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Application of Ground and Aeromagnetics as Reconnaissance tool for Hydrocarbon Exploration in Part of Ikom Embayment and Lower Benue Trough, Nigeria.

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Abstract: *In addition to ground magnetic survey carried out in the study area to appraise its hydrocarbon potentials, three aeromagnetic maps on a scale 1:100,000 covering part of Ikom Embayment and Lower Benue Trough were manually digitized and analysed using computer-based programmes such as Hdep, Surfit, Mfinite, Mffilter, Mfdesign, Jmerger, Frtp, Pc Contour, P2 Grid, Oasis Montaj, Geocon And Surfer 9.0 to determine thedepth to basement as well as the configuration of the sub-basins within the study area. The average depth of the shallow and deep basins is 1.5Km and 2.5Km respectively with Nkum axis of the Ikom Embayment having the thickest sediments (about 4.0Km). The presence of few intrusives, thick pile of sediments and faults around Nkum- Edor area of Ikom Embayment indicates that they may have good prospects for hydrocarbon accumulation.*

I. Introduction

The study area extends from south eastern Ikom Embayment basin to lower Benue Trough (fig.1). According to Petters (1991), Ikom Embayment in southeastern Nigeria is a bifurcation of the Benue Trough. It is a sedimentary basin that borders Cross River State of Nigeria and lies within longitude $8^{0}20^{'}$–$8^{0}50^{'}$E and latitude $5^{0}30^{'}$-$6^{0}20^{'}$N. It is bounded to the North and South by the Middle Benue Trough and the Cross River drainage basin respectively; and to the East and West by the Oban Massif and pull-apart basins of the Lower Benue Trough respectively.

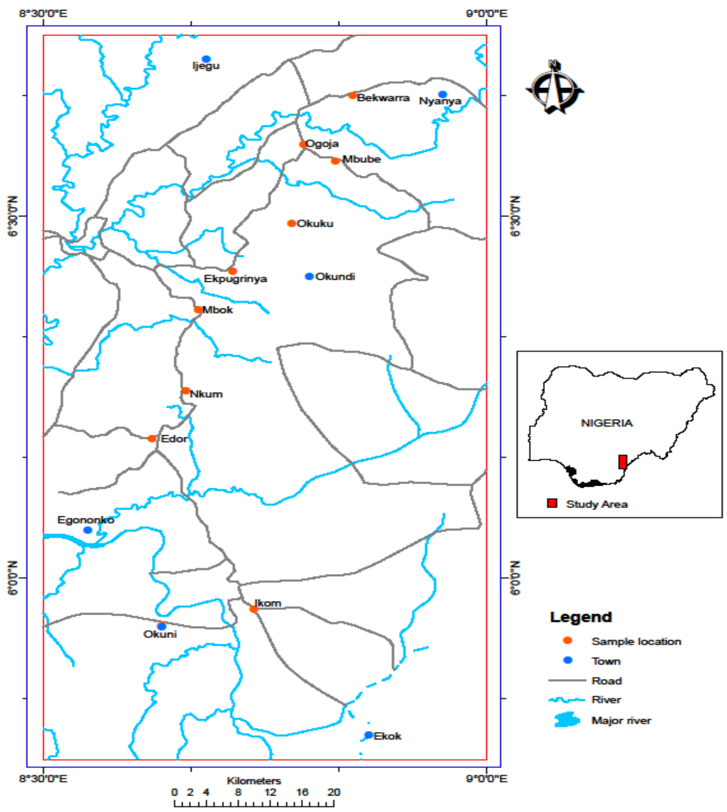


Fig. 1.Loation map of the study area

The Lower Benue Trough is a linear intracratonicgraben trending NE-SW (Obi, et al., 2013) and lying between longitude $8^{0}00^{'}$-$9^{0}30^{'}$E and latitude $5^{0}00^{'}$-$7^{0}00^{'}$N (Kogbe, 1989). However, the study area covers part of Ikom Embayment and part of Lower Benue Trough hence it lies between longitude $8^{0}38^{'}$-$9^{0}00^{'}$E and latitude $5^{0}40^{'}$-$6^{0}50^{'}$N.

Geology of the study area

The origin of the Benue Trough is associated with the separation of Africa and South American continents in the Early Cretaceous (Olade, 1975; Obaje, 2009; Wright, 1985). Tectonic events had folded and faulted the piles of sediments in the Lower Benue Trough and previous geophysical surveys reveal a crustal thinning beneath this sedimentary pile (Okereke et al., 1990; Fairhead and Okereke, 1990) flanked on both sides by linear sub-basins. These sub-basins, according to Nwajide (2013), are pull-apart basins. The oldest sedimentary rocks in the study area belong to the Asu River Group of Middle Albian age, which comprises of shale, limestone and arkosic sandstones deposited in a shallow marine environment (Kogbe, 1989;Reijers, 1996 and Akande et al, 2011). These sediments lieunconformably on the Precambrian Basement (granites and biotite gneisses) (fig. 2).Overlying the Asu River Groupunconformably is the Eze-Aku Formation (Turonian) which comprises of shale, limestone and siltstones (Obi et al., 2013, Onuba et al., 2013). The Ikom Embayment has fossil wood and fish proportheus as its main fossils (Nwajide, 2013).The Basalts (Tertiary) and mineral veins are latter emplacements within these Cretaceous sediments. The Benue Trough is marked by a lot of igneous activity(Coulon et al, 1996). It is also economically important with the occurrence of Lead-Zinc mineralization, brine, barytes and a large reserve of good quality limestone. (Kogbe,1989).

