IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 10, Issue 5 Ver. III (Sep. – Oct. 2018), 39-47
www.iosrjournals.org

Investigation of Magnetic Anomalies Of Lokoja And Dekina Areas, Lower Benue Troughnigeria, Using High Resolution Aeromagnetic Data

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Abstract: *The airborne magnetic data of Lokoja and Dekina, lower Benue Trough,Nigeria have been interpreted qualitatively and quantitatively. Two aeromagnetic data sheets covering an area bounded by latitudes 7° 30' to 8° 00' North and longitudes 6° 30' to 7° 30' East were used for this study.Regional anomaly was removed from the total magnetic intensity field to obtain the residual anomaly field using polynomial fitting. The total magnetic intensity and residual intensity field showed range of magnetic anomalies which reveal that the study area is magnetically heterogeneous. Forward and Inverse modeling techniques were employed in quantitative interpretation with the aim of determining magnetic susceptibilities and type of mineralization prevalent in the area. The result from the forward and inverse modeling analysis of airborne magnetic data shows that susceptibility values obtained from the modeled profiles 1 - 5 are 0.0003,0.0002,0.025,0.040,0.0009 SI respectively, with respective depths of 2607, 2911, 1477, 1627 and 1874 m. The modeling of the residual map revealed some minerals in the study area, which are; Casseterite, Clay and rock bearing minerals like Granite, limestone, Dolomite and marble. The study area has revealed potentials for mineral deposit, which could serve as raw material(s) for many factories and industries in Nigeria.*

Keywords *: Airborne magnetic data, forward and inverse modeling, lower Benue Trough.*

Date of Submission: 01-11-2018 Date of acceptance: 15-11-2018

I. Introduction

Magnetic surveying is an aspect geophysical survey that investigate the subsurface of the earth based on the variations in the earth magnetic field which result from the magnetic properties of the underlying rock. Rocks differ in their magnetic mineral content; hence the magnetic anomaly map allows a visualization of the geological structure of the upper crust in the subsurface particularly the spatial geometry of bodies of rock and the presence of faults and folds. The main purpose of magnetic survey is to detect rocks or minerals possessing unusual magnetic properties that reveal themselves by causing disturbances or anomalies in the intensity of the earth's magnetic field. The purpose of magnetic surveying is to identify and describe regions of the earth's crust that have unusual (anomalous) magnetization. It can be carried out on land (ground survey), at sea (marine borne) and in air (air borne). The airborne magnetic survey is an important aspect of magnetic surveying that allows faster and usually cheaper coverage of large exploration area. The aeromagnetic survey is carried out using magnetometer attached behind an aircraft. The principle is similar to a magnetic survey carried out with a hand-held magnetometer, but allows much larger areas of the Earth's surface to be covered quickly for regional reconnaissance. The aircraft typically flies in a grid-like pattern with height and line spacing determining the resolution of the data (and cost of the survey per unit area). As the aircraft flies, the magnetometer records tiny variations in the intensity of the ambient magnetic field due to the temporal effects of the constantly varying solar wind and spatial variations in the Earth's magnetic field because of the regional magnetic field, and the local effect of magnetic minerals in the Earth's crust (Telford et al., 1990; Robinson and Coruh, 1998).

No geophysical work on the determination of magnetic susceptibility and possible mineralization using forward and inverse technique has been carried out on aeromagnetic data of Lokoja andDekina areas, though some work have been done in Lower Benue trough in which the study area falls. Some of them are Ofoegbu (1984), Ugwu and Ezema (2012), Ugwuet al. (2013), Ezemaet al. (2014), Obioraet al. (2018). In order to contribute to the understanding of geology and solidmineral potentials of the Trough, we have considered the use of aeromagnetic survey to delineate the subsurface structures which control the anomalous mineralization zones. Forward and inverse modeling techniques have been employed for this purpose. This is with a view to delineating the areas of possible magnetic intrusions and their lateral and vertical extents.

GEOLOGY OF THE STUDY AREA

The study area lies between latitudes 7° 30' to 8° 00' North and longitudes 6° 30' to 7° 30' East. It is located within parts of Southern Benue Trough of Nigeria and Anambra Basin. Benue Trough is part of West African central rift. Sedimentation in the Southern Benue Trough commenced with the deposition of the Asu River group. The Asu River group comprises of the shales, limestones and sandstones lenses of the Abakiliki Formation in the Abakiliki area and the Mfasoming limestone in the calabar flank (Peters,1982). Ojoh (1992) also reported some pyroclastic of Aptian-early Albian ages. Awi Formation is the basal, non- calcareous, sandy conglomeratic unit of Asu River Group directly overlying the basement complex (Oban Massif north of calabar). The Cenomanian-Turonian Nkalagu formation and the interfingering regressive sandstones of the Agala and Agbani Formation are resting on the Asu River group. The Ogoja sandstone, the basal aspects of the Asu River Group directly overlying the basement complex have been characterised as consisting of conglomerates and arkosic sandstones in both Ikom and ogoja areas (Uzuakpunwa,1980;Peters et al.,1987). The Eze- Aku Group: The “Eze-Aku Group” includes all the stratigrphic units deposited in the late Cenomanian to Turonian in the southern Benue Trough and in the southern parts of the central Benue Trough (Nwajide,2013). These comprises of Eze-aku shales and the correlative units, the Konshisha Group, Amaseri sandstone, Nkalagu Limestone, the Igala sandstone and the Igumale sandstone. The Igumale formationunit is a lateral equivalent of the makurdi Formation based on stratigraphic position. The Awgu Formation lies within the southern segment of the trough. It conformably overlies the facies of the Ezeaku Group. The succession commonly consists of the shale, sandstone and limestone. The age of Awgu formation span from late Turonian through Coniacian to early Santonian has been suggested by (Nwajide,2013). The age of the Agbani Formation is thought to be largely same as for the Awgu formation.Following Mid-Santonian tectonism and magmatism, depositional axis in the Benue Trough was displaced westward resulting in subsidence of the Anambra basin (Nwajide,2013). Being a related structure that developed after the compressional stage, they implied that it was logical to include the Anambra basin in the Benue Trough.Nwajide (2013), showed that the Anambra basin is a distinct and well demarcated lithostratigraphic entity overlying the Southern Benue Trough and is in turn overlain in its southern part by the Niger Delta Basin. The lithostratigraphic units that filled the Anambra Basin have been divided into two groups: the Nkporo group and the coal measures (Nwajide,2013) overlie the Nkporo shale. This consists of fine grained sand, carbonaceous shales and coal with the thickest seam of l km typifying a transitional environment. Its type locality is the Enugu Cuesta. The Ajali Sandstone (Middle coal measures) overlies the Mamu Formation conformably. The Nsukka Formation (Upper coal measures) is the youngest formation from this cycle consisting of interdigitations of very finegrained sandstones, dark shale and coal indicating a parallic environment of Maastrichtian to Paleocene age. Fig 1 is the geology of the area

