STRUCTURAL TRENDS AND SPECTRAL DEPTH ANALYSIS OF THE RESIDUAL FIELD OF PATEGI AREA, NIGERIA, USING AEROMAGNETIC DATA

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Abstract

Pategi area is located between longitude 5° 30´E and 6° 00´E and latitude 8° 30´N and 9° 00´N and lies at the southwestern part of the Bida basin in west central Nigeria and is filled with Campanian-Maestrichtian sediments comprising mainly sandstones that are underlain by basement rocks comprising of granite-gneiss and migmatites. The area is covered by one half-degree aeromagnetic map, which was digitized at 1.5 km grid and re-contoured. The compiled magnetic map shows that an approximately NE-SW trending fabric characterizes the upper part of the area down to latitude 8.84°N. This trend changes to largely E-W in the central portion between latitudes 8.63°N and 8.84°N. Below latitude 8.63°N the trend changes again to approximately NE-SW particularly at the southwest fringe of the map. A major lineament depicting the Romanche paleofracture zone was found in the area. The Pategi area has complex magnetic signature. Short to moderately long discontinuities were found in the magnetic map. Several magnetic closures of various sizes were also noticed. While the discontinuities indicate the presence of minor to moderately long fault zones in the area, the closures depict the sizes of the anomalies that lie beneath the basin. Spectral depth determination indicates that the area contains average sediments up to a thickness of 3.27km. A sedimentary thickness of this size may be recommended for further investigation for petroleum exploration. The intra-basin fault zones may have hydrocarbon implication.

Key words: *Magnetic, Bida basin, fault zones, Pategi area.*

Introduction

The study area is located in the Bida Baisn (also called the Middle Niger basin or Nupe basin) in the west-central part of Nigeria. It covers an area of approximately 3025km^2. It is bounded by longitudes 5.50°E and 6.00°E and latitudes 8.50°N and 9.00°N. The area is filled with Campanian-Maestrichtian sediments comprising mainly sandstones and siltstones, which are underlain by the Precambrian rocks of the basement complex (Russ1957, Adeleye 1973 and 1976), Figure 1.

The epeirogenesis responsible for the genesis of the basin seems closely connected to the crustal movements of the Santonian orogeny of south western Nigeria and the nearby Benue Trough. The Basin is filled with past orogenic molasses facies and a few thin marine strata. The original geometry of the basin may have been altered by tertiary uplifts, which seems to have affected the northern half more than the southern half of the basin (Adeleye, 1976). The main type of rock found in the area is sandstone. The basal sediments in the area may be of alluvial fan origin. They are overlain

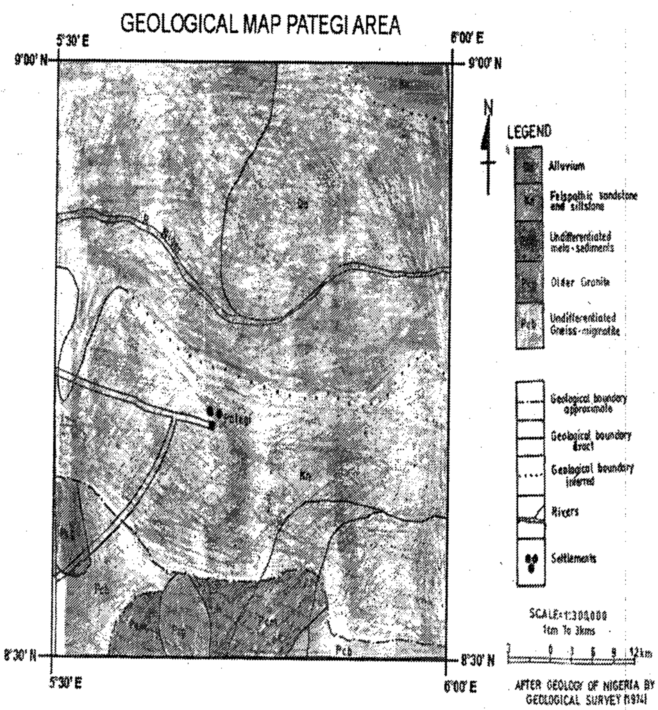

Fig. 1: Geological Map of Pategi
(After Geology of Nigeria by Geological Survey of Nigeria 1974)

By lithology comprising mainly sandstone, shales, subsidiary sandstone, fine conglomerates and siltstones. The layers of sandstone and siltstone exhibit cross bedding. The main mineral found in the area is clay. In this paper the trends of the total magnetic field map are analyzed qualitatively and the characteristics of the residual magnetic field over the area are studied using statistical spectral analysis method.