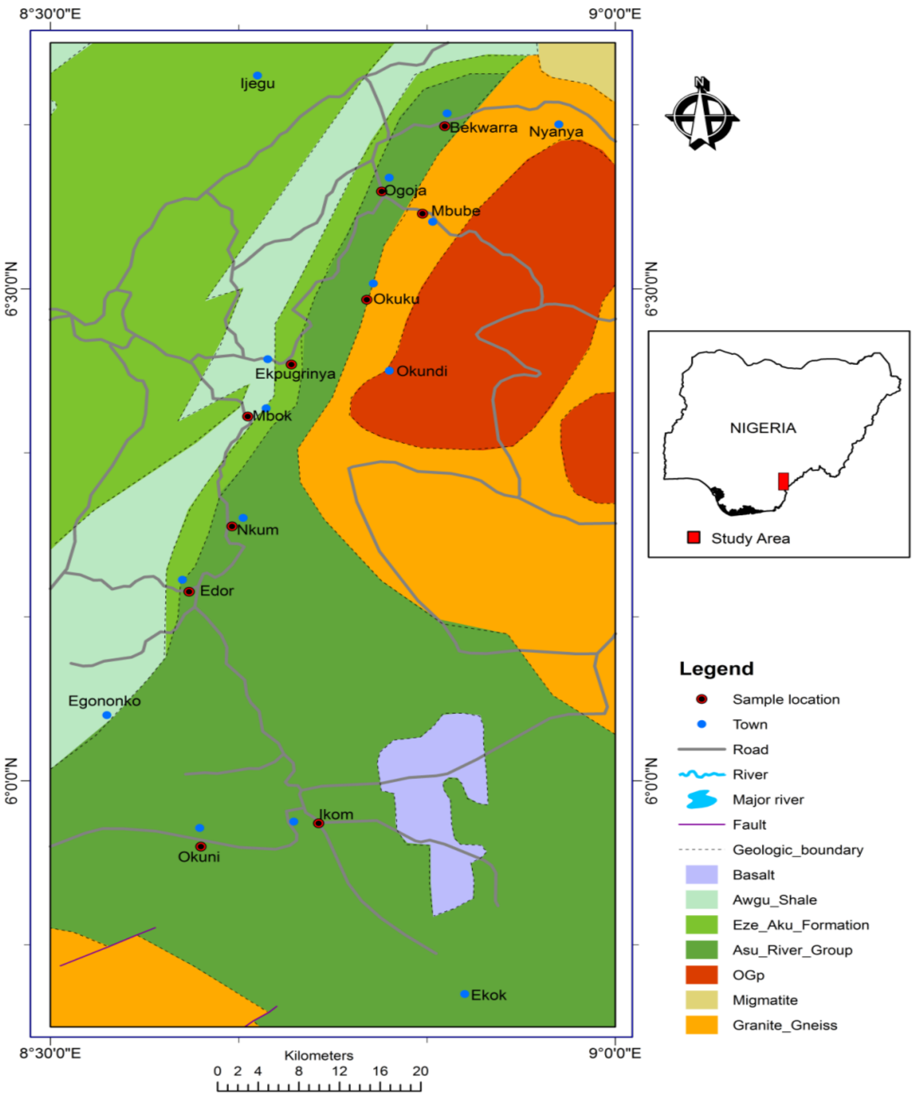


Fig. 2: Geologic Map of the study area

Data analysis

Three half by half (0.5^{o} x 0.5^{o}) degree airborne total magnetic field intensity maps (on a scale of 1:100,000) that cover the study area were digitized at 1cm interval to avoid frequency aliasing. The maps were acquired from the Geological Survey of Nigeria. The flight line and tie line directions for the aeromagnetic survey carried out at an altitude of 500feet were NW-SE and NE-SW respectively. The flight line spacing was 2Km while the tie line spacing was 20Km.

Processing of the digitized maps was done using United States Geological Survey potential field software version 2.2. The software has suite of programmes that were used to process this data namely, A2XYZ, P2GRD, JMERGER, PC

CONTOUR, GEOCON, FRTP, SURFIT, HDEP, MFINITE, MFDESIGN and MFFILTER.The A2XYZ programme was used to convert the data from binary to ASCII (American Standard Code for Information Interchange). JMERGER andP2GRD were used to respectively map-merge and grid the data set before contouring it with PC CONTOUR. The contoured map was viewed using GEOCON before taking it to SURFER 9.0 for final productionof total magnetic field map of the study area (fig. 3).

