American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-9, pp-232-247
www.ajer.org
Research Paper Open Access

Utilization of Aeromagnetic and Land Sat Data for Structural Interpretation: A Case Study of Ikom-Mamfe Embayment, Southeastern Nigeria.

*Dr. Christopher I. Effiong,[1] Dr. Anietie E. Ekot,[2] Dr. Clement E. Bassey,[3] Mr. Abraham C. Udoh[4]

[1,] *(Department of Geology, Federal University of Technology, P. M. B 1526 Owerri, Imo State, Nigeria).*
[2,3,,4] *(Faculty of Natural & Applied Sciences, Akwa Ibom State University, Ikot Akpaden, P.M. B. 1167 Uyo, Akwa Ibom State, Nigeria)*
Corresponding Author: Dr. Christopher I. Effiong

Abstract: *This paper presents a detailed structural interpretation over Ikom – Mamfe Embayment using aeromagnetic and land sat data. The study was carried out to determine depth to the magnetic basement, delineate basement morphology, relief, structural and tectonic features associated with the area. The aeromagnetic and remote sensing data were subjected to various image, data enhancement and transformation routines. Oasis montaj and ILWIS softwares were used for data analysis. Maps such as the total magnetic intensity map, 3-D surface map of the basement topography of the area, power spectrum plots of the aeromagnetic data of the area, first to fourth degree residual/regional magnetic intensity field map of the area, lineament density maps, rose diagram of the study area were generated for the analysis. Results show that the area has a very complex pattern of magnetic anomalies of both short and long wavelengths. Result of the 2-D spectral analysis revealed a two layer depth model. The shallower magnetic source (D_1) has an average depth of 3.27km while the deeper magnetic source (D_2) has an average depth of 2.626km. The shallower magnetic anomalies are as a result of basement rocks which intruded into the sedimentary rocks while the deeper magnetic anomalies are associated with magnetic basement surface and intra basement discontinuities like faults, fractures and lineation. Structural analysis of these shallow anomalies using 3-D, Euler deconvolution with structural index values ranging from 0-3 revealed two main structural models in the study area which include sills/pipes and horizontal cylinders/pipes. The dominant structural trend direction of the study area is in the N-S direction. Other lineament trend directions are in the E – W, NE – SW and NW- SE directions. With shallow basement depth, abundance of intrusives and linear features, the area has a high mineral prospectivity but low petroleum prospects.*

Keywords: *Structural, Aeromagnetics, Remote Sensing, Basement, Sediments, Lineaments, Anomalies and Tectonics.*

Date of Submission: 08-09-2017 Date of acceptance: 20-09-2017

I. INTRODUCTION

In the past geological mapping was performed through fieldwork, a rather daunting task which involved traversing the length and breadth of the area in search of data. But nowadays, with the recent advances in technology sophisticated method such as remote sensing has been developed. This technique if used in tandem with traditional geological mapping gives a much better result. Remote sensing can provide detailed information on the lithologies on the earth surface. The recent development in sensor technology has made remote sensing to become an increasingly veritable tool for mapping lithologies, structures and ore deposits, particularly for remote areas where there is little or no access, or areas that lack topographic or geologic base map. This technique when used together with field mapping makes geological mapping more cost-effective and efficient. [1] used aeromagnetic to estimate the depth to basement in part of Dahomey basement, Southwestern Nigeria. The application of remote sensing faces setbacks when it comes to interpretation of geological and structural data because different surface conditions such as vegetation, agricultural activities, weathering, urbanization and industrialization may act as hindrances to geological and structural signals. The present paper deals with structural interpretation using aeromagnetic and land sat data.

1.1 Geology of the Study Area.

The Ikom- Mamfe embayment exhibits enormous lithologic variations, although they are fairly comparable in sedimentary thickness. Gravity estimates of sedimentary thickness in the area by [2] and [3] suggested 3,000 – 4,000m of predominantly non-marine beds. A detailed geologic map of the area is shown in figure 1.

II. METHOLOGY

The aeromagnetic data were acquired during the nationwide aeromagnetic survey which was sponsored by the Geological Survey of Nigeria in 2005. Flight lines were NNW – SSE at station spacing of 2km with flight line spacing of 20km at an altitude of about 150km. For this study, aeromagnetic sheets 314 and 315 were used. The aeromagnetic sheets were subjected to low pass filtering achieved through manual digitization of the map using 2cm by 2cm (equivalent to 2km by 2km) grid spacing. The nature of filtering applied in this study in the Fourier domain was chosen to eliminate certain wavelength and to pass longer wavelengths. Regional – residual separation was carried out using polynomial fitting. This is purely analytical methods in which matching surface of low order exposes the residual features as random errors. The regional gradients were removed by using multi – regression least squares analysis and many analytical maps were produced. Similarly Land sat Thematic Mapper (Landsat -TM) image acquired from Nigerian Air Space Research Development Agency (NASRDA) on March 18, 2014 to map linear structures in the study area was used. The raw data were geoinferenced using the coordinates of the topographic sheets in the study area. The geoinferencing was carried out using the Universal Transverse Marcator (UTM). Image processing enhancement and analysis were carried out using ILWIS 3.1 Academic software. Ach View 3.2 software was used to extract the lineament and carry out statistical analysis of the interpreted lineaments in the area. The interpreted lineaments were further superimposed on the geologic map (figure 22). The lineament trend directions were summarized by using a Rose Diagram as shown in figure 23. The primary objective of this study was to identify structures expressed as lineaments and classify them according to the spatial and directional attributes. It was necessary to process the aeromagnetic data and land sat – TM data in a manner that would both enhance trends and facilitate the computation of locations and depths to magnetic sources.

III. RESULTS AND DISCUSSION

The different maps produced are shown in the diagrams below. Figure 2 is the total field of the magnetic data presented as a contour. The total field of the aeromagnetic data revealed that the underlying basement within Ikom has an estimated magnetic range of 7780 to 7860 gammas. Within this area, there are places with magnetic intensity as low as 7720 to 7760 gammas. The 3-D map revealed two distinctive relief patterns; low and high relief. Areas with low relief are observed around Ikom and Bansara . The high relief areas are believed to be more tectonically active than the low relief areas [4]

Figure 3 is the 3-D image of the total magnetic intensity of the area. From the 3-D surface map of the basement, the area is observed to be made up of uplifts and depressions. The tectonism responsible for the folding is believed to have been initiated during Mesozoic time due to the separation of African and South American land masses which causes folding on the basement surfaces.

The first to fourth degree regional fields are presented in figures 4 to 7 while figures 8 to 11 show first to fourth degree residual magnetic field of the study area. From the residual magnetic field maps of the area, it was observed that the residual magnetic intensity of the study area ranges from -48.3 to 53.0 gammas. The area is observed to be dominated by low residual magnetic intensity. The residual intensity range in these areas was shown to be between -48.0 to -0.2 gammas. The negative residual areas reflect zones of low magnetization while the positive residual anomalies reflect areas of high magnetization. This implies that there is an existence of shallow to near surface magnetized bodies in areas having positive residual values. Areas with negative residual values are underlain by deep seated magnetized bodies. Another probable reason for the predominance of negative residual anomaly signatures in this area may be due to its nearness to the magnetic equator.

The regional fields establish the major tectonic elements of deeper and regional extent which affect and control the structural framework of the study area. First to fourth degree regional anomalies of the aeromagnetic data revealed a dominant regional trend N-S, NE-SW trends and some E-W trends. This trend was also evident on the lineament map and Rose diagram of the study area.

IV. LIST OF FIGURES AND TABLES

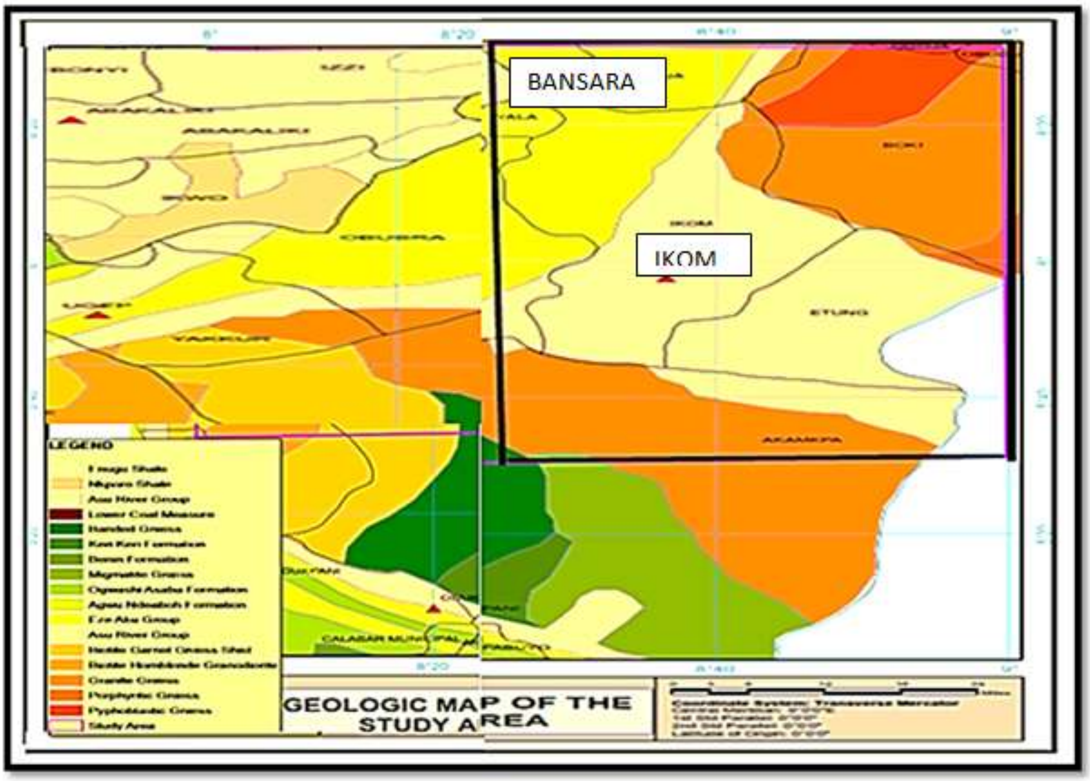

Fig.1; Geologic map of the study area. (Taken from Nigerian Air Space Development Agency, 2016)