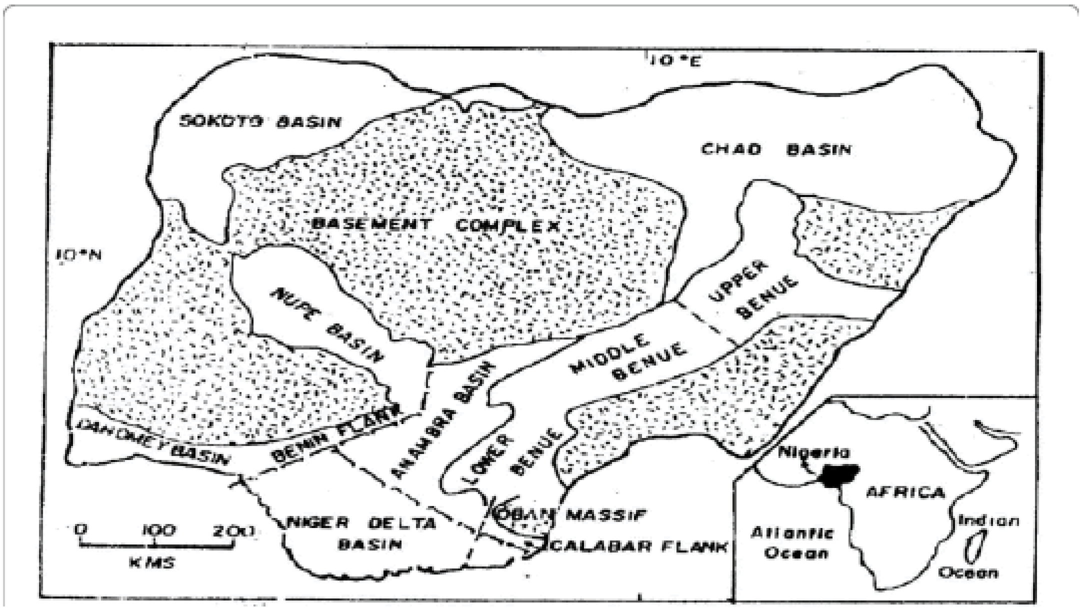

Figure .1 Map of Nigeria showing the study area (Nwajide,2013)

II. Materials

The high resolution airborne magnetic data of Lokoja (sheet 247) and Dekina (sheet 248), used for this study, were obtained from the Nigerian Geological Survey Agency (NGSA). The airborne magnetic survey was flown at 80 m elevation along flight lines spaced 500 m apart. The flight line direction was 135° while the tie line direction was 225°. The geomagnetic gradient was removed from the data using International Geomagnetic

Reference Field (IGRF). The two sheets were merged into a single composite sheet which formed the study area using Ms Excel software. Other data reduction techniques applied include : the regional – residual separation first vertical and the horizontal derivatives calculations.

METHOD

Five profiles were taken from the aeromagnetic residual grid (Figure 7) of the study area and modeled. Each profile produced a degree of strike, dip and plunge where the observed values matched well with the calculated values. The blue curves in Figure 8(a - e) represent the observed field values while the red curves represent the calculated field values. The forward modeling being a trial and error method, the shape, position and physical properties of the model were adjusted in order to obtain a good correlation between the calculated field and the observed field data. The field of the model was calculated using PotentQ 3D tool of the Oasis Montaj software. The root mean square (RMS) difference between the observed and calculated field values was minimized by the inversion algorithm. The RMS value was displayed at the end of the inversion. The RMS value decreased as the fit between the observed and calculated field continues to improve, until a reasonable inversion result was achieved. Less than 5% of root mean square value was set as the error margin.

III. Results And Discussion

The two-dimension (2D) TMI map is shown in Figure 2. The analysis of the map shows the general magnetic susceptibility of basement rocks and the inherent variation in the basin under study. The map is presented as colour map for easy interpretation. The coloured maps aided the visibility of a wide range of anomalies in the magnetic maps and the ranges of their intensities were also shown. Areas of strong positive anomalies likely indicate a higher concentration of magnetically susceptible minerals (principally magnetite). Similarly, areas with broad magnetic lows are likely areas of low magnetic concentration, and therefore lower susceptibility. The Total Magnetic Intensity (TMI) of the study area ranges from -92.9 nT (minimum) to 149.6 nT (maximum).