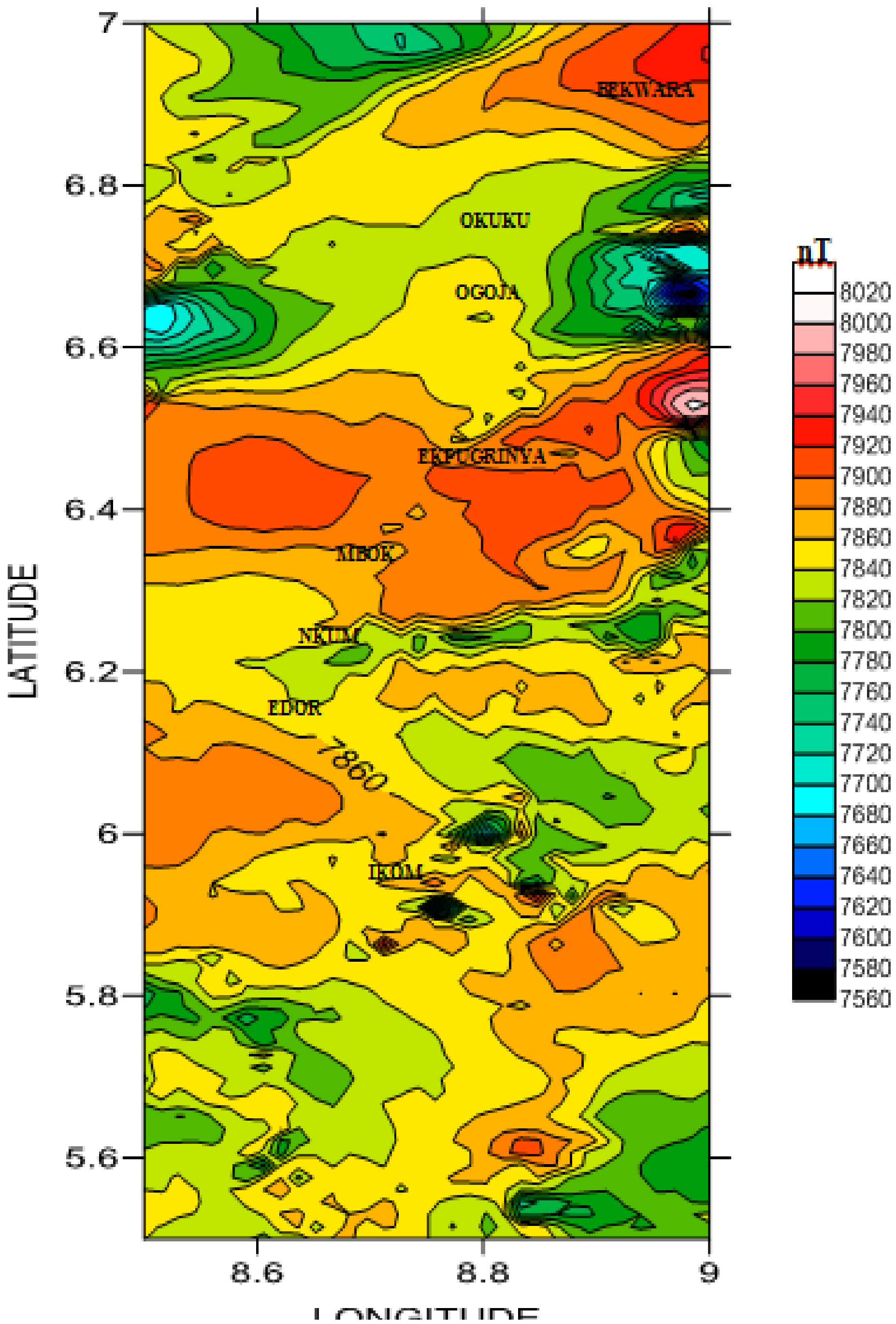


Fig. 3: Total magnetic field intensity map of the study area. (contoured interval of 20nT

Oasis Montaj was also used to produce total magnetic field intensity map of the study area (fig. 4) from ground magnetic survey carried out in ten communities with significant magnetic anomalies as revealed through analysis and interpretation of aeromagnetic data of the study area. Each traverse through these communities was 5Km long with a station interval of 250m and was perpendicular to the regional trend of geologic structures in order to unravel the causative bodies of magnetic anomalies in the study area.