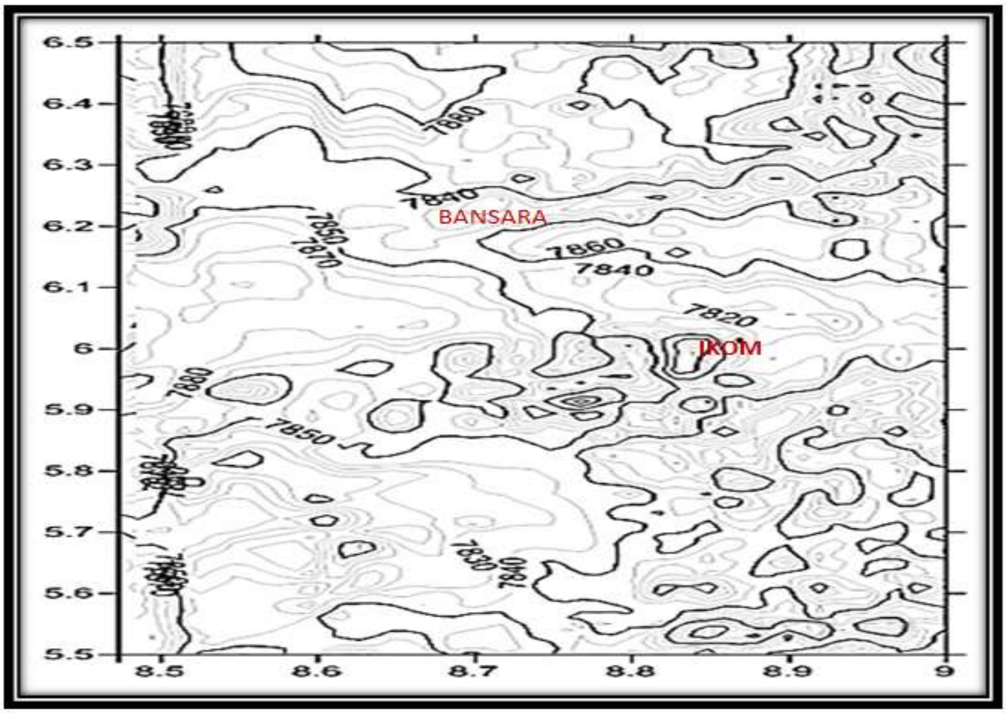

Fig. 2 Total field magnetic intensity contour map of the study

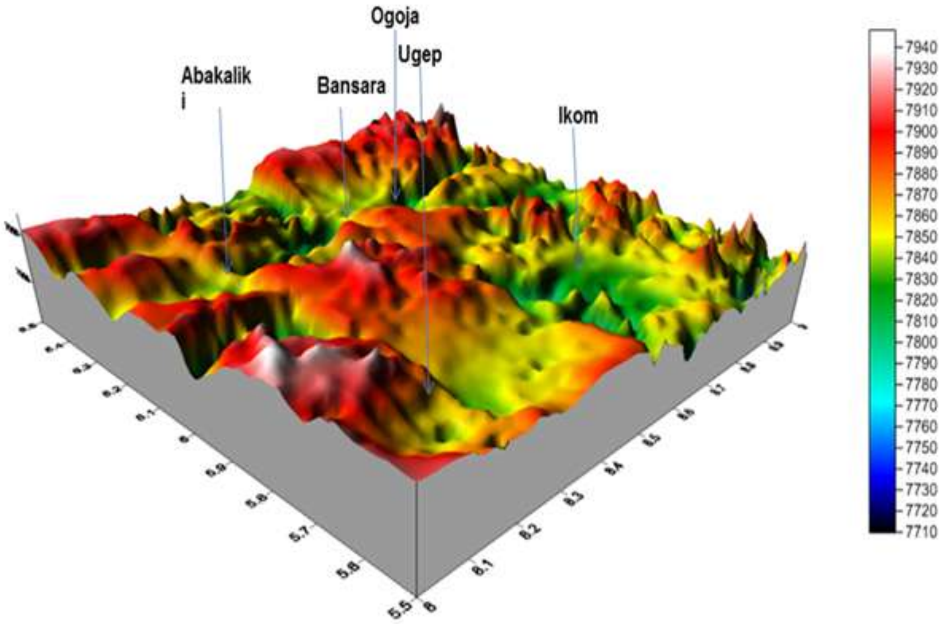

Fig 3 3-D Image of the total magnetic field intensity of the study area

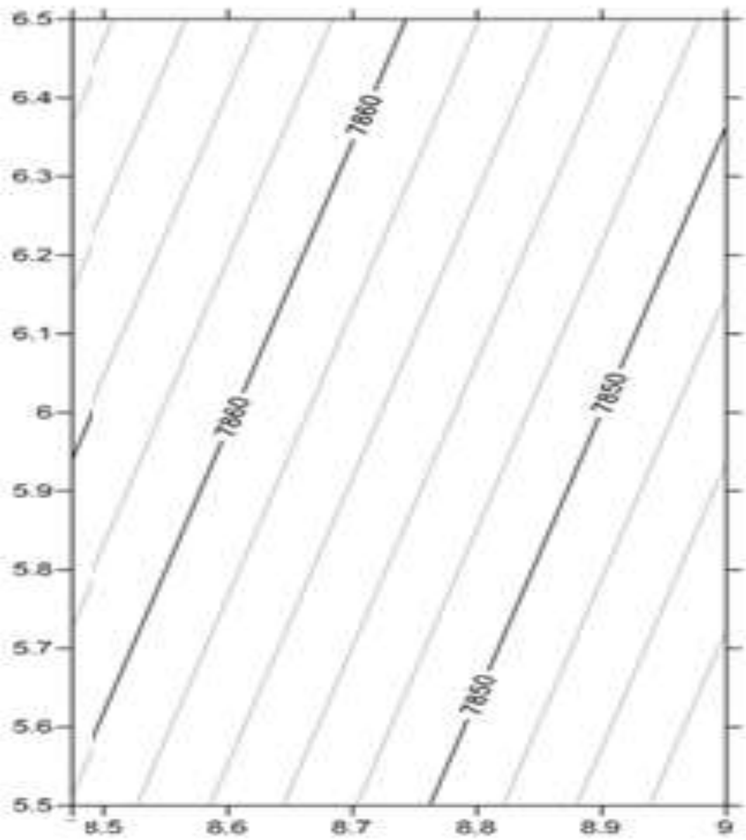

Fig. 4 First Degree Regional of total Magnetic Field of the Study Area

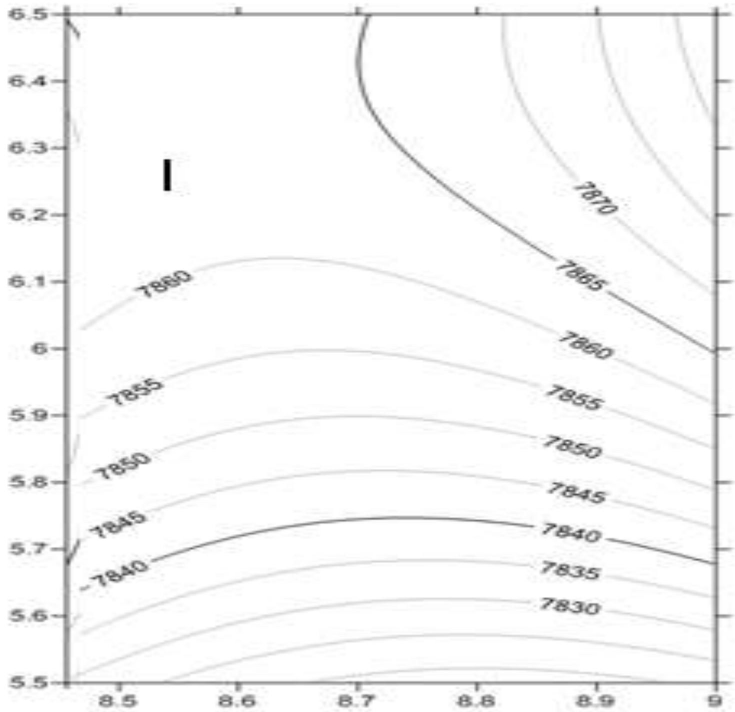

Fig. 5 : Second Degree Regional Field of the Total Magnetic Field of the Study Area