Procedure

The following procedure was adopted for the study:

(i) The Pategi aeromagnetic map was digitized manually on a 38 by 38 grid system.

(ii) The data were arranged in a contourable form and contoured for further analysis and interpretation of the study area.

(iii) Trends on the magnetic field map were analyzed qualitatively.

(iv) The regional and residual magnetic field maps for the area were determined by fitting a first degree polynomial field to the total data using the Polynomial fitting (least square) method.

(v) Depths to the magnetic layers were determined using statistical spectral depth analysis of the residual magnetic field. Surface maps of depth to the corresponding magnetic layers were produced and analyzed.

Results

Qualitative trend analysis

The reproduced aeromagnetic map of the Pategi area is shown in Figure 2. It shows that an approximately NE-SW trending fabric characterizes the upper part of the area down to latitude 8.84°N. This trend changes to largely E-W in the central portion between latitudes 8.63°N and 8.84°N. Below latitude 8.63°N the trend changes again to approximately NE-SW particularly at the southwest fringe of the map. Of interest in this map is the magnetic lineament identified as A-B and trending E - W. Udensi *et al.*, (2000) identified it as the Romanche paleofracture zone and correlated it with an earlier study by Ajakaiye *et al.*, (1991). It could thus be said that Pategi lies in the Romanche paleofracture zone.

