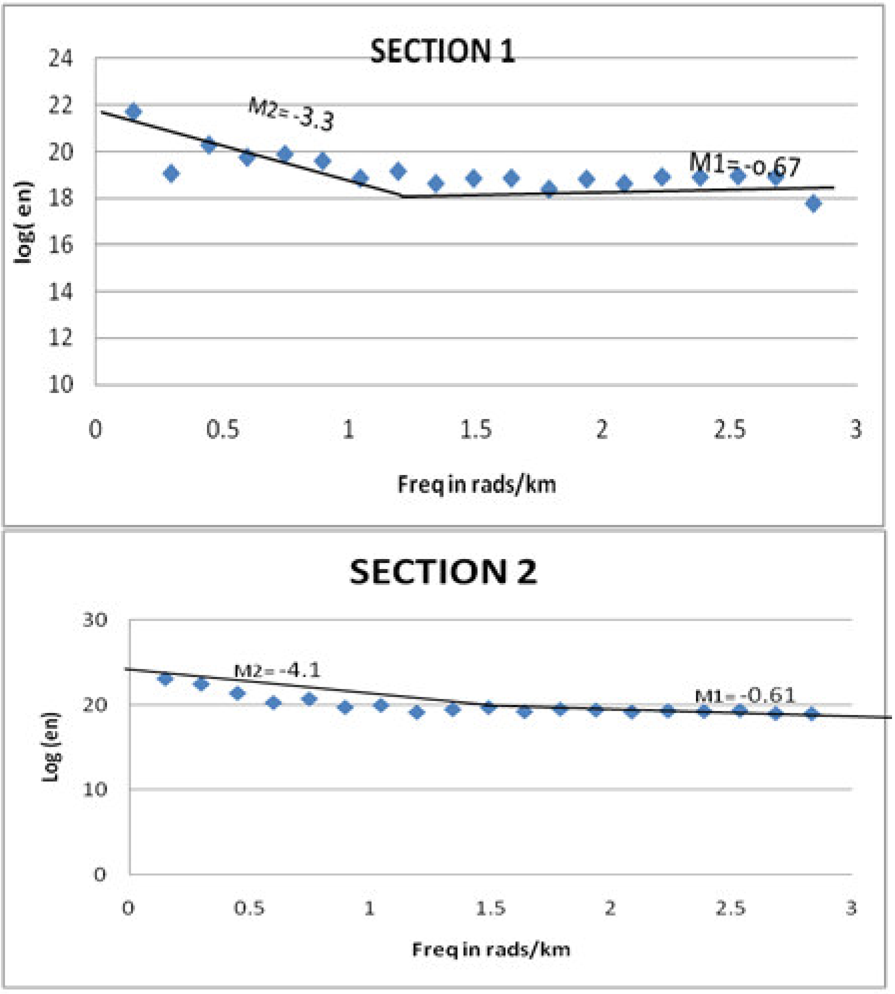

Fig 4: Energy Spectral of Section 1 and 2

TABLE 1: LOCATION AND MAGNITUDE OF FISRT AND SECOND SPECTRAL DEPTHS

SECTION	LONGITUDE	LATITUDE	DEPTH H_1(KM)	DEPTH H_2(KM)
1	5.75	8.75	0.335	1.65
2	5.75	9.25	0.305	2.05
3	5.75	8.95	0.55	4.7
4	5.75	8.85	0.61	3.35
5	5.625	8.75	0.65	3
6	5.975	8.875	0.505	2.65
7	5.725	8.775	0.4	2.35
8	6.025	8.635	0.39	3.25
9	5.625	8.875	0.395	2.35
10	5.625	9.25	0.285	2.45
11	5.975	8.75	0.325	2.75
12	5.75	8.625	0.59	2.05
13	5.725	8.725	0.55	1.55
14	5.775	8.75	0.445	2.25
15	5.875	9.2	0.89	2.85

DISCUSSIONS

The result of the spectral analysis of the aeromagnetic data over Pategi and Egbako identified two main magnetic horizons under the area; the deeper source are represented by low frequency segments of the spectrum, while the shallower magnet sources are represented by the high frequency segment of the spectrum.