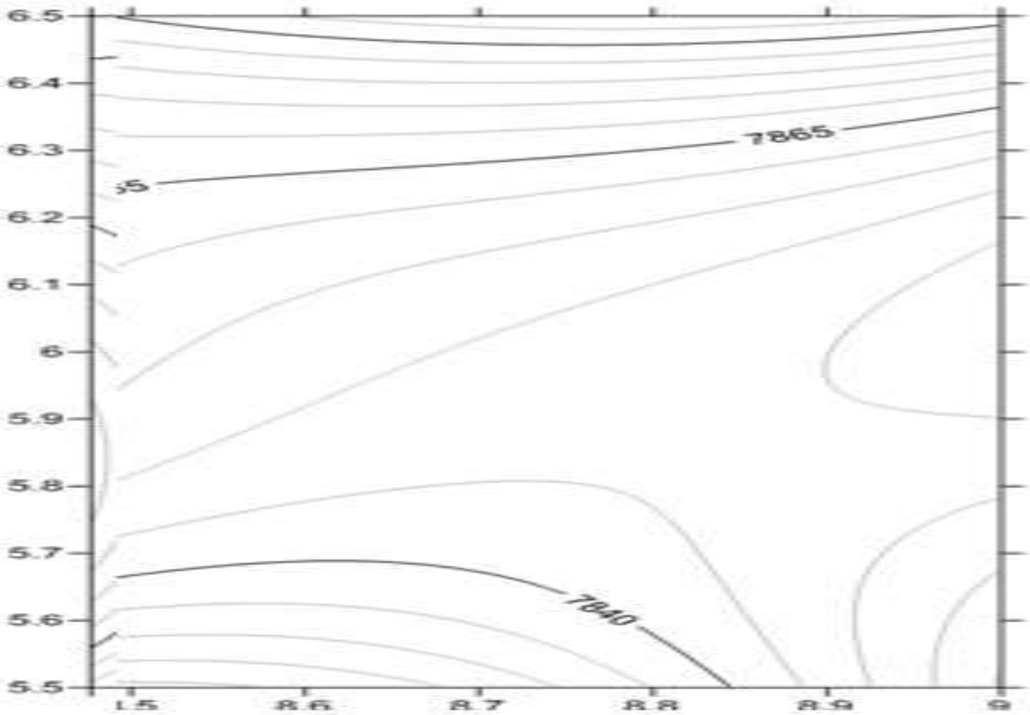

Fig. 6 Third Degree Regional Field of the Total Magnetic Intensity of the Study Area

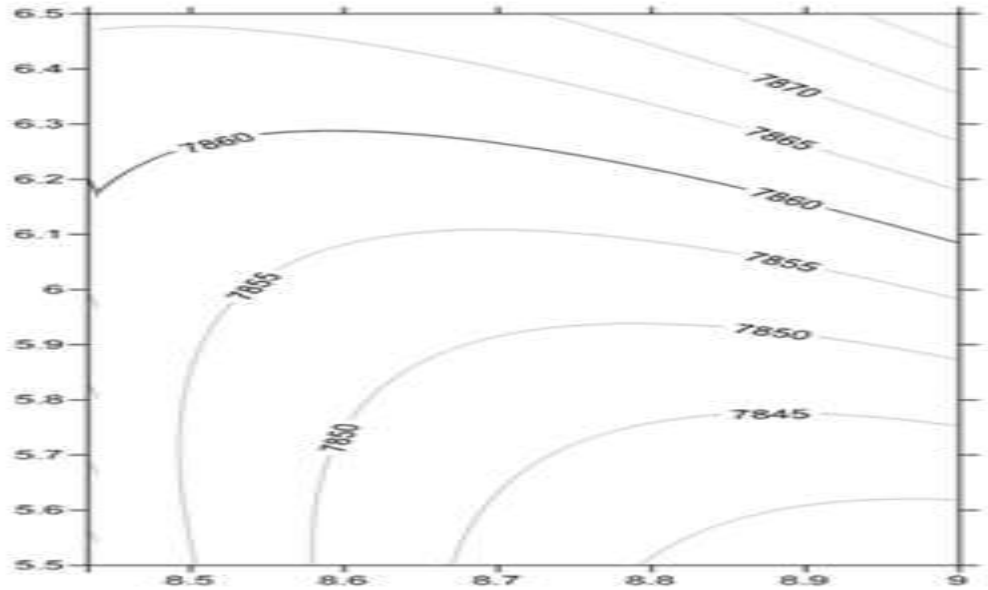

Fig. 7: Fourth Degree Regional Field of the Total Magnetic Intensity of the Study Area