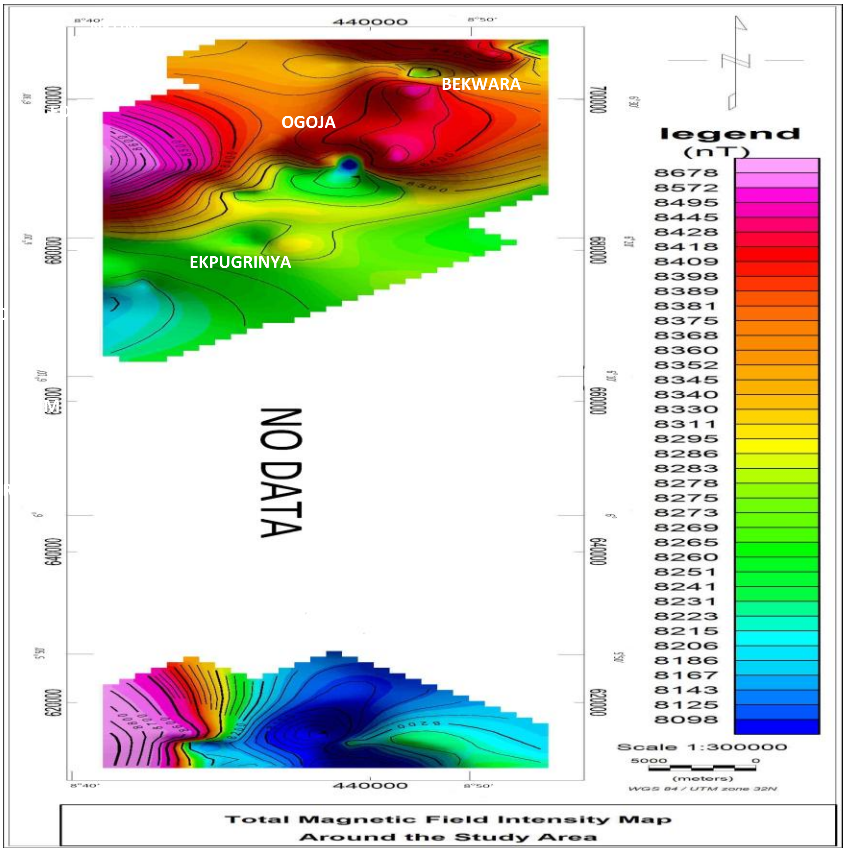


Fig. 4

FRTP programme does reduction to the pole in order to center individual anomalies at their true positions prior to filtering (fig.5). SURFIT uses polynomial fitting technique to filter reduction to the pole data to obtain both residual and regional anomalies which were contoured using PC CONTOUR programme (fig. 6 and 7). For detail understanding of these software programmes, readers should refer to United States Geological Survey potential field version 2.2 and Phillips (1997).

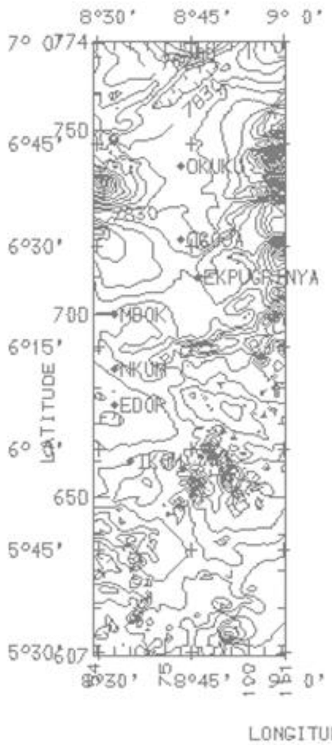


Fig.5: Reduction to pole magnetic field intensity map of the study area

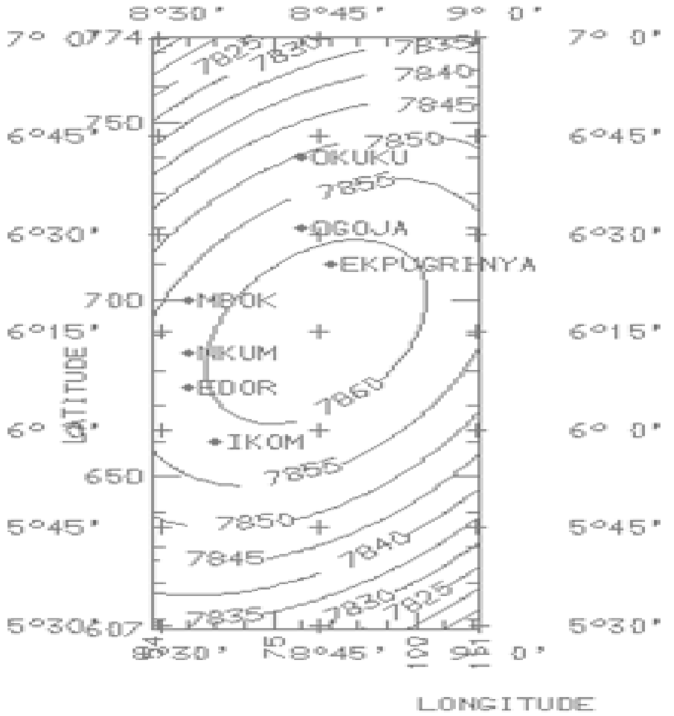


Fig. 6: Regional magnetic anomaly map of the study area.