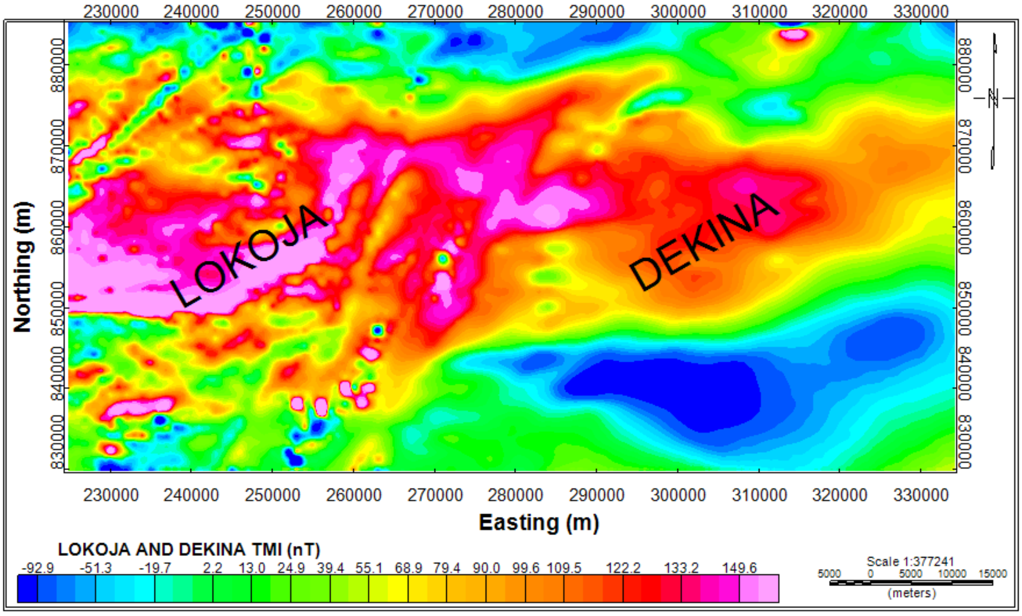

Figure 2: Two dimension (2D) view of TMI of the study area

Figure 3 is the 2D residual magnetic intensity map of the study area obtained from the total magnetic intensity map using Oasis montaj software. The 2D residual map of the study area revealed that the magnetic field intensity ranges from -144.4 nT (minimum) to 94.4nT (maximum). This indicates that the study area is characterized by low (blue colour) and high (pink colour) magnetic signature.

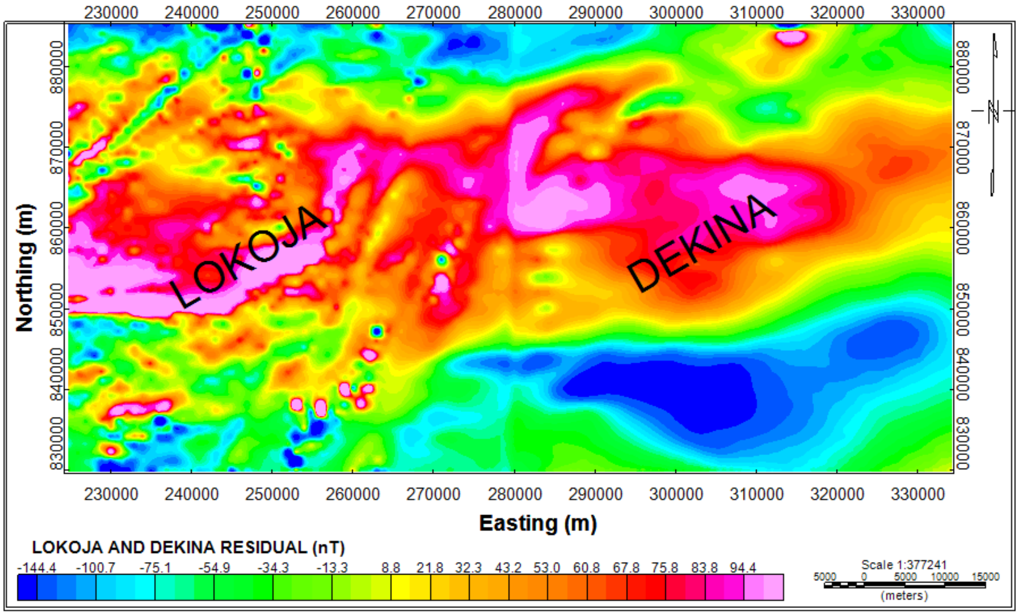

Figure 3: Two dimension (2D) view of residual map of the study area

The regional magnetic intensity map of the study area (Figure. 4) was produced using Oasis Montaj software. The regional magnetic values ranges from 33.0 nT to 72.9 nT and the value is lowest in the Dekina part, indicating there is a fill of sediments more in the Dekina part of the study area.