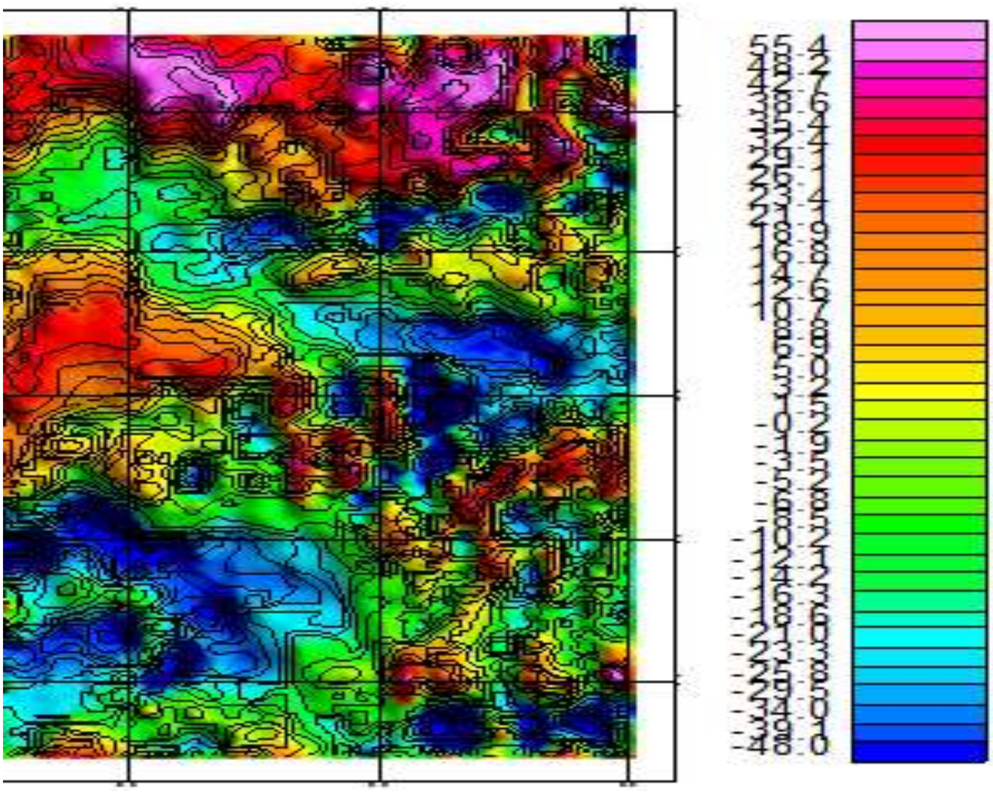

Fig. 8: First Degree Residual Magnetic Field of the Study Area

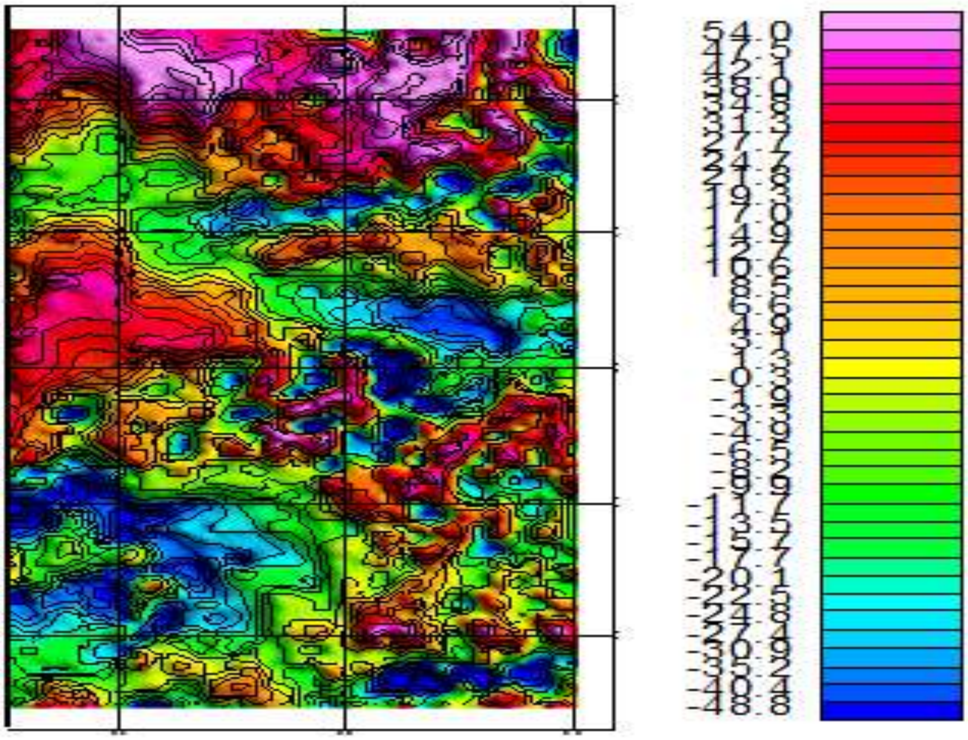

Fig. 9 : Second Degree Residual Magnetic Field of the Study Area

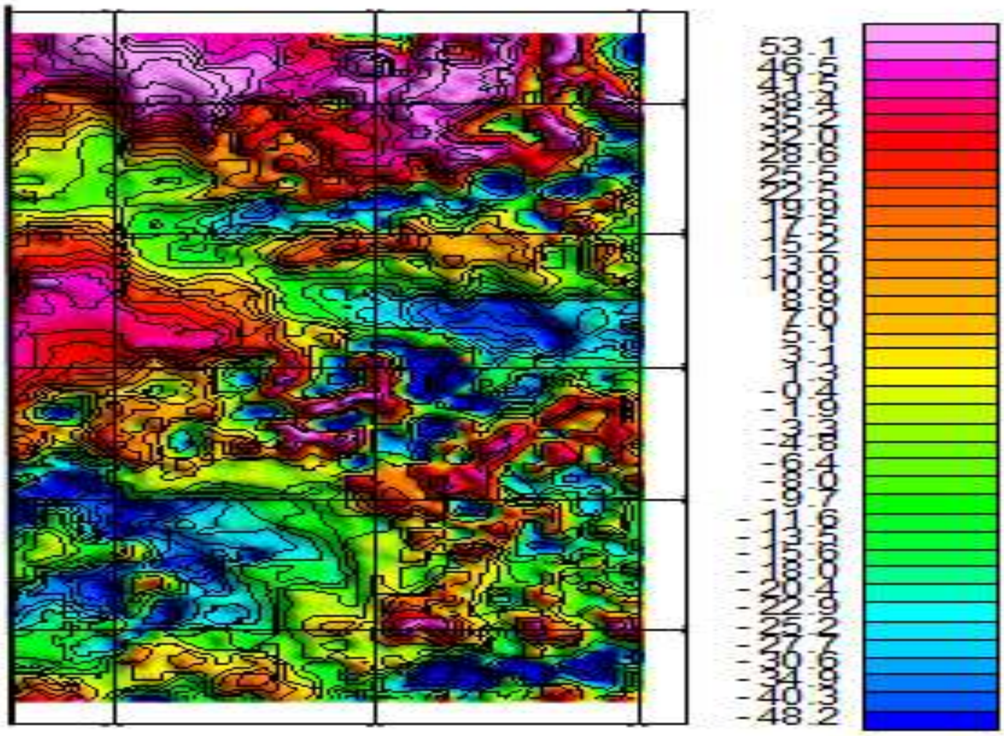

Fig.10: Third Degree Residual Magnetic Field of the Study Area

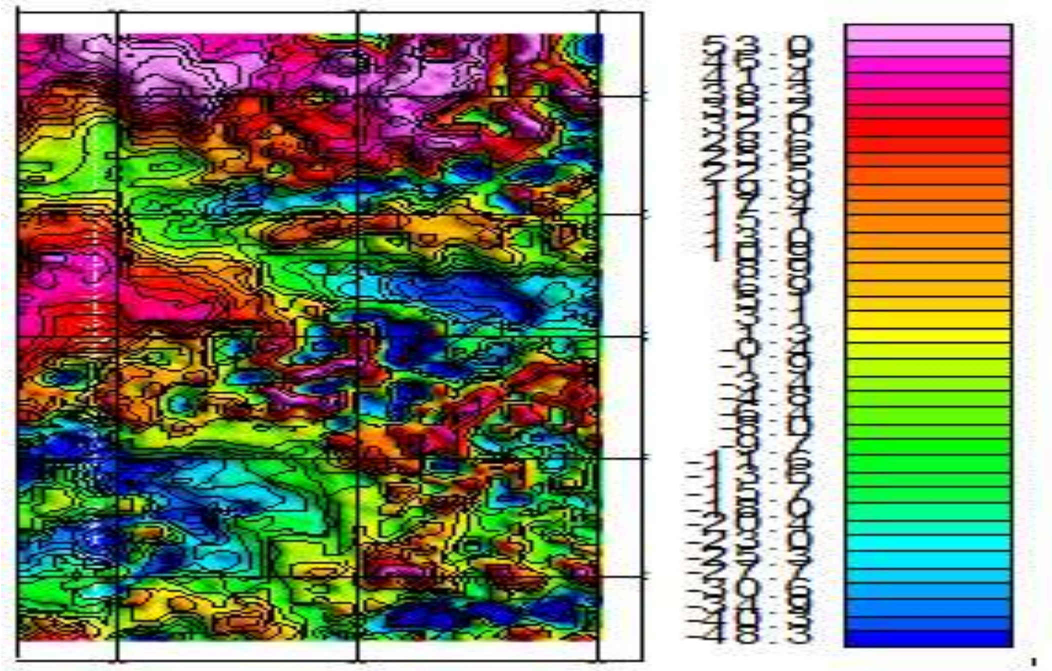

Fig. 11 Fourth Degree Residual Magnetic Field of the Study Area

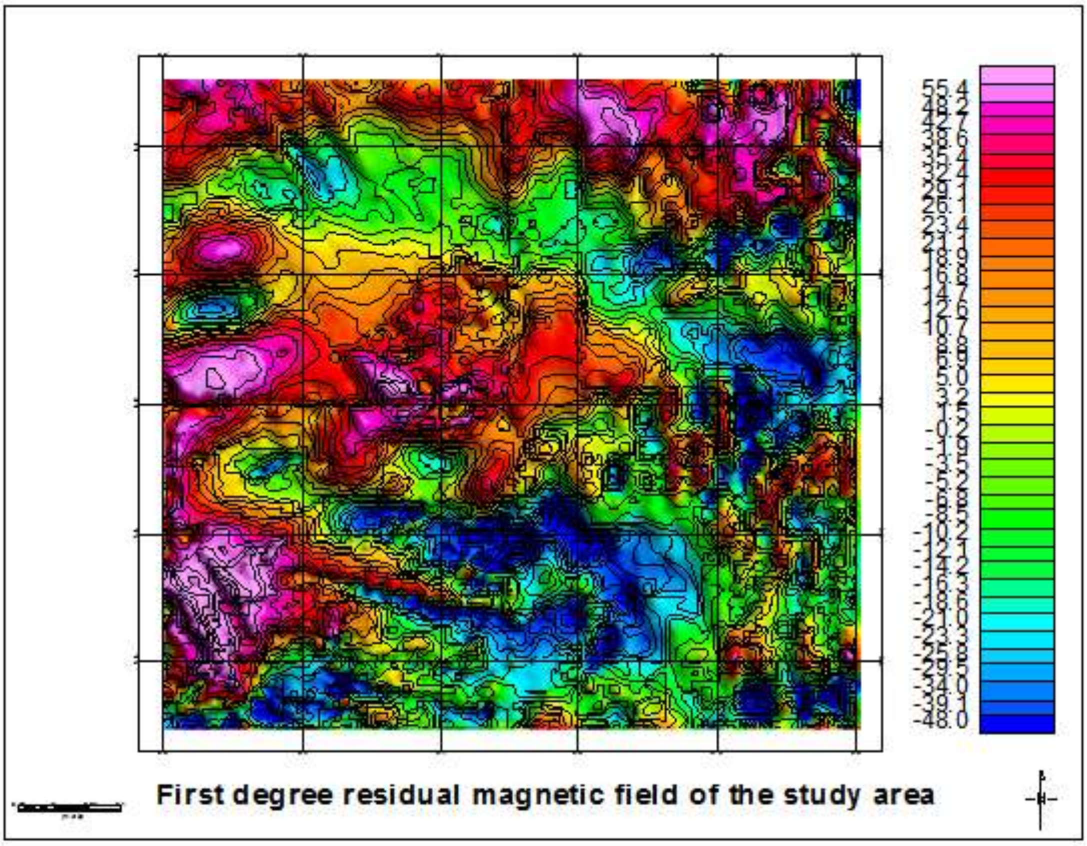

Fig. 12: First degree residual magnetic field of the study area