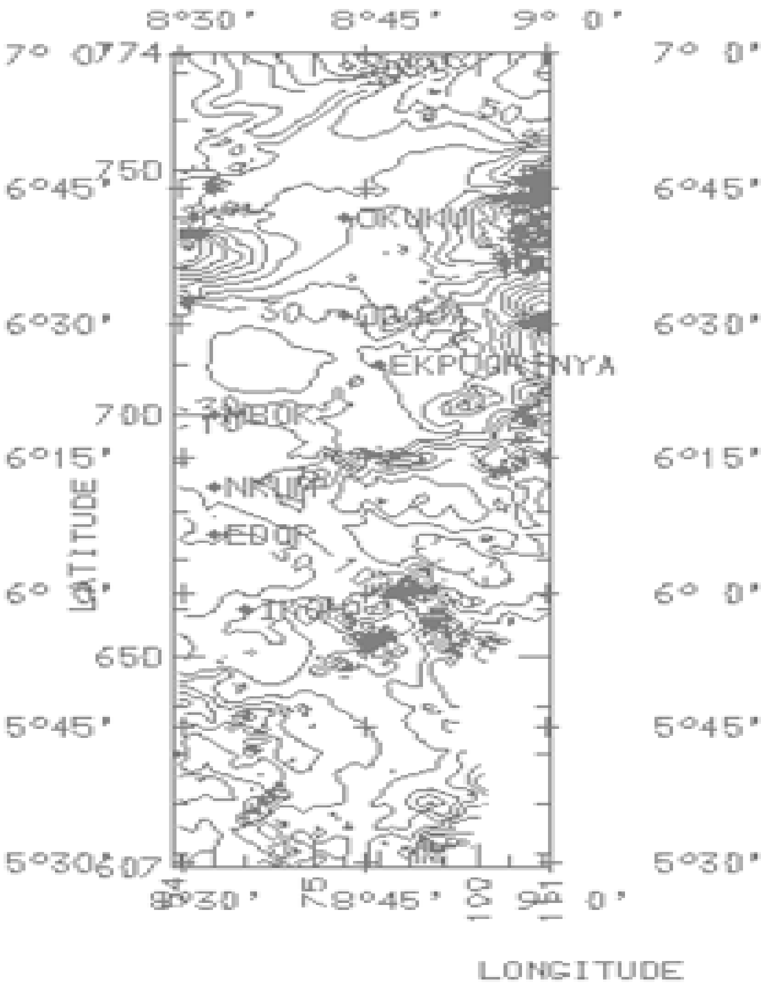


Fig. 7: Residual magnetic anomaly map of the study area.

Depth to magnetic basement was done by HDEP, MFINITE, MFDESIGN and MFFILTERprogrammes. HDEP generated 163 solution points to produce the horizontal gradient magnitude map for the study area (fig. 7). The mathematical concept of reduction to pole and horizontal gradient magnitude is treated in Dobrin et al (1988) and Akani-Hamed (1988).

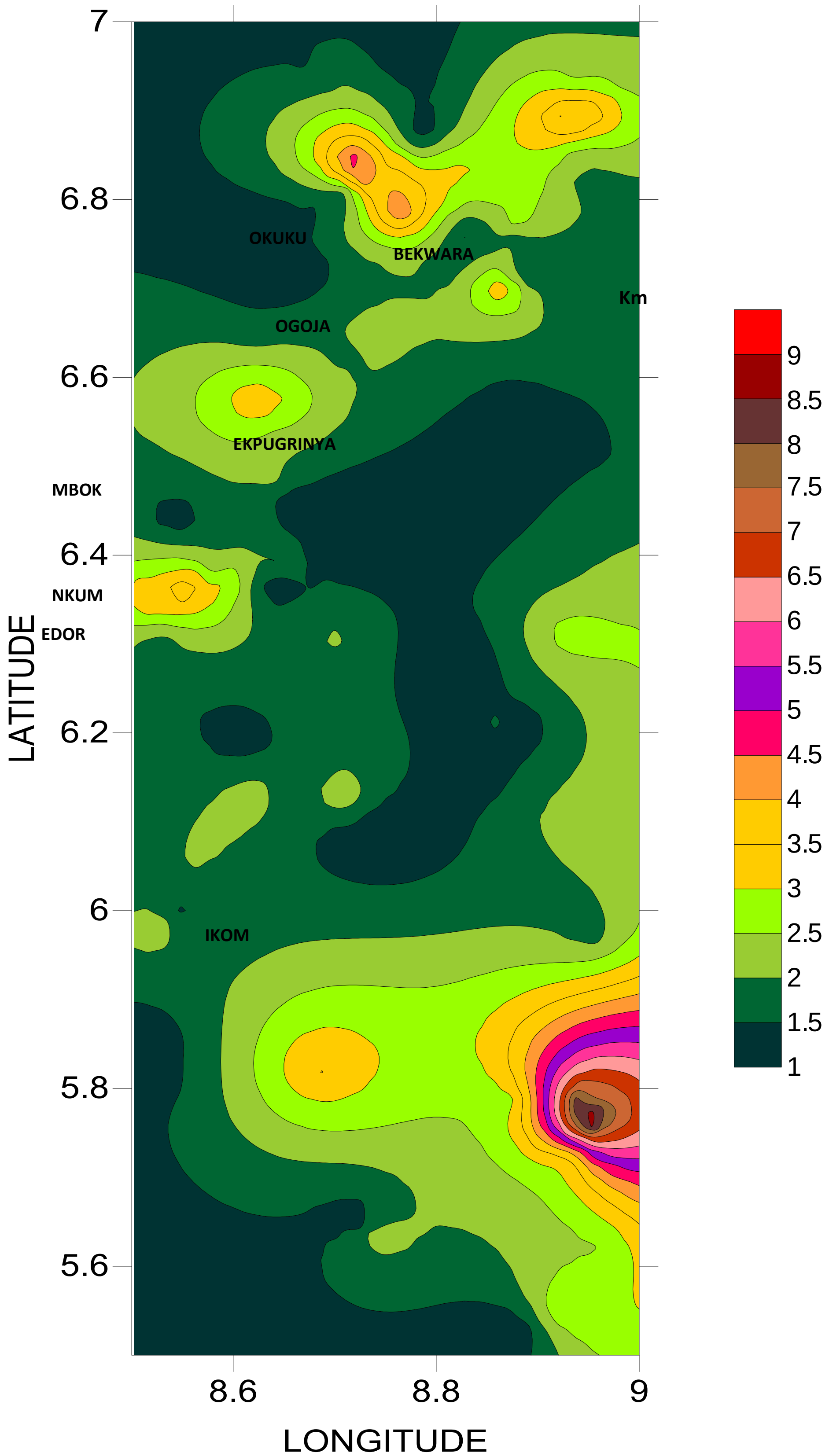
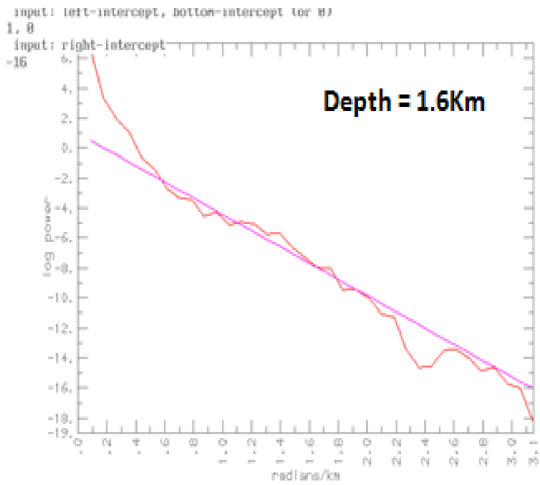
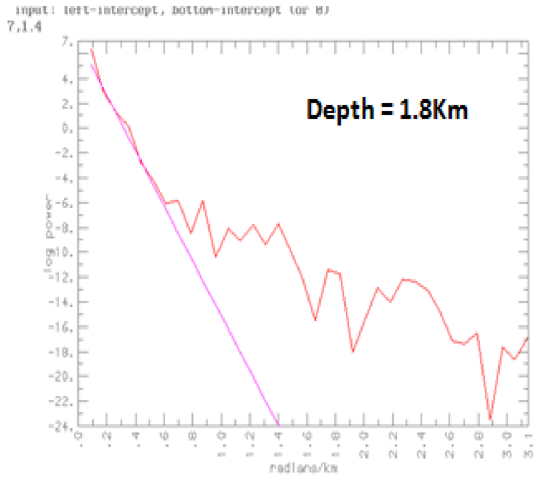