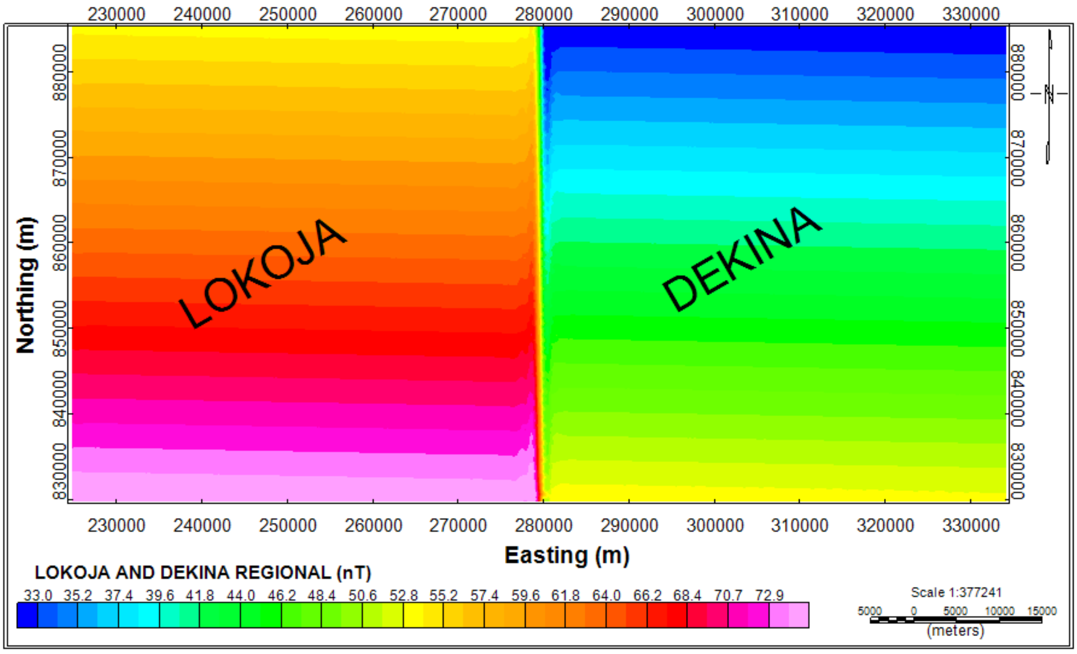

Figure. 4: 2D Regional Magnetic Intensity Map

The first vertical derivative computed on the residual data of the study area enhanced the shallow sources by suppressing the effect of the deeper ones, this helped to reveal near surface intrusions in (Figure 5). The second derivative sharpens the effect of the first vertical derivatives and helps to determine the edge of the anomalous body in (Figure 6).

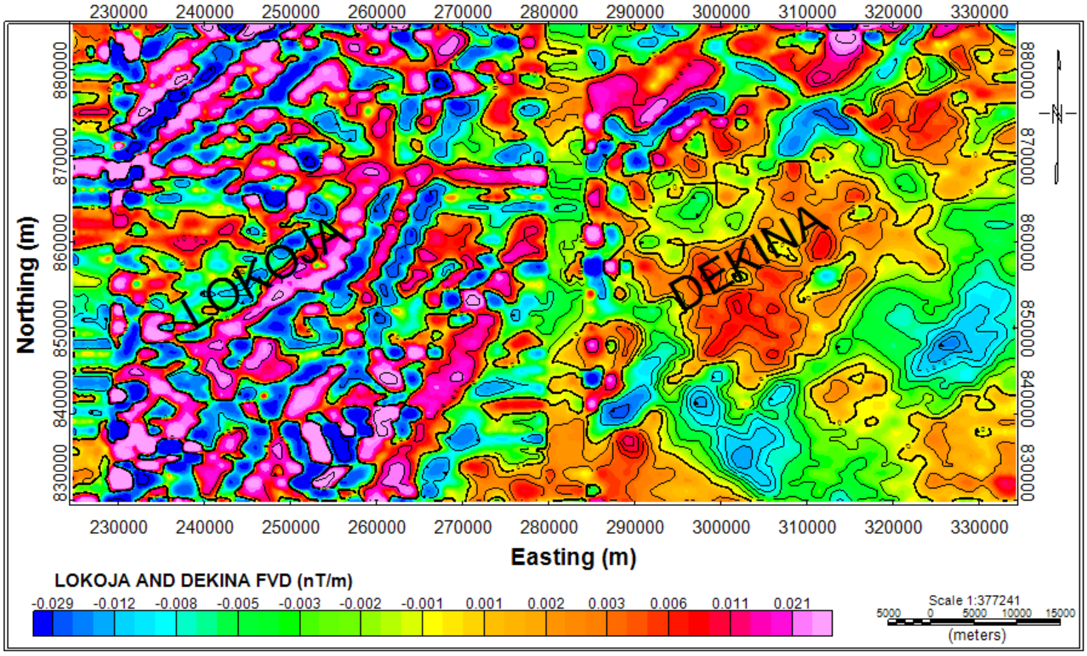

Figure. 5: Aeromagnetic First Vertical Derivative (FVD)