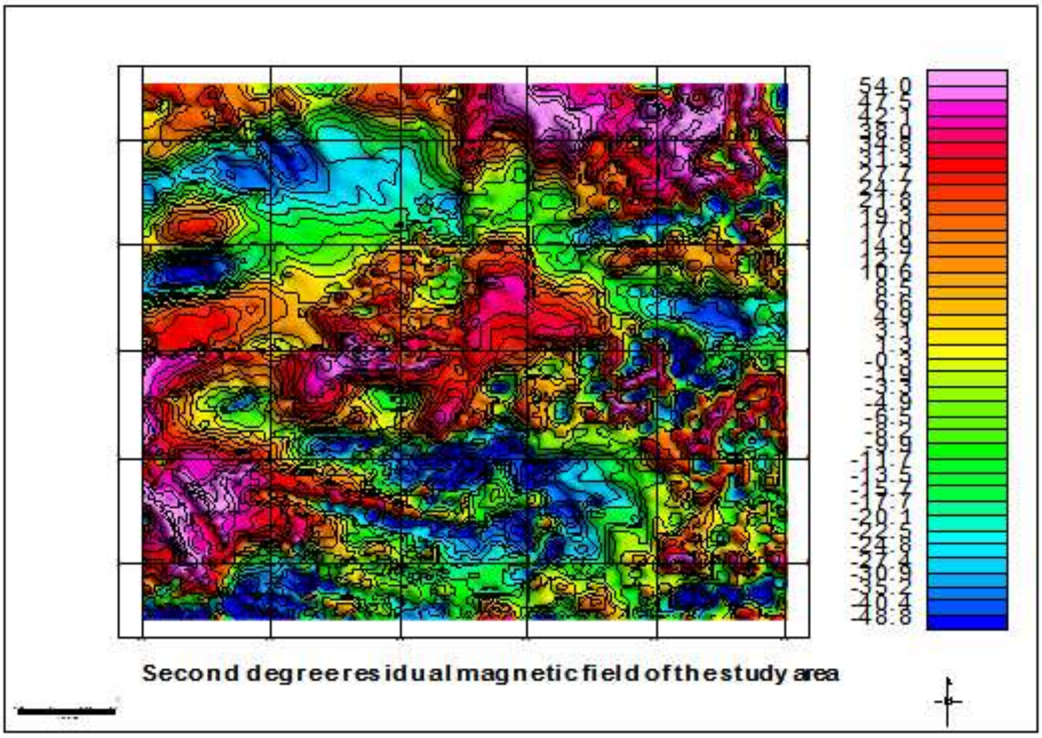

Fig. 13 Second residual magnetic field of the study area

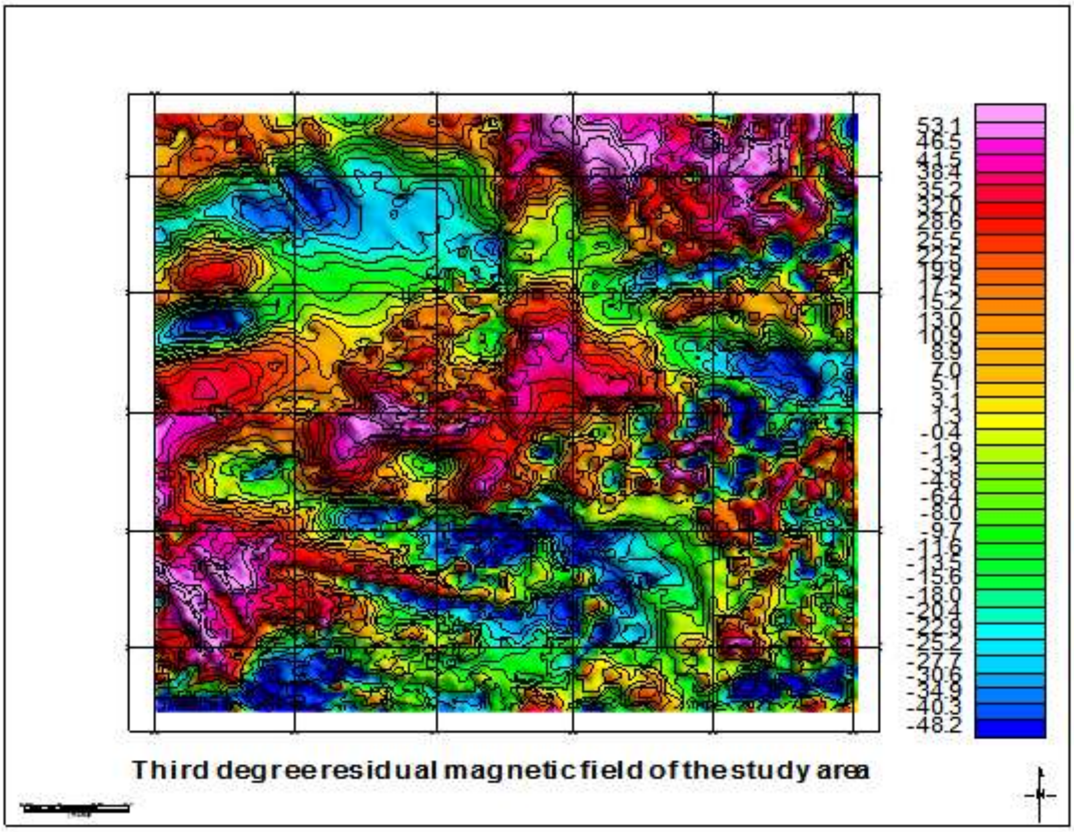

Fig.14 : Third degree residual magnetic field of the study area

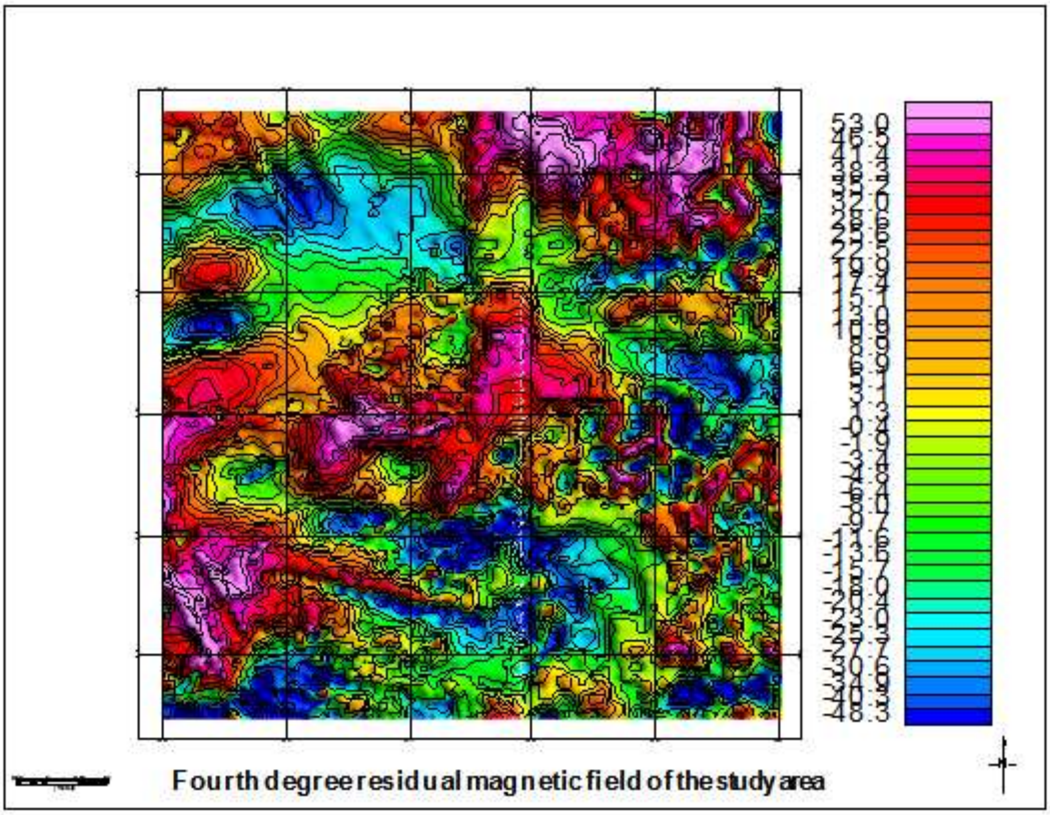

Fig. 15: Fourth degree residual magnetic field of the study area

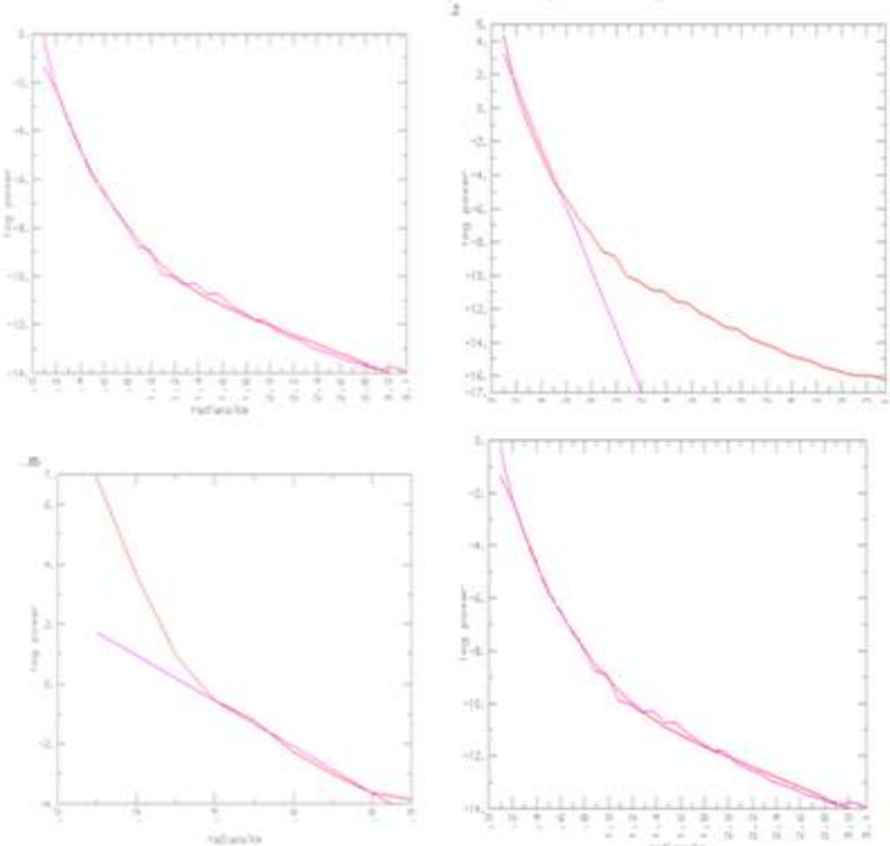

Fig 16: Power spectrum plots of aeromagnetic data of blocks I- L(Ikom)

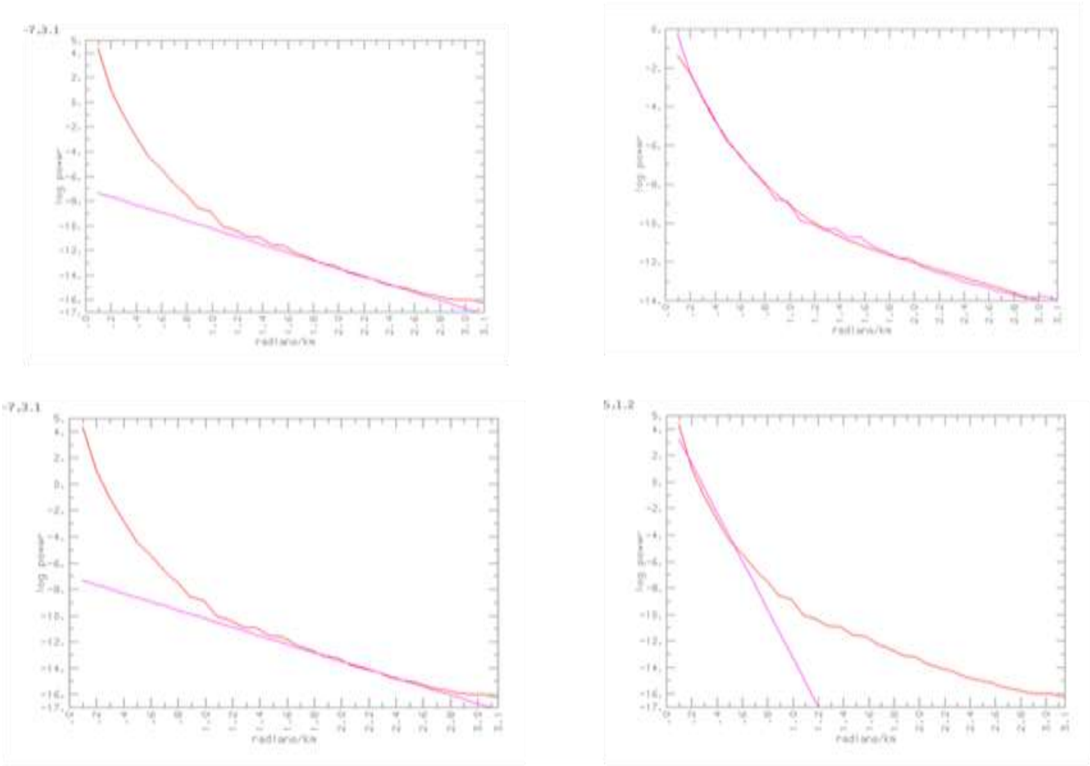

Fig. 17: Power spectrum plots of aeromagnetic data of blocks M- P(Bansara)