Fig.8 Horizontal gradient magnitude depth map of the study area, contoured at 0.5Km interva

MFINITE and MFDESIGN were used to generate power spectrum plots needed for depth estimation (fig. 9a-e).



a



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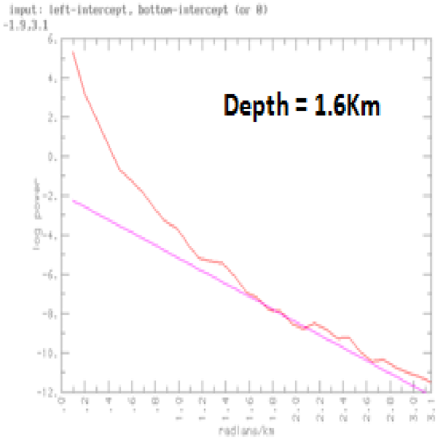

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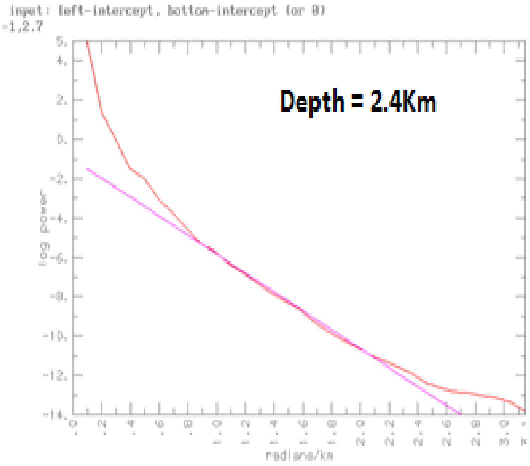

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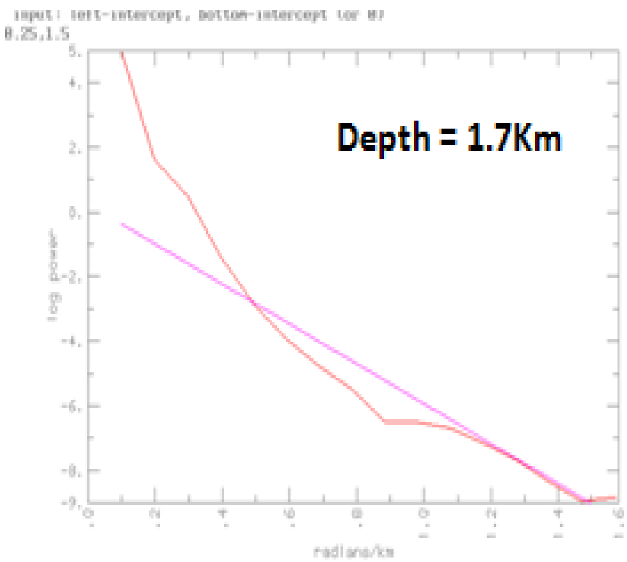


e

Fig. 9a-e: Power spectrum plots for processed layers 1&2 of Ikom, Bansara and Ogoja area respectively

45 depth points were generated and were used to produce the spectral depth analysis map for the study area (fig. 10).