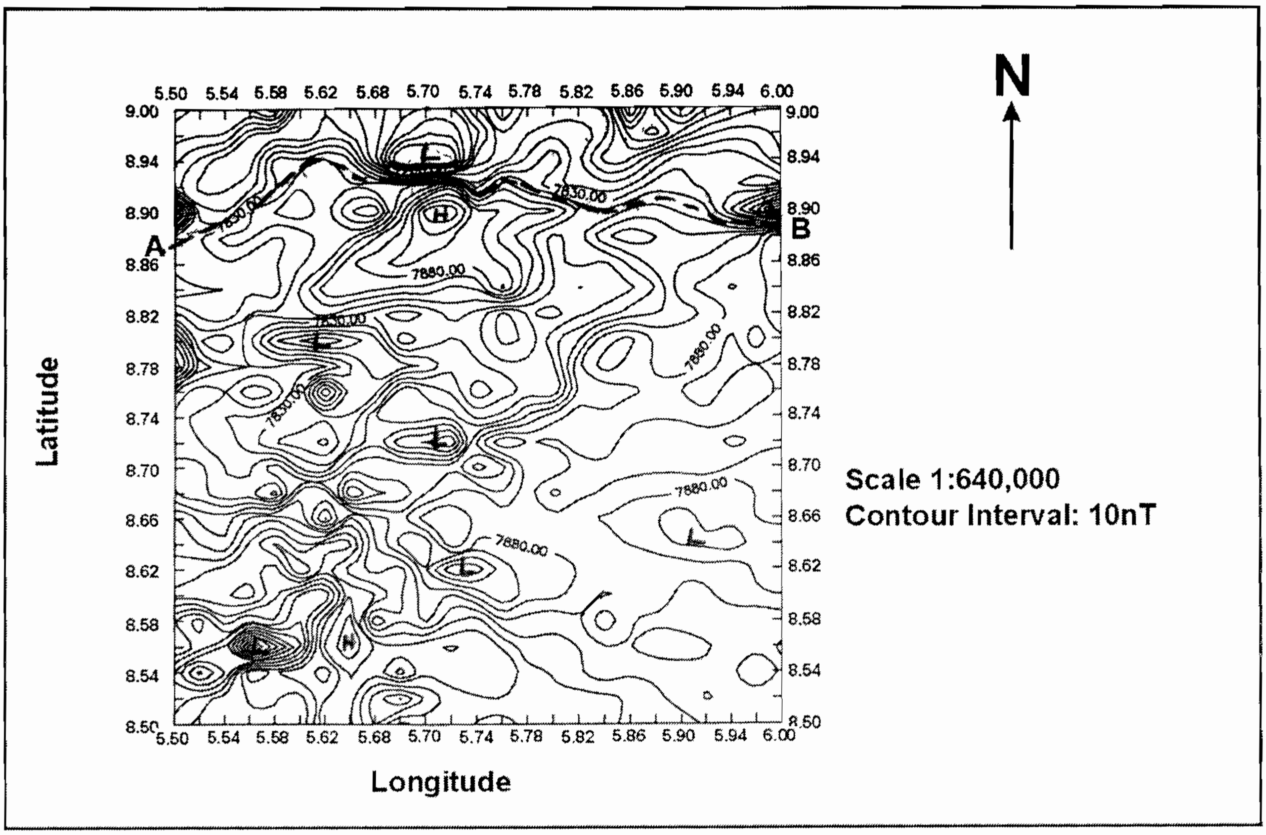

Fig. 2: Reproduced magnetic map of the area. (Axes and in degrees)

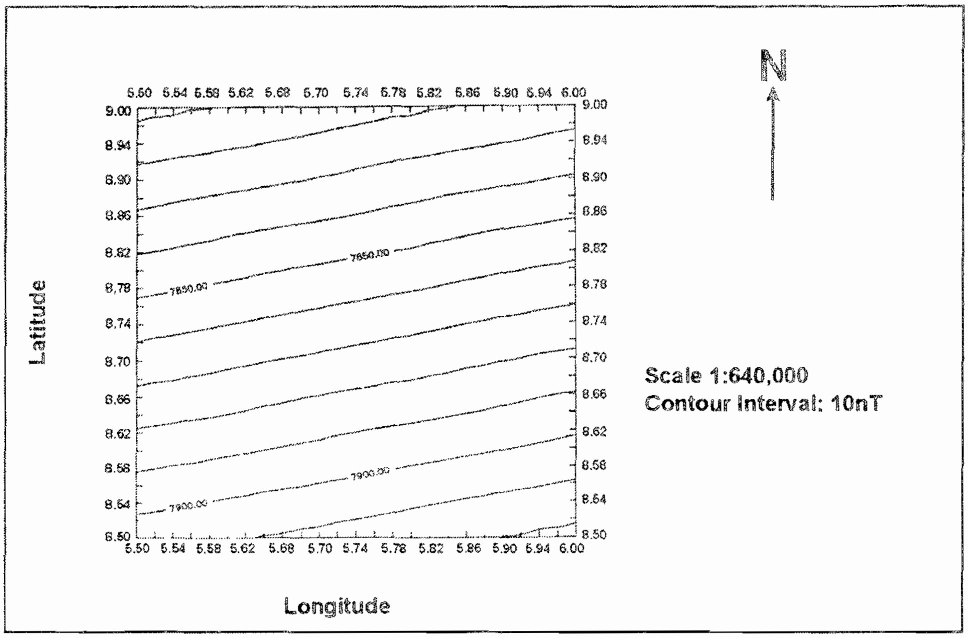

Fig. 3: Regional magnetic map of Pategi area (Axes are in degrees)

Several magnetic highs and lows are present in the study area. The closures of the magnetic low are marked L while the magnetic highs are marked H. Apart from the discontinuities that outline the Romanche fracture zone, some short discontinuities exist within the study area. Among these are an E-W trending discontinuity between latitudes 8.96°N and 9.00°N and longitudes 5.58°E and 5.99°E, a NE-SW trending discontinuity between latitudes 8.90°N and 8.72°N and longitudes 5.80°E and 5.99°E which changes direction to NW-SE at approximately longitude 5.80°E and latitude 8.70°N down to latitude 8.60°N. These discontinuities indicate the several short to moderately long fault zones that exist in the area.

Spatial variations in the total magnetic field over an area reflect the variations in the magnetizations of rocks below the measurement area. The study area is covered by sedimentary rocks (sandstones and shale), which do not exert much magnetic effect (Dobrin, 1976). Thus, virtually all variations in magnetic intensity measurable at the surface would result from topographic or lithologic changes associated with the underlying Precambrian basement complex.