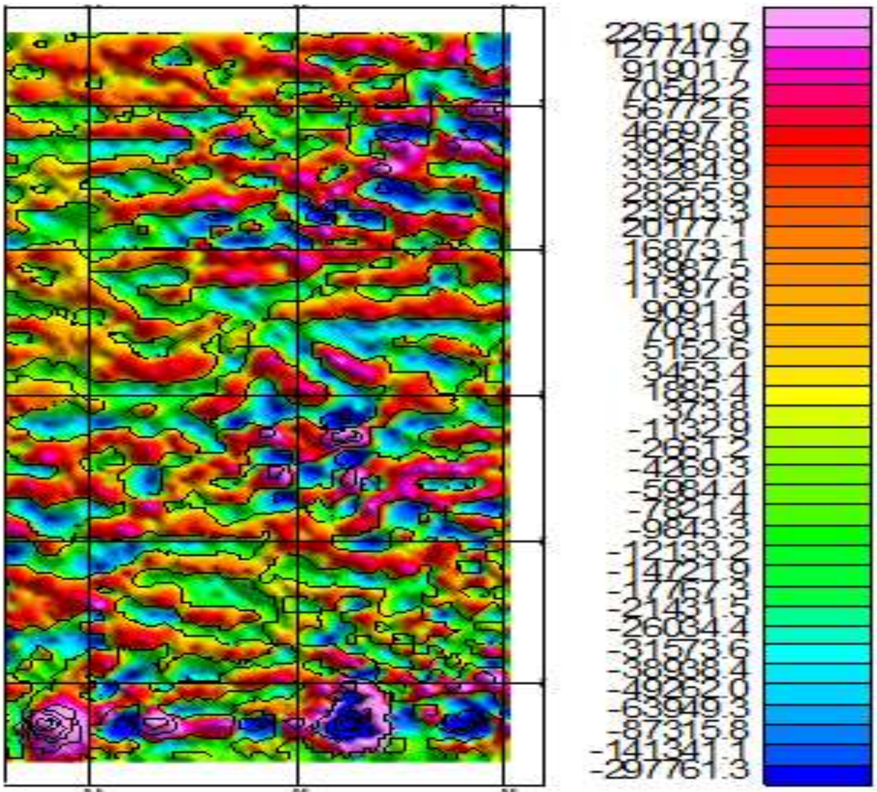

Fig. 18: Second Vertical Derivative Map of the Study Area

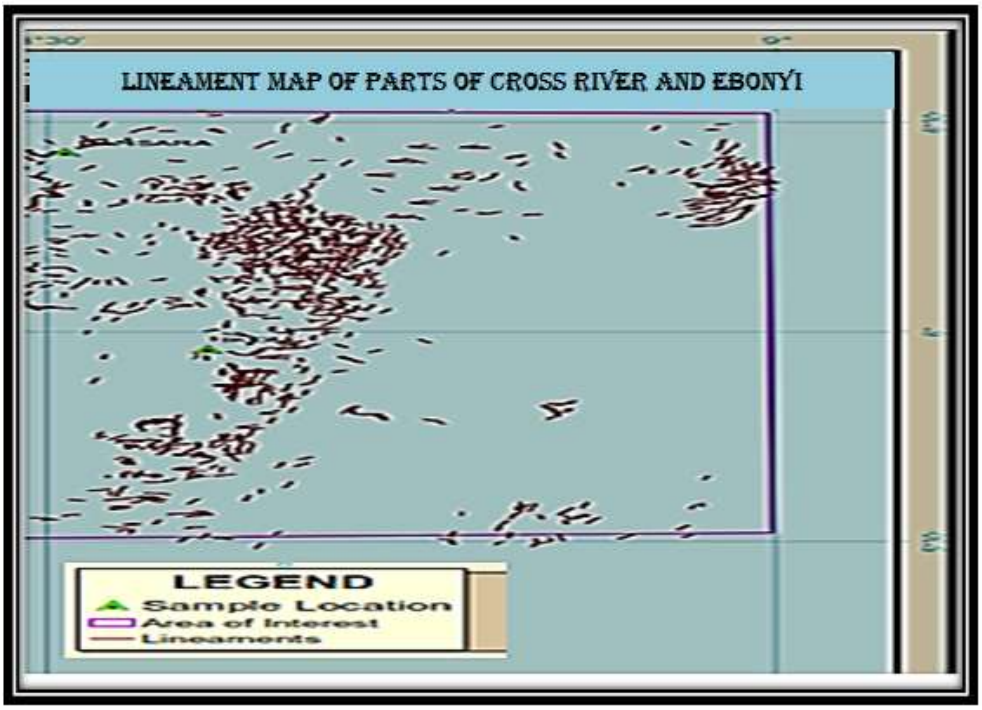

Fig. 19: Lineament Map of the Study Area

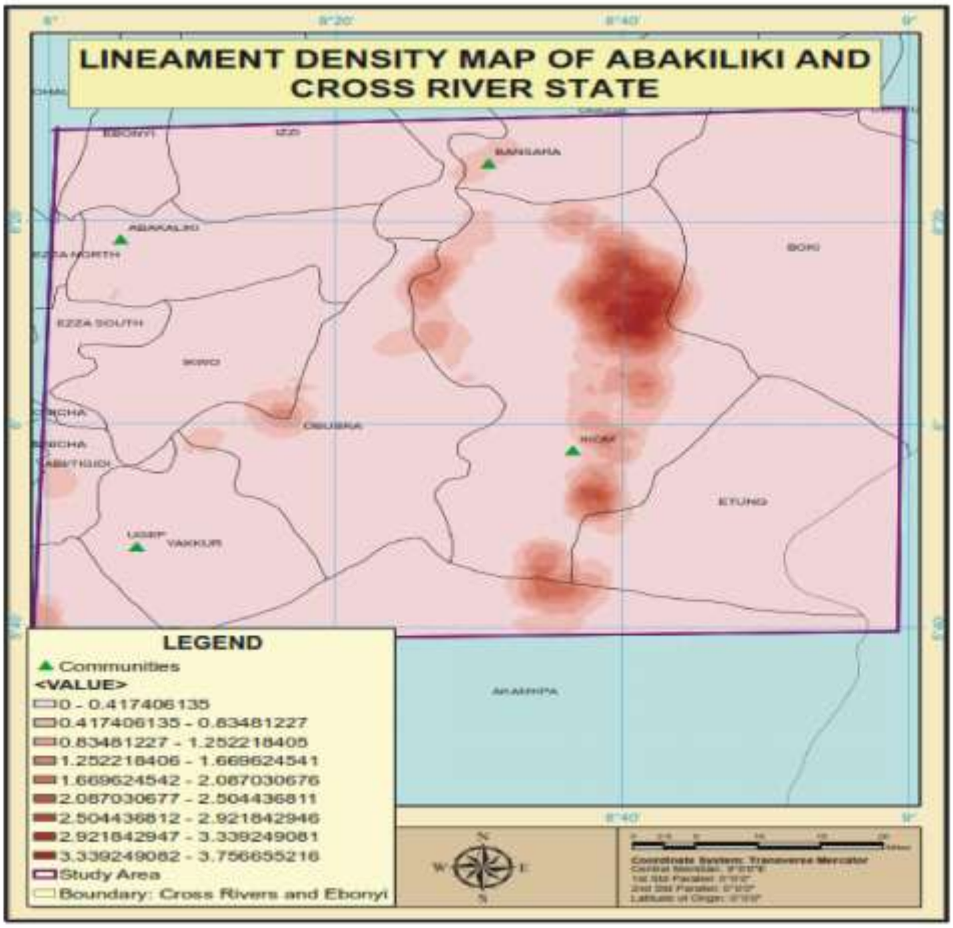

Fig.20 : Lineament density map of the study area

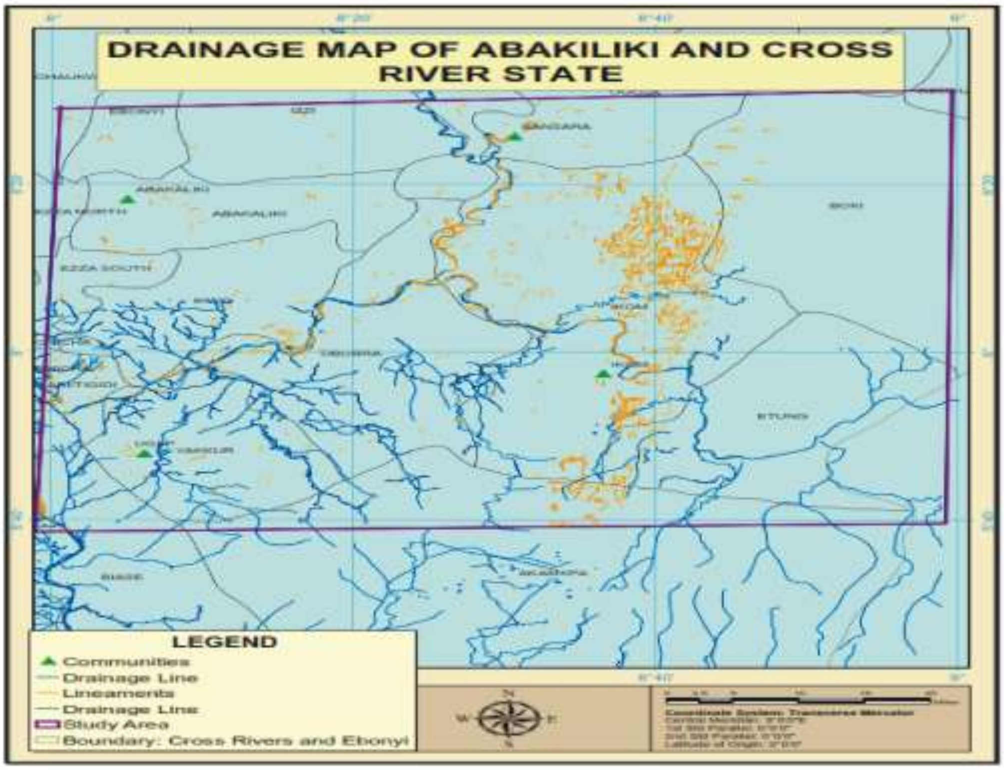

Fig.21 Drainage map of the study area.

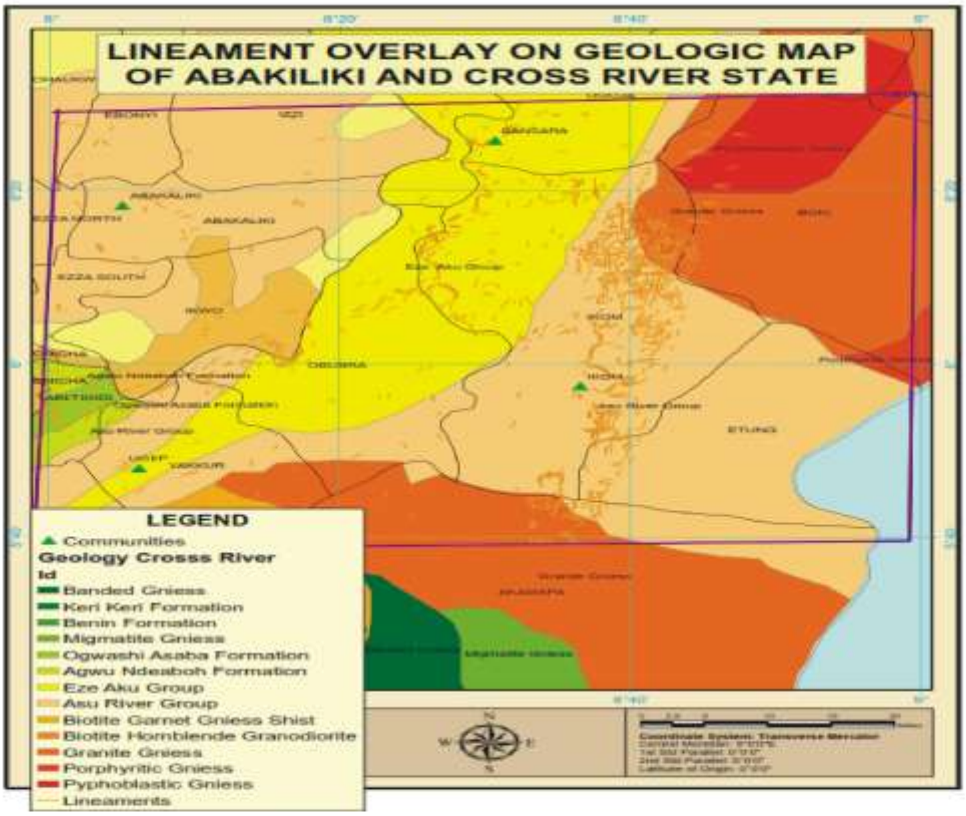

Fig. 22 Lineament overlay on Geologic Map

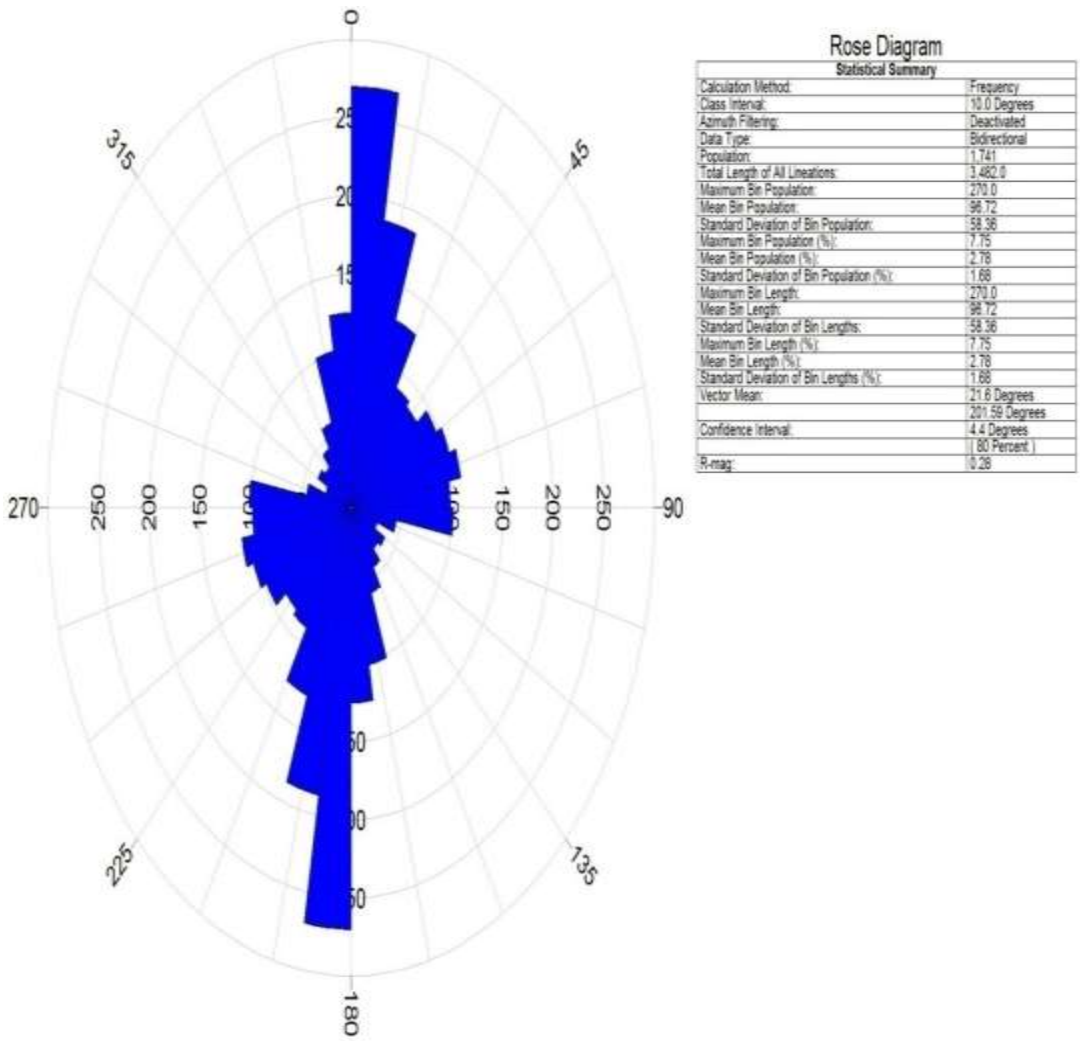

Fig.23 : Rose diagram of the study area.

Table 1: Location and Magnitude of First and Second Layer Spectral Depth

TOWN	SPECTRAL BLOCKS	LONGITUDE (E)		LATITUDE (N)		DEPTH (KM)	
		X_1	X_2	Y_1	Y_2	D_1	D_2
BANSARA	E	8.75	9.00	6,25	6.50	0.985	3.016
	F	8.50	8.75	6.0	6.25	0.535	2.585
	G	8.75	9.00	6.0	6.25	0.329	2.995
	H	8	8.25	5.75	6.00	-1.235	2.236
IKOM	M	8.50	8.75	5.75	6.00	-1.035	2.236
	N	8.75	9.00	5.75	6.00	0.285	3.016
	O	8.50	8.75	5.5	5.75	-1.002	2.585
	P	8.75	9.00	5.50	5.75	0.329	2.995

Spectral analyses revealed a two layer (D_1 and D_2) depth model. These depths were established from the slope of the log-power spectrum at the lower end of the total wave number of frequency domain. The estimated depths to magnetic basement are shown as D_1 and D_2 respectively in table 1. The first layer depth (D_1) is the depth to the shallower source represented by the second segment of the spectrum as seen in figures 16-17. This layer (D_1) varies from 0.285km to 0.985km with an average of 3.27km. The second layer depth (D_2) varies from 2.236km to 3.016km, with an average of 2.626km. This layer may be attributed to magnetic rocks intruded onto the basement surface. Another probable origin of the magnetic anomalies contributing to this layer is the lateral variations in basement susceptibilities, and intra-basement features like faults and fractures [5]. It can therefore be deduced that the D_2 values obtained from the spectral plots, represent the average depths to the basement complex (sedimentary thickness) in the blocks considered.

