IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 1 Ver. I (Jan. - Feb. 2016), PP 117-122
www.iosrjournals.org

Tectonic Patterns Interpreted From Ground Magnetic Survey of Part of Southern Margin of Hawal Basement Complex, Northeast Nigeria

Agbo Peter[1], Nsikak E. Bassey[2]
[2]*Federal Ministry of Environment, Abuja - Nigeria*
[3] *Geology Departments, Akwa Ibom State University Mkpat Enin PMB 1167, Uyo, Nigeria*

***Abstract**: Ground Magnetic survey was done using a proton precession magnetometer to delineate lineament patterns and to see their relationship to the tectonics framework of the Hawal Basement Complex. The study area geologically is made up of gneisses, granite and basalt. Bima sandstone occurs as sedimentary unit in the area. The magnetic anomalies show short-wavelengths of positive polarity, which indicate shallow/superficial sources. The anomalies also show two dominant trends in the NE – SW and NW – SE. These correlate with emplacement directions of basalts and directions of flow of major rivers. These directions are consistent with mapped structural (foliational/fracture) trends in the Hawal Basement Complex. Field geological observation also shows NE-SW dextral strike slip fault which is also typical of the adjoining Benue Trough tectonics. 2-D modeling of magnetic anomalies gave depths to basic intrusive of > 500 m. This work has shed more light on the occurrences and emplacements of basic rocks beyond what is presently known/ published.*

***Keywords**: magnetic anomalies, lineaments, basic extrusive & intrusive, tectonics, Benue Trough.*

I. Introduction

Lineaments are significant evidences of differential stresses that accompany tectonics during crustal deformation. They are reflective of crustal structures and can be fault lines, rocks boundaries, straight streams course, shear zones, aligned volcanoes etc. Mapping and analyzing these structures from potential field data like magnetic data are essential in tectonics study of regional extent. Such studies will perhaps enhance the general perception of geologic events, and have overtime become important indices for hydrogeological and mineral exploration in the basement complex areas [1].

Most of the related studies in the region and in many other places across the world in delineating important signature of structures and crustal deformation pattern using the magnetic field were based on the interpretation of aeromagnetic and satellite data [2]. But in many such studies, their setbacks are often paucity in the underlying regional structural data. However, in this work the authors used ground based survey because it provides detail information which may not be revealed in the aeromagnetic data, and can be useful in the study of subsurface geology[3].The authors also did field geological mapping to provide supplement to magnetic data analysis. This study sheds some light on the surface and subsurface occurrences of basic igneous rocks in the area.

The Study Area

The study area is bounded by latitudes 9° 41΄N and 9° 45′ N, and longitudes 12° 30′ E and 12° 40′ E extracted from Zummo SW topographic sheet 197 published by Federal Surveys of Nigeria.. Its covers area around Mararaba Dumne, and is located along Yola – Song road in Adamawa State, Nigeria. See: Fig. 1 for location map.

The study area form part of the southern limit of the Hawal Basement Complex in NE Nigeria. This complex shares some similarities with other areas of the Nigerian basement complex i.e. it is dominated by rocks of Precambrian age. Early Cretaceous, and Tertiary rocks are also found. Locally, the study area has five lithologic units which include porphyroblastic gneiss, granite gneiss, biotite granite (Precambrian), Bima sandstone (Cretaceous) and basalt (Tertiary), see: Figure 1b. The basalt occurs as flows outcropping along river channels and as volcanic bombs with vesicular textures. The Bima sandstone, a sedimentary deposit overlies the basement at the extreme southwest of the study area. This rock has been fully described by [4]. Granite gneiss and porphyroblstic gneiss exhibits weak to strong foliation predominantly in a NW-SE direction with dip values of between 22^0 and 80^0 in many places.