Regional- residual separation

The picture that emerges from a magnetic contour map such as fig 2 is one that shows the superposition of disturbances of noticeably different order of sizes. The larger features generally show up as trends, which continue smoothly over considerable distance. They are caused by the deeper heterogeneity of the earth's crust. These trends are called the regional fields. Superimposed on the regional fields, but frequently camouflaged by them is the smaller, local disturbances which are secondary in size but of primary importance. These are the residual anomalies, which may provide direct evidence of the existence of reservoir-type structures or mineral ore bodies.The regional field was calculated as a 2-d first degree polynomial surface. The resultant map (fig3) trends in an ENE-WSW direction. A simple program was used to derive the residual magnetic field at grid cross points. The residual magnetic values range from -388.05nT to +114.61nT. Negative residuals dominate the area because the area is close to the magnetic equator (Affleck, 1963). From the residual field map (fig4) we see that the features are not linear i.e. we have closures on the map this is because basic igneous rocks are believed to intrude the basement complex within the nupe basin (Ojo, 1990). The presence of intrusions are usually seen on the map as closures. The nature of the closure depicts the depth of burial and size of intrusions that are within the basement underlying the area.

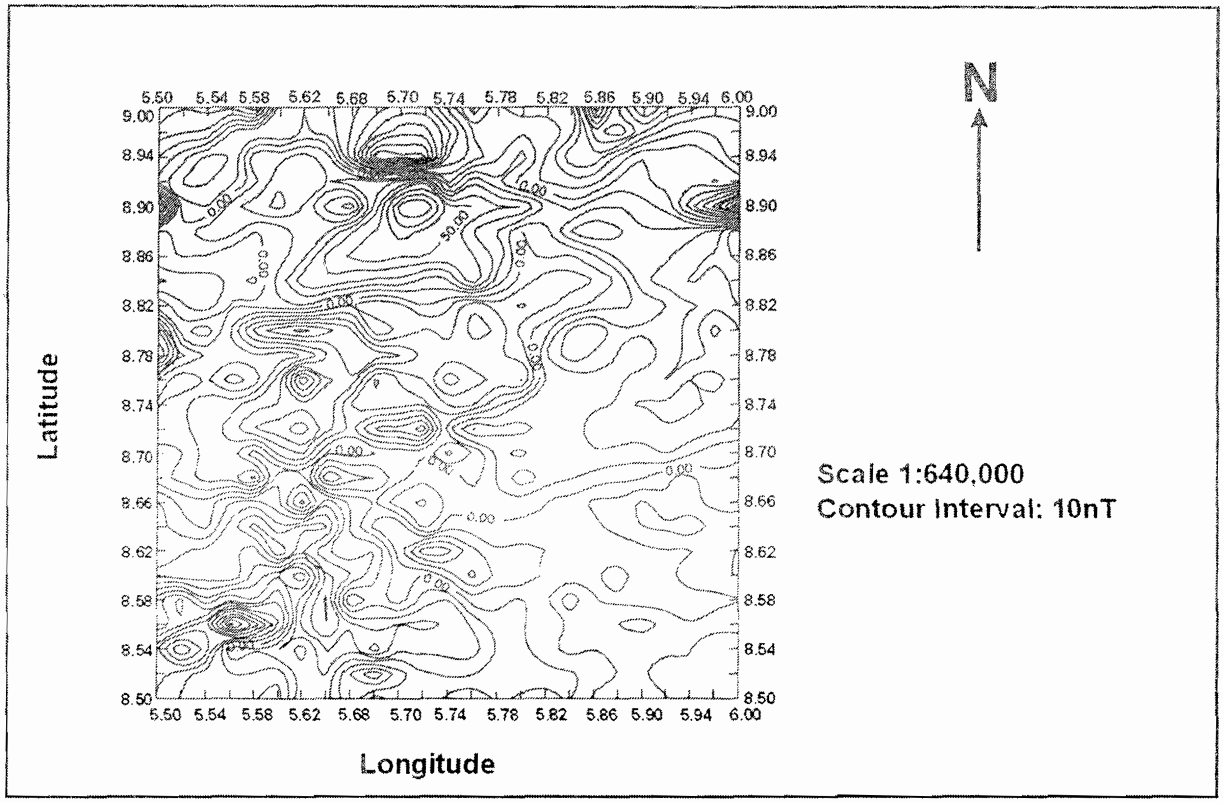

Fig. 4: Residual magnetic map of Pategi area(Axes are in degrees)

Spectral depth determination

The residual total magnetic field of Figure 4 was used to determine the average thickness of sediments within the Pategi area using statistical spectral analysis. Statistical approach has been found to yield good estimates to mean depth to the basement underlying a sedimentary basin (Treital et al.;1971, Hahn et al.;1976). The method used in this study was developed by Spector and Grant (1970) with an improvement by Fedi et al (1997). Graph of the logarithm of the spectral energy against frequencies obtained for the area is shown in Figure 5. In the general case the radial spectrum may be conveniently approximated by straight line segments, the slopes which relates to the depths of possible layers (Spector and Grant.;1970, Naidu.;1970 and Hahn et al,;1976). Two linear segments were drawn from the graph. From the earth's surface downwards, the result shows that the first layer has an average thickness of 1.68km while the second layer has an average thickness of 3.27 km.