Similarly, second vertical derivative filters were used to enhance subtle anomalies while reducing regional trends. These filters are considered most useful for defining the edges of bodies and for amplifying fault trends. In mathematical terms, a vertical derivative can be shown to be a measure of the curvature of the potential field, while zero second vertical derivative contours defines the edge of the causative body. Thus, the second vertical derivative is in effect a measure of the curvature, i.e., the rate of change of nonlinear magnetic gradients. The zero magnetic contours of the second vertical derivative often coincide with the lithologic boundaries while positive and negative anomalies often match surface exposures of the mafic and felsic rocks respectively [1] The second vertical derivative map of the study area is shown in figure 18.

Lineaments are surface expression of subsurface deformation that reveals the hidden architecture of the basement rock [6]. However [7] defines lineament as a mappable, simple or composite linear feature of a surface whose parts are aligned in a rectilinear or slightly curvelinear relationship and which differ from the pattern of adjacent features and presumably reflects some subsurface phenomenon. The lineament and lineament density maps (figures 19 and 20) reveal high concentration of lineament within the basement rocks. Lineaments in this area cross – cut each other and some run parallel to each other. This implies that the area has gone through many tectonic events. The concentration of lineament in an area indicates the level of tectonic activity in the area [8]. The lineaments image of the study area reveals that lineaments traces are seen along the drainage channels which suggest that they may be lineaments of hydrographic origin and that the river may be structurally controlled as seen in the drainage map of the study area in figure 16. Lineaments quantification and statistical analysis were done regarding the orientation and frequency of these lineaments to reconstruct a rose diagram. The rose diagram (figure 23) shows a peaks of preferential direction, N-S

A detailed structural study was carried out using aeromagnetic and remote sensing data. The presence of intrusive bodies and faults in some areas shows that these areas are more tectonically active than others. The tectonism is believed to have been initiated during the separation of African and South American land masses [9]. Structural analysis of the interpreted anomalies using 3-D Standard Euler deconvolution with structural index values ranging from 0 -3 revealed the dominant presence of two geological structural features which include sills/dykes and horizontal cylinders/pipes. This confirms the presence of intrusives in the area [10].

Result of the 2-D spectral analysis revealed a two layer depth source model. The depth of the first layer varies from 0.285km to 0.985km while that of the second layer varies from 2.236km to 3.016km. This depth is in agreement with depth estimates from [11] of 2.5km to 3.0km and [1] using 3-D Euler deconvolution estimated sedimentary thickness of 3.3km in the Benue Trough. Depth to source interpretation of aeromagnetic field data provides important information on basin architecture for mapping areas where the basement is shallow enough for mineral exploration. Magnetic basement is an assemblage of rocks that underlies sedimentary basins and may also outcrop in places. If the magnetic units in the basement occur at the basement surface, then depth determinations for these will map the basin floor morphology, relief and structure [11]

The second vertical derivative map of the area shows that there is abundance of mafic and felsic minerals in the area. They are formed by hydrothermal processes. According to [6] Pb –Zn mineralization is farther away in the zoning of minerals around an igneous intrusion while tin and copper are closer. The occurrence of Pb – Zn, copper and tin related minerals shows the presence of intrusions in which the minerals are of hydrothermal processes. This is in agreement with the result of investigations carried out by [12] of various rock samples in Oban and Obudu massifs. Lineament quantification and statistical analysis were done regarding the orientation and frequency of these lineaments to construct a rose diagram. From the rose diagram N –S trend is dominant. Other trends are NE –SW and NW-SE. The NE-SW trend in the study area is in conformity with [1] suggests a relationship between the Younger Granite of Nigeria and the Benue Trough. This event suggests that the tectonic activity that took place in the Benue trough may have extended to the Younger Granite of Nigeria. However, several other trends are observed which have low frequency on the diagram.

Economically, the area has low petroleum potential because the average sedimentary thickness of 2.626km is very thin for entrapment of crude oil. Also high magnetic anomalies may be associated with igneous and/or metamorphic rocks which have high susceptibility than sedimentary rocks. This implies that the temperature accompanying tectonic activity in the area must have cooked the source rock, if any beyond the oil window phase of maturation [1]. However, the area is viable for ore deposits exploration.

The interpretation of aeromagnetic and land sat data of the study area reveals that the area has a dominant N-S trend which reflects the basin. The present study is therefore in agreement with previous studies which suggested that Nigeria has a complex network of fractures and lineaments with dominant trends of N-S, NE-SW, NW-SE and E-W directions. These linear structures running NE-SW observed from the study are suggested as the continental extension of the known pre-Cretaceous oceanic fracture zones viz; Charcot and Chain fracture zones which run along the trough axis beneath the sedimentary cover [13]. Therefore, the structural and tectonic facts put in were in accordance with those of previous workers.

V. CONCLUSION

Structural interpretation of the area was carried out using aeromagnetic and remote sensing data. The aeromagnetic maps gotten from Geological Survey of Nigeria were digitized at 2cm by 2cm (equivalent to 2km by 2km) grid spacing. The Oasis Montaj software was used to analyze the data to produce different contour and enhanced maps. The total magnetic field intensity map of the area shows a very complex pattern of magnetic anomalies of both short and long wavelength. The area has many closed contours with major anomalies striking north – south. Areas of highly magnetic values could be as a result of magnetic eruption or igneous intrusions to the earth surface. Both the 3 – D and 2- D maps revealed two distinctive relief patterns; low and high relief. The high relief is more tectonically active than the low relief area. This is due to the presence of intrusive bodies. Result from spectral depth calculation showed that the first layer D_1 has an average depth of 3.27km while the second layer depth D_2 has an average depth of 2.626km. 3-D standard Euler method was incorporated in calculating depth to magnetic source body. Results revealed that sills/dykes and horizontal cylinders/pipes are dominant structural/geological features in the area

Land sat Thematic Mapper imagery acquired from Nigeria Airspace Research Development Agency (NASRDA) was used to map linear structures in the study area. With ILWIS software, image enhancement operations were carried out while the Arc View 9.3 software was used to extract lineament and carry out statistical analysis of the interpreted lineament in the area. Result from lineament revealed high concentration of lineament within the basement area. Lineaments cross – cut each and some run parallel to each other. This implies that the area has gone through many tectonic episodes. The lineament revealed two groups of linear features: the maxima having N – S direction and the other trend is NW – SE. Lineament traces were seen along the drainage channels which suggest that they may be lineaments of hydrographic origin and that the rivers may be structurally controlled. Linear structures running NE – SW observed from the study are suggested as the continental extension of the known pre – Cretaceous oceanic fracture zones viz; Charcot and Chain fracture [12] which run along the trough axis beneath the sedimentary cover.

The combined interpretation of airborne magnetic data and landsat imagery data added several significant structural elements that were previously unrecognized from the seperate interpretations of the respective data sets. The lineament density is greater on land sat images than on aeromagnetic data, partly due to the resolution of the land sat data and also because not all land sat lineaments have a magnetic signature. The derived maps revealed several previously undetected linear structures. Some of these linear features correspond to the strike and direction of some paleo structures, fault and tectonically related joints with dominant trend direction of N –S.

REFERENCES

[1] Opara, A. I., Ekwe, A. C., Okereke, C. N.,Oha, I. A. & Nosori, O. P. (2012). Integrating airborne magnetic and land sat data for geological interpretation over part of the Benin basin, Nigeria. The Specific Journal of Science and Technology, 556 - 571

[2] Okereke, C. S. & Onwumesi, G. A 1989. Gravity anomalies in the Nigerian sector of the Mamfe basin. Journal of Minning and Geology 25(1 & 2), 11 – 214.

[3] Fairhead J. D., Okereke, C. S. & Nnange, J. M., 1991. Crustal structure of the Mamfe Basin,West Africa based on gravity Data. Tectonophysics, 186,351-358.

[4] Opara, A. I. 2011. Estimation of the depth to magnetic basement in part of the Dahomey basin, southwesternNigeria. Australian Journal of Basic and Applied Sciences, 5(9), 335 – 343.

[5] Ofoegbu, C. O., & Onuoha, K. M., 1991. Analysis of magnetic data over the Abakaliki Anticlinorium of the lower Benue trough, Nigeria. Marine and Petr. Geol, 8.

[6] Whitten, D. G. A and Brook, J. R. V., 1978. The Penguin Dictionary of Geology. Penguin Books.

[7] O'Leary, D. W., Friedman, J. D., & Phn, H.A., 1976. Lineament, linear, lineation: Some proposed new standard for old terms. Geological Society American Bulletin, 87, 1463-1469.

[8] Nedal Quoud, 2014. Utilization of Space – Borne Imagery for Lithologic Mapping: CaseStudy From Um Had Area, Central Eastern Desert, Egypt. Journal of Geography and Geology 6(2), 113 -123

[9] Akanbi, E. S., & Udensi, E.E. 2006. Structural trends and structural depth analysis of the residual field of Pategi Area, Nigeria; using aeromagnetic data. Nigeria Journal of Physics, 18(21), 271-276

[10] Kogbe, C. A., 1989. The Cretaceous and Paleocene sediments of southern Nigeria. Geology of Nigeria 2nd Edition. Rock View (Nig) Ltd, 325-334

[11] Onyedim, G. C., & Awoyemi, E.A. 2006. Aeromagnetic imaging of the basement morphology in the part of the middle Benue trough. Journal of mining and Geology, 42(2), 157-163.

[12] Ekwueme, B. N 2004. The Precambrian Geology and Evolution of the Southeastern Nigeria Basement Complex. 7 -14

[13] Ananaba, S. E. 1991. Dam sites and crustal megalineaments in Nigeria. ITC Journal 1, 26-29.

Dr. Christopher I. Effiong. "Utilization of Aeromagnetic and Land Sat Data for Structural Interpretation: A Case Study of Ikom-Mamfe Embayment, Southeastern Nigeria." American Journal of Engineering Research (AJER), vol. 7, no. 9, 2017, pp. 232–247.