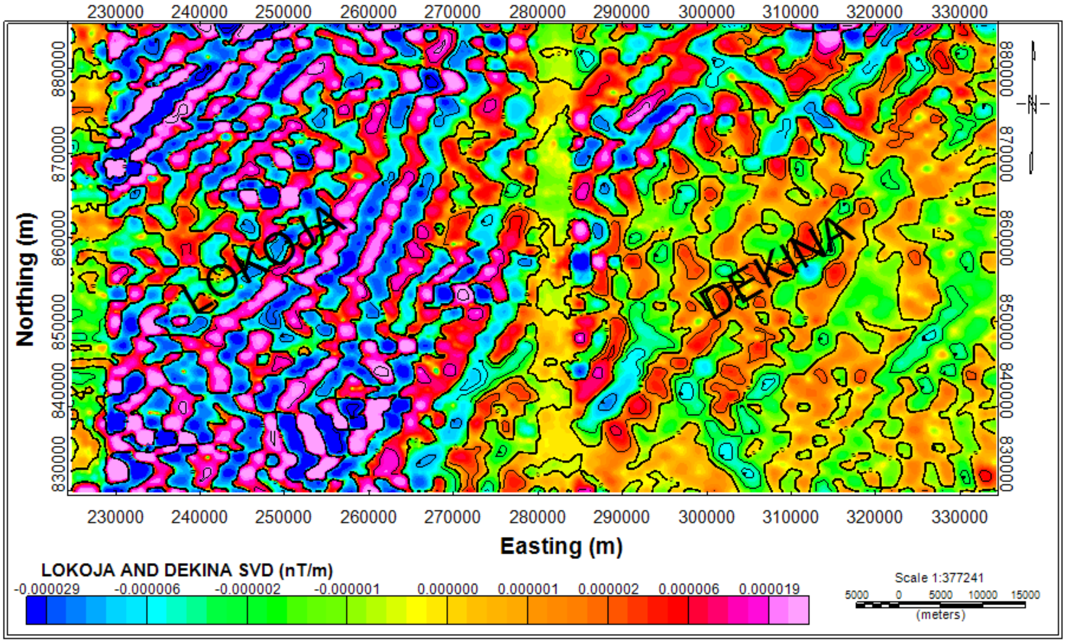

Figure. 6: Aeromagnetic Second Vertical Derivative (SVD)

The modelled parameters used in modelling the five selected profiles (figure. 7) are shown in Figure. 8 (a - e). The results of the forward and inverse modeling are summarized in Table 1. These results show that susceptibility values obtained from the modeled profiles 1 - 5 are 0.0003,0.0002,0.025,0.040,0.0009 SI respectively, with respective depths of 2607, 2911, 1477, 1627 and 1874m.

This indicates the presence of minerals like Casseterite, Clay and rock bearing minerals like Granite, limestone, Dolomiteand marble in the study area. This is according to Telford et al. (1990) who showed that different minerals and rock bearing minerals have a particular magnetic susceptibility or range of magnetic susceptibilities assigned to each of them.