The value of the second layer depth, H_2 obtained (Table 1) was used to produce the contour map of the second layer spectral depth, (Fig 5) and the surface plot for the second layer (Fig)6 which was used for interpretation. The first layer, which is of shallower magnetic sources brought out by the above analysis, can be attributed mostly to lateritic ironstone capping and the effect of surrounding basement magnetic rocks. The second layer which is of deeper sources may be attributed to magnetic rocks that intrude unto the basement surface. Another probable origin of the magnetic anomalies contributing to this layer is lateral variations in basement susceptibilities features like fault and fractures (Kogbe, 1981).In either case we can reasonably deduce that the H_2 values obtained from the above spectral analysis represent the average depth of the basement complex in the section considered.

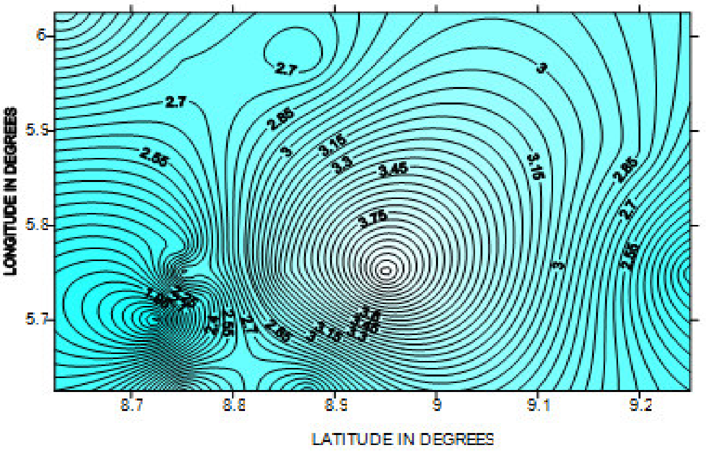

Fig 5: CONTOUR MAP OF SECOND LAYER DEPTH CONTOURED AT 0.05KM INTERVAL

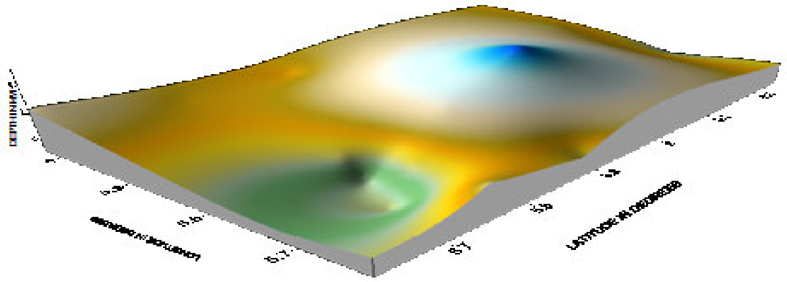

Fig 4..4 : SURFACE PLOT MAP OF THE SECOND MAGNETIC LAYER OF THE STUDY AREAS

CONCLUSION

Result of the basement depth estimate in this study is in agreement with the results obtained by Udensi and Osazuwa (2004) which reported average depth to basement rock of 3.39km while the present study estimated an average basement of 3.13km.We therefore make the following conclusions.

The result of this study shows that this part of the middle Niger basin has an average thickness of 3.13km for sediments. One important significance of this result is in its consideration of hydrocarbon potential of the basin. If all other conditions for hydrocarbon accumulation are favorable, and the average temperature gradient of 1^0 C per 30m which obtains in the Niger Delta is applicable then the maximum thickness of sediments to achieve the threshold temperature of 115^0C for the concealment of oil formation from organic remains (Wright et al 1985) would be 2.3km. The result obtained showsthat the prospect for hydrocarbon accumulation may be promising.

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