The sources that account for the first layer depth derived from the statistical spectral analysis are the effect of the outcropping basement rocks surrounding the study area and/or the magnetic rocks that intrude the sedimentary formation and even sometimes extrude on the surface. The second layer may be attributed to magnetic rocks that intrude the basement surface. Intra basement features like fractures and faults are other sources of the second layer. The first layer of average thickness of 1.68km will not be considered as this is as a result of shallower sources. The second layer depth of 3.27km which is due to deeper sources represent the depth to basement in the area and also represent the average thickness of sedimentary formation overlying the basement complex within the Pategi area.

The spectral average depth of 3.27 km agrees well with the views of Kogbe (1989) that the total thickness of Cretaceous sediments in the eastern portion of Southern Nigeria basins is about 3.3 km. The result also agrees with the result of 3.39km deduced for the Bida Basin by Udensi and Osazuwa (2003) for the entire Bida Basin.

Conclusion

The aeromagnetic map over Pategi in west-central Nigeria has been analysed in this study. A major lineament depicting the Romanche paleo fracture zones was found in the area. Short to moderately long discontinuities were found in the magnetic map. Several magnetic closures of various sizes were also noticed. While the discontinuities indicate the presence of minor to moderately long

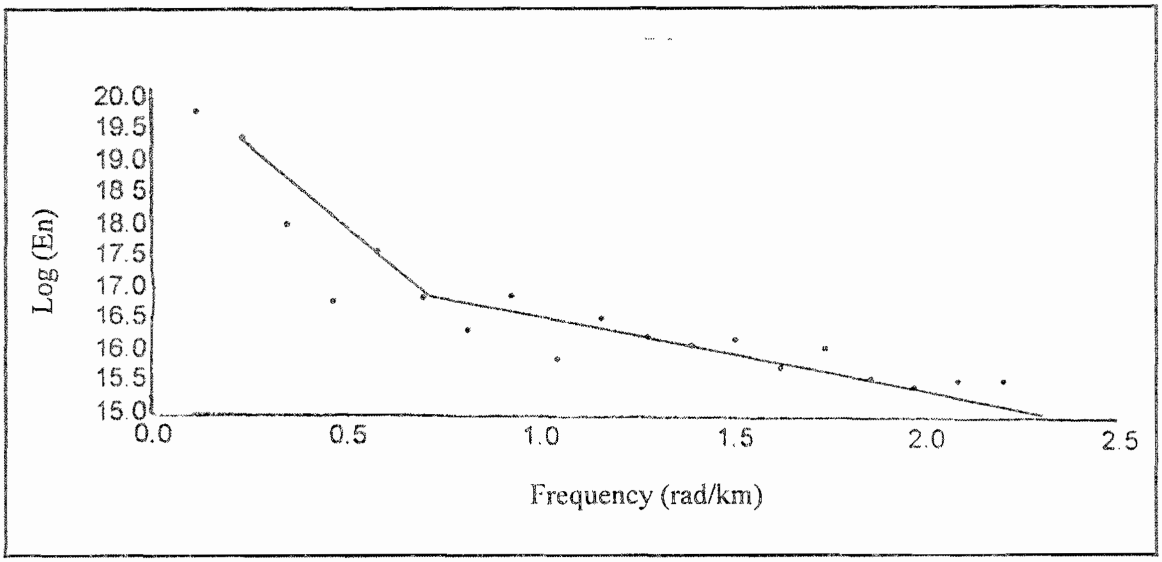

Fig. 5: Energy spectrum of Pategi area

fault zones in the area, the closures depict the sizes of the anomalies that lie beneath the basin. The point here is that the Pategi contains intra basin faults and is overlying several intra basement intrusions of various sizes, shapes and alignments. The areas contain sediments up to a thickness of 3.27 Km. A sedimentary thickness of this size may be recommended for further investigation for petroleum exploration.

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