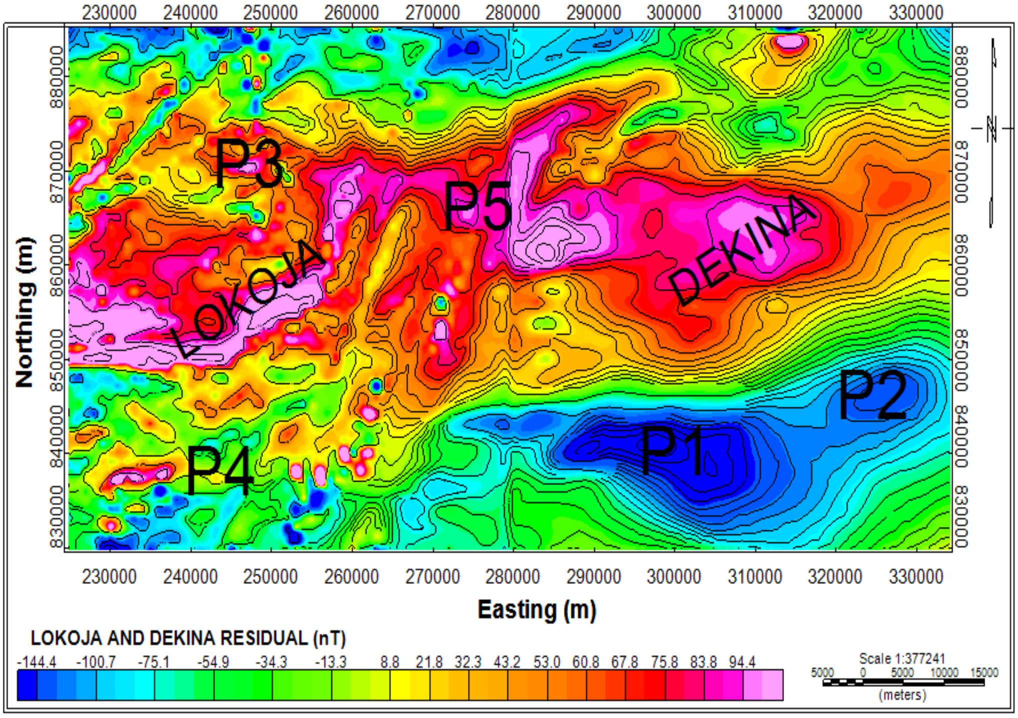

Figure 7: Residual grid of the study area

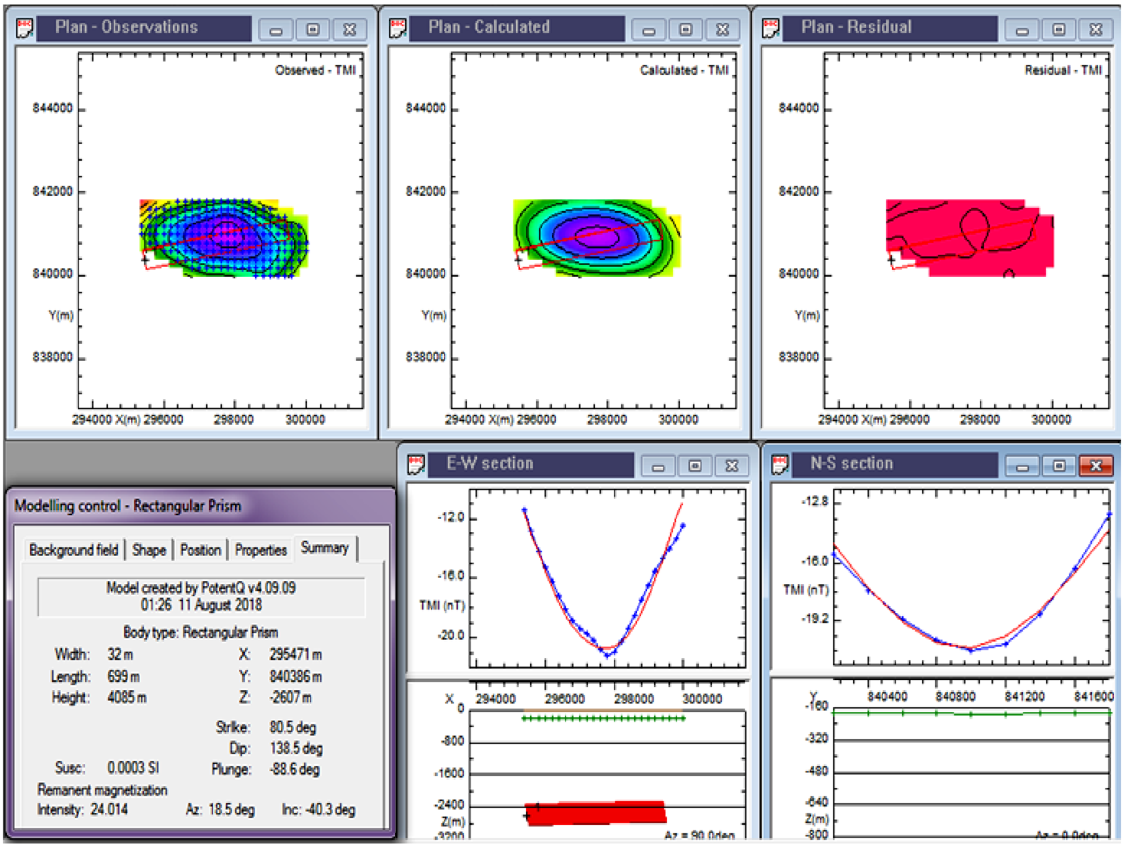

Figure 8a: Profile 1 (P1) modeled

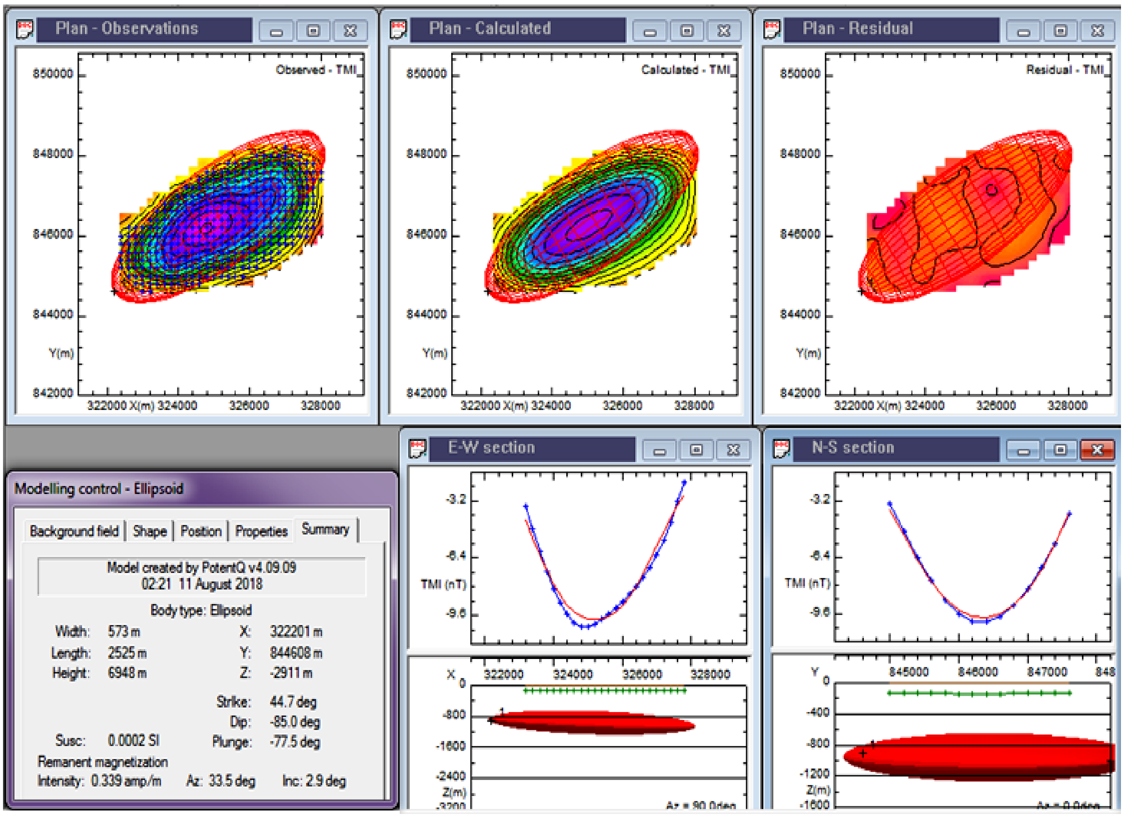

Figure 8b: Profile 2 (P2) modeled

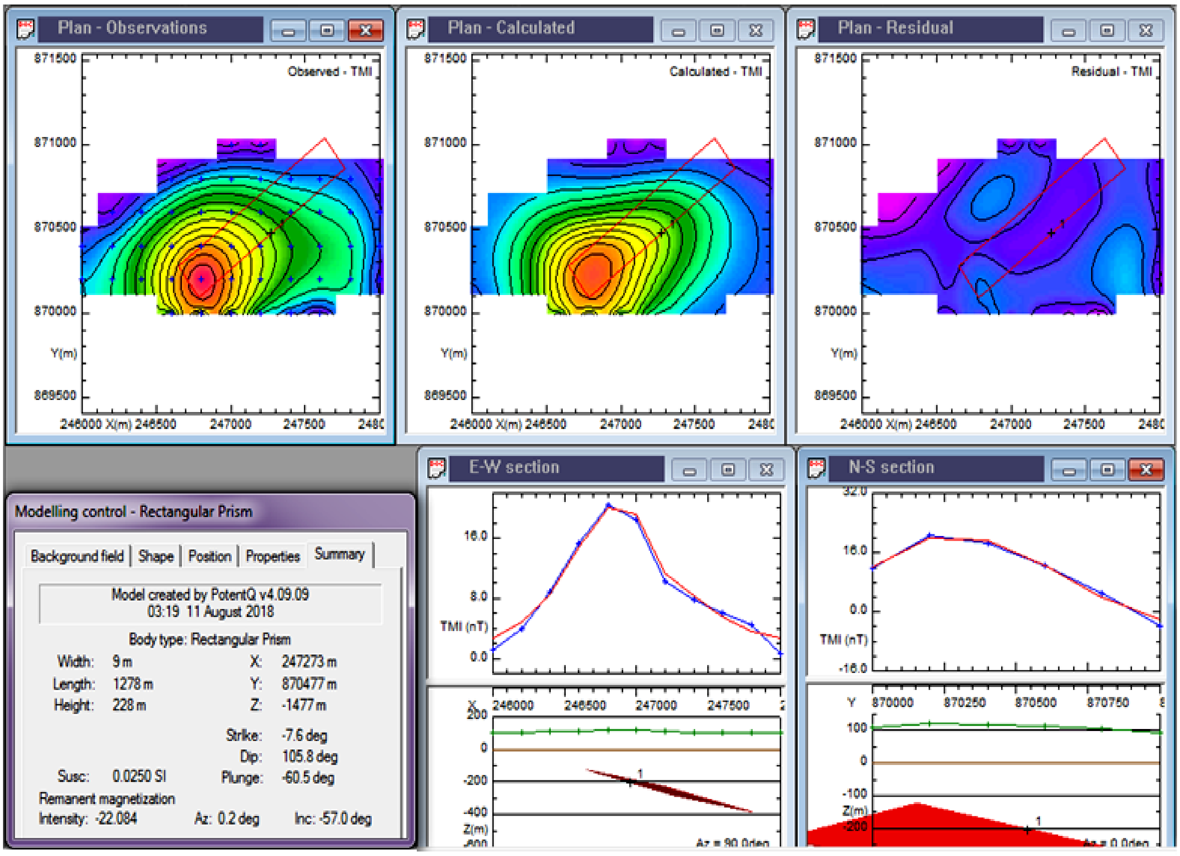

Figure 8c: Profile 3 (P3) modeled

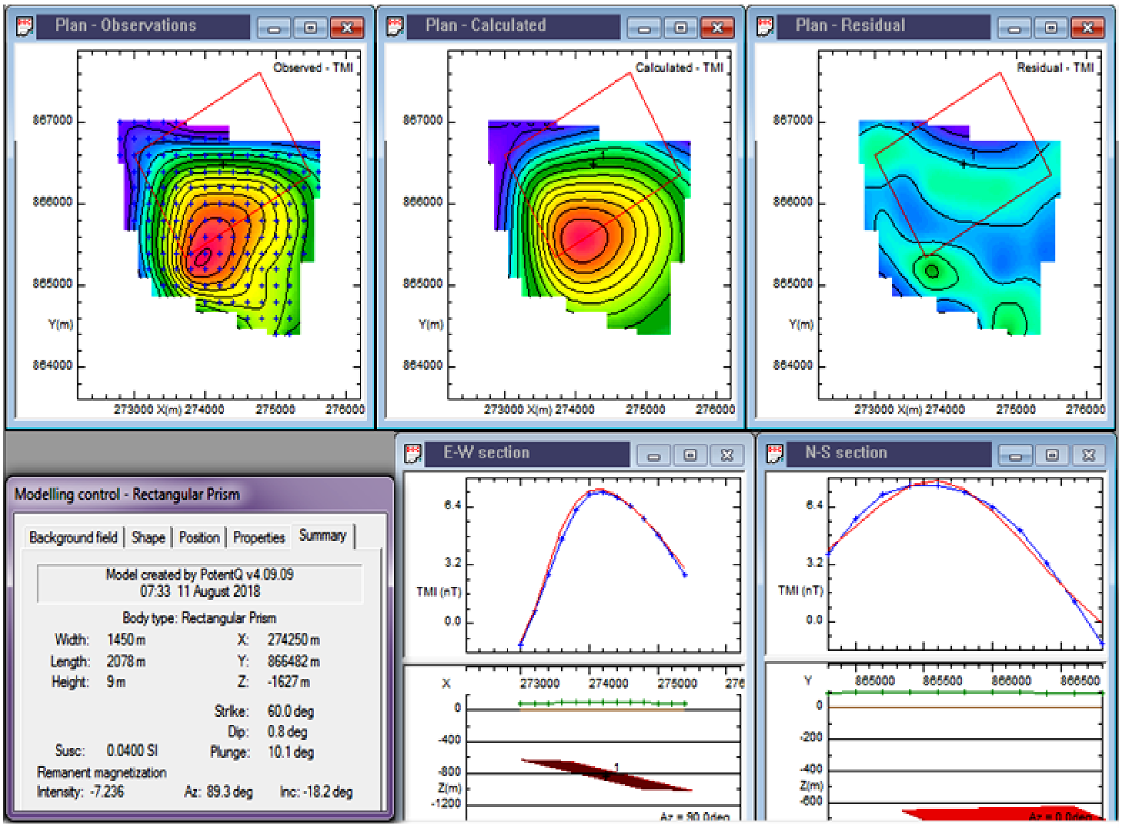

Figure 8d: Profile 4 (P4) modeled

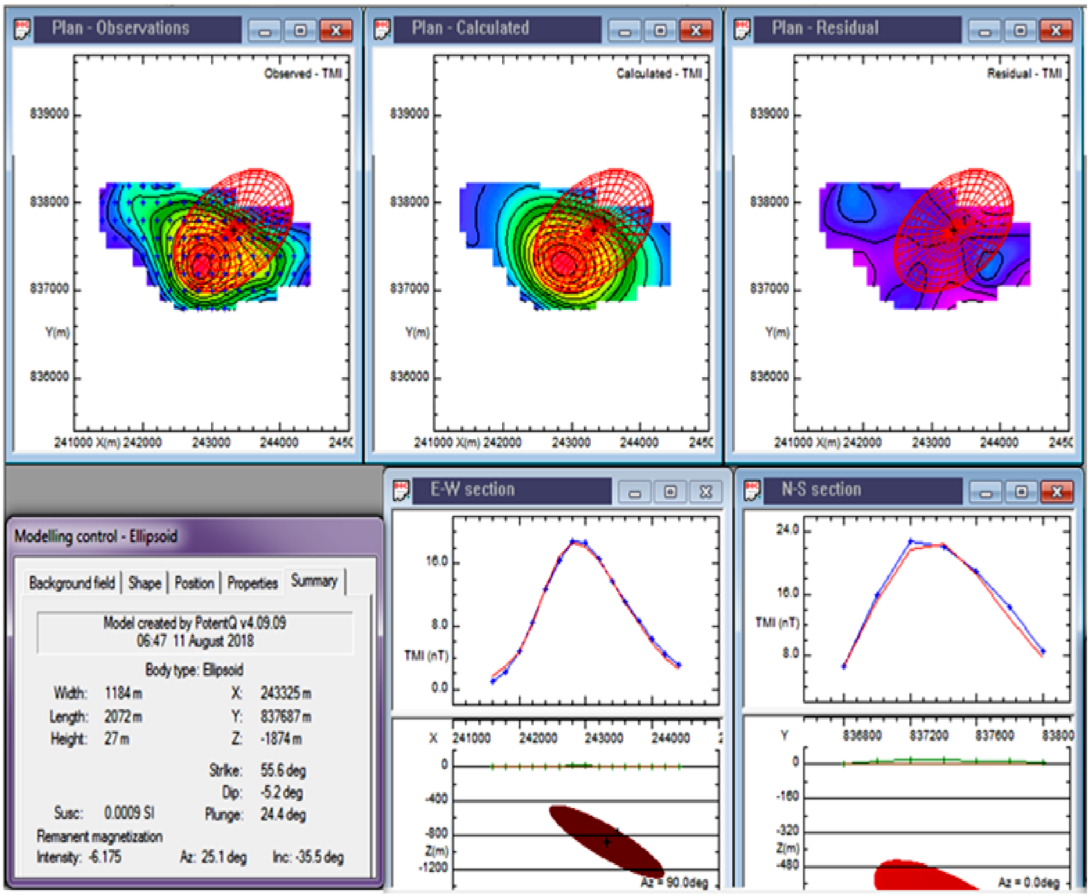

Figure 8e: Profile 5 (P5) modeled

Table 1: Summary of Aeromagnetic Forward and Inverse modelling results

Model	Model shape	X(m)	Y(m)	Depth to anomalous body (m)	Plunge (deg)	Dip (deg)	Strike (deg)	K-value (SI)	Possible cause of anomaly
P1	Rectangular Prism	295471	840386	2607	-88.6	138.5	80.5	0.0003	Limestone
P2	Ellipsoid	322201	844608	2911	-77.5	-85.0	44.7	0.0002	Clay
P3	Rectangular Prism	247273	870477	1477	-60.5	105.8	-7.6	0.025	Marble