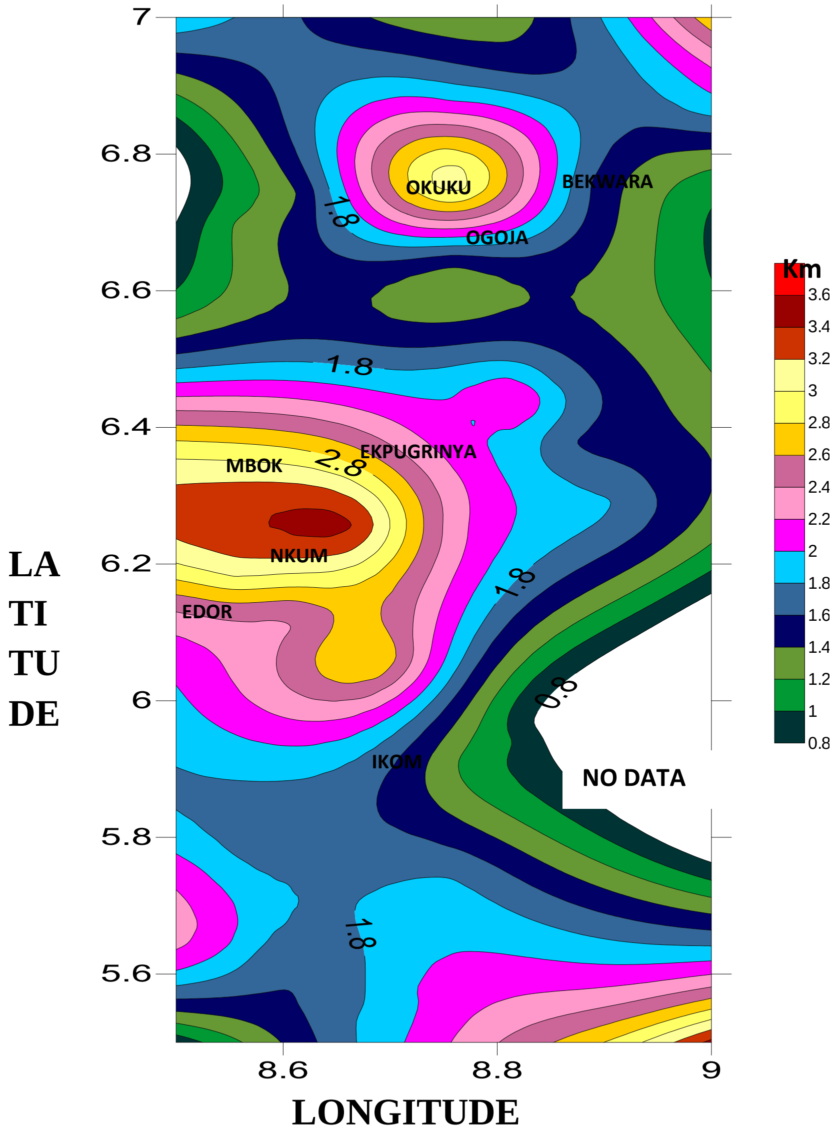
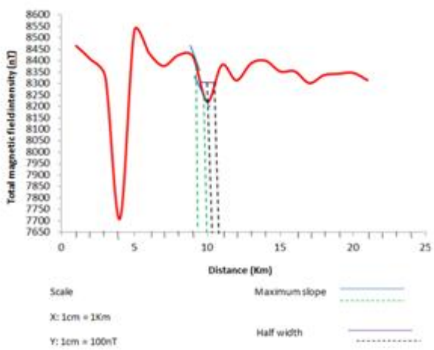


Fig. 10: Spectral depth analysis map of the study area, contoured at 0.2Km interval

The ground magnetic data after being corrected for diurnal variation was copied to Microsoft Excel to generate magnetic profiles, which were employed in manual computation of depth using maximum slope and half-width methods (fig. 12a-h).



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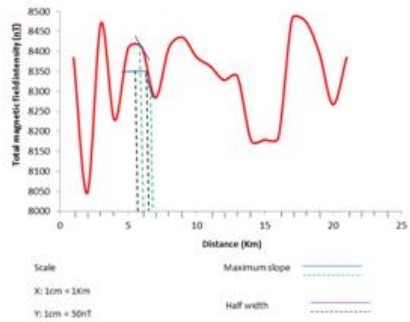

b

Fig. 12: Magnetic profiles across Bekwara, Ogoja, Nkum, Edor, Ikom, Ekpugrinya, Okuni andMbube respectively

Table 1: Depth across the study area, estimated by maximum slope and half width methods

Location	Manual depth estimation from ground magnetic data (using maximum slope method)	Manual depth estimation from ground magnetic data (using half width method)
IKOM	0.8Km	0.7Km
EDOR	1.0Km	1.0Km
NKUM	1.5Km	2.0Km
OGOJA	0.9 Km	1.0Km
BEKWARA	0.8Km	0.6Km
OKUNI	0.8Km	0.9Km
MBOK	0.7Km	1.0Km
EKPUGRINYA	0.9Km	1.1Km
OKUKU	1.1Km	1.0Km
MBUBE	0.5Km	0.5Km