P4	Rectangular Prism	274250	866482	1627	10.1	0.8	60.0	0.040	Granite
P5	Ellipsoid	243325	837687	1874	24.4	-5.2	55.6	0.0009	Dolomite/Cassiterite

IV. Conclusion

The airborne magnetic data of Lokoja and Dekina area have been interpreted qualitatively and quantitatively. The total magnetic intensity and residual intensity field showed range of magnetic anomalies which reveal that the study area is magnetically heterogeneous. The magnetic lineament map showed the occurrence of subsurface linear structures which could be the presence of faults in the study area. Forward and Inverse modelling technique was employed in quantitative interpretation with the aim of determining the magnetic susceptibilities and type of mineralization prevalent in the area. The modelling of the residual map revealed some minerals in the study area, which are; Casseterite, Clay and rock bearing minerals like Granite, limestone, Dolomite and marble. The study area has revealed potentials for mineral deposit, which could serve as raw material(s) for many factories and industries in Nigeria. The sedimentary thickness obtained from different methods obtained in this work indicate the possibility of hydrocarbon accumulation in the study area but the real possibility of that and potential assessment needs further research.

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IOSR Journal of Applied Physics (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

Nwobodo, A.N. " Investigation of Magnetic Anomalies Of Lokoja And Dekina Areas, Lower Benue Troughnigeria, Using High Resolution Aeromagnetic Data.” IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 5, 2018, pp. 39-47.