II. Discussion of results

Though there is variation in the depth estimated by manual and computer-based techniques, it is obvious that in all the techniques, Nkum remains the deepest basin in the study area. Results of Horizontal Gradient Magnitude depth to basement analysesreveal that the average depth of shallow and deep basins in the study area is 1.5Km and 2.5Km respectively. However, Nkum area has the thickest pile of sediments averaging 4.0Km. The sediments thicknesses decrease southwards towards Ikom, averaging 2.0Km around Ikom.Ogoja-Okuku area also has thick piles of sediments averaging 3.0Km around Okuku. While the regional anomaly map of the study area reveals a NE-SW lineament trend, the residual anomaly map points out areas of thick sediment accumulation with low negative magnetic anomaly values of -10 to -30nanotesla and areas with possible intrusives having values of +30 to +50nanotesla, while the basement has magnetic anomaly values greater than zero to +10nanotesla. This variation in magnetic anomaly values portrays a horst-graben configuration in the study area thus corroborating earlier works done by Okereke et al (1990) and Obi et al (2013).

III. Conclusion

Aeromagnetic and ground magnetic analysis and interpretation have revealed depths to the magnetic basement as well as basinal configuration of the study area, with NE-SW structural trend being dominant. The depth estimates and structural analysis have pointed out that Nkum-Edor area in Ikom Embayment and Ogoja-Okuku area in Lower Benue Trough have moderate to good prospects for hydrocarbon accumulation. The study serves as a reconnaissance tool prior to seismic reflection surveys for hydrocarbon investigation.

References

[1]. Akande, S. O., Eghenhoff, S. W., Obaje, N. G. and Erdtmann, B. D. (2011). Stratigraphic evolution and petroleum potentials of Middle Cretaceous sediments in Lower and Middle Benue Trough. *Petroleum Technology Development Journal* 1, pp. 1-34.-

[2]. Akani-Hamed, J. (1988). Differential reduction to the pole of regional magnetic anomalies. Geophysics 53 (12), pp. 1592-1600.

[3]. Coulon, C., Vidal, P., Dupuy, C., Baudin, Popoff, M. Maluski, H. and Hermitte, D. (1996). The Mesozoic to Early Cenozoic Magmatism of the Benue Trough (Nigeria); Geochemical Evidence for the Involvement of the St Helena Plume. *Journal of Petrology*37 (6), pp. 1341–1358.

[4]. Dobrin, M. B and Savit, C. H. (1988). Introduction to geophysical prospecting (4th Ed.). Newyork: McGraw-Hill Book Company.

[5]. Fairhead, J. D. and Okereke, C. S. (1990). Crustal thinning and extension beneath the Benue Trough based on gravity studies. *Journal of African Earth Sciences.* 11 (3/4), pp.329-355.

[6]. Kogbe, C. A. (1989). Geology of Nigeria. Nigeria: Rock View Ltd, pp. 366-368.

[7]. Nwajide, C. S. (2013). Geology of Nigeria's sedimentary basins. Nigeria: CSS Press, pp. 131-182.

[8]. Obaje, N. G. (2009). The Benue Trough.*Geology and Mineral Resources of Nigeria. Springer,* pp.57-65.

[9]. Obi, D. A., Obi, E. O. &Okiwelu, A. A. (2013). Basinal configuration and IntrasedimentIntrusives as revealed by Aeromagnetics data of South East Sector of Mamfe Basin, Nigeria. *IOSR Journal of Applied Geology and Geophysics 1, pp. 1-8.*

[10]. Okereke, C. S., Ofoegbu, C. O. &Ezeayim, V. I. (1990). Cretaceous sediment thickness in the Benue Trough Gravity Interpretation. In D. A. Obi , E. O. Obi & A. A. Okiwelu (Eds.), Basinal configuration and IntrasedimentIntrusives as revealed by Aeromagnetics data of South East Sector of Mamfe Basin, Nigeria, *OSR-JAGG*, pp. 1–2.

[11]. Olade, M. A. (1975). Evolution of Nigeria's Benue Trough (Aulacogen): A tectonic model. Geological Magazine 112, pp. 575-583.

[12]. Onuba, L. N., Onwuemesi, A. G., Egboka, B. C., Anudu, G. K. and Omali, A. (2013). A review of hydrocarbon prospects in the Lower Benue Trough, Nigeria: Another insight from potential field study. *Search and Discovery article,* 20194, pp. 1-11.

[13]. Petters, S. W. (1991). Regional Geology of Africa. Germany: Springer Verlag Berlin Heldenberg, pp. 595-601.

[14]. Phillips, J. D. (1997). Potential field geophysical software for the PC, version 2.2. *United States Geological Survey Open File Report* 97-725, pp. 1-32.

[15]. Reijers, T. J. A. (1996*). Selected Chapters on Geology*. Nigeria: SPDC Corporate Reprographic services, pp. 106-107.

[16]. Wright, J. B. (1985). The Benue Trough. *Geology and mineral resources of West Africa*. Springer, p. 98.