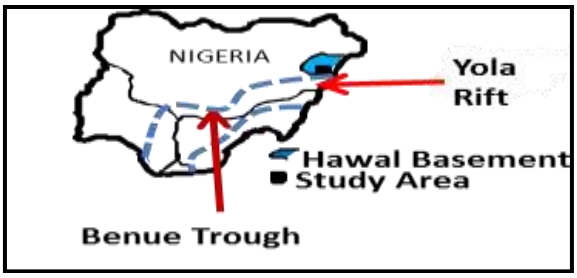

Fig.1a. Map of Nigeria showing location of the study area

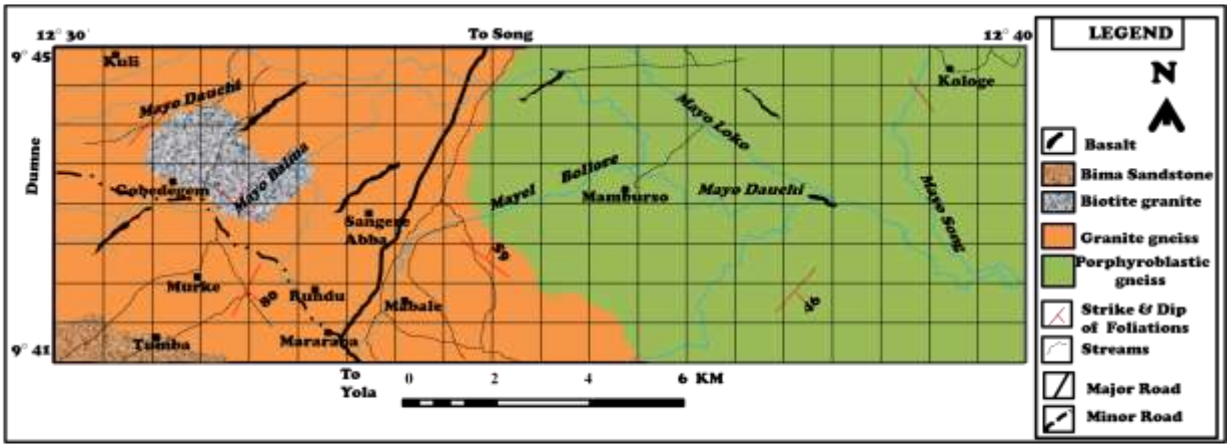

Fig.1b. Geological map of the study area

II. Materials And Methods

A topographic map of the study area was acquired from the Federal Surveys of Nigeria and was gridded at 1 km interval and station readings of the total magnetic intensity were taken where the grids intersect. The magnetic survey was carried out using Geometric 856 Memory-Mag^{TM} proton precession magnetometer (P/N18101-02 Rev. C). Global Positioning System (GPS) was used for station location. A base station was established near the study area where the magnetometer was continuously returned between two and three hours after each loop of survey to check for diurnal variations of the earth magnetic field. The magnetic data were diurnally reduced and IGRF was removed using IGRF11. The data were filtered using first vertical derivative technique. The software used was *Winglink*. Geological field mapping was also carried out alongside magnetic survey to see the surface lithological variations and structural features such as faults, foliation and joints systems. Structural data were plotted on azimuth rose diagram.

III. Results And Discussion

Total Magnetic Intensity

The map of total magnetic intensity (TMI) field is presented in Figure 3a and b. The TMI map consists of a broad region of intermediate magnetic anomalies (34350 nT – 34450 nT), which dominates the study area except the extreme southwest where sandstone outcropped. The sandstone is expected to have low magnetism and will usually give only an insignificant contribution to the magnetic anomalies [5]. Upon this broad region of anomalies are superimposed linear belts of high magnetic anomalies (34475 nT – 34625 nT). The belts trend dominantly in the NE-SW and NW-SE, with minor N-S and NNW- SSE directions. These structural trends are characteristic of the Hawal basement province. This similarity in the positive anomalies pattern and the structural characteristic of the Nigerian Basement Complex shows that the anomalies are strongly controlled by the regional basement structures and tectonics. The zone of negative anomaly in the southwest is due to the existence of low susceptibility Bima sandstone of the Upper Benue Trough (see: Figure 2a).

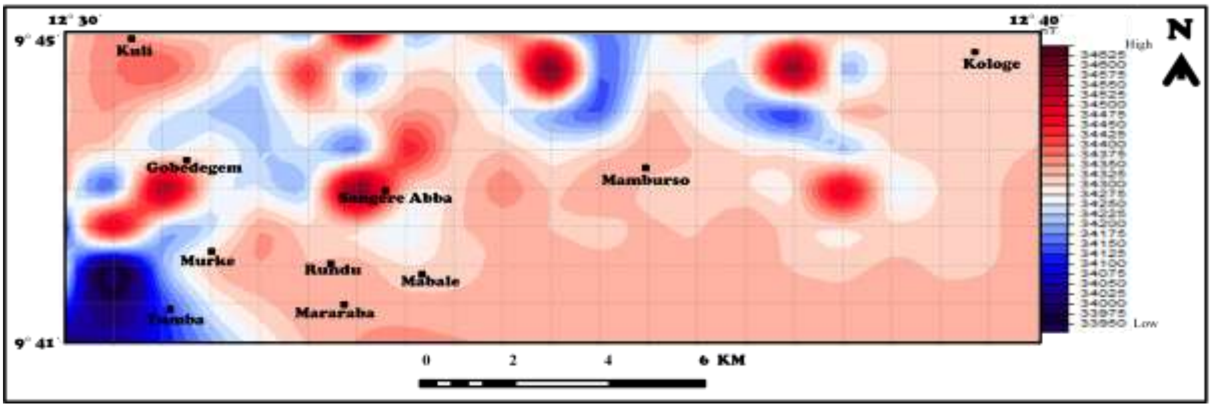

Fig. 2a. Total Magnetic Intensity map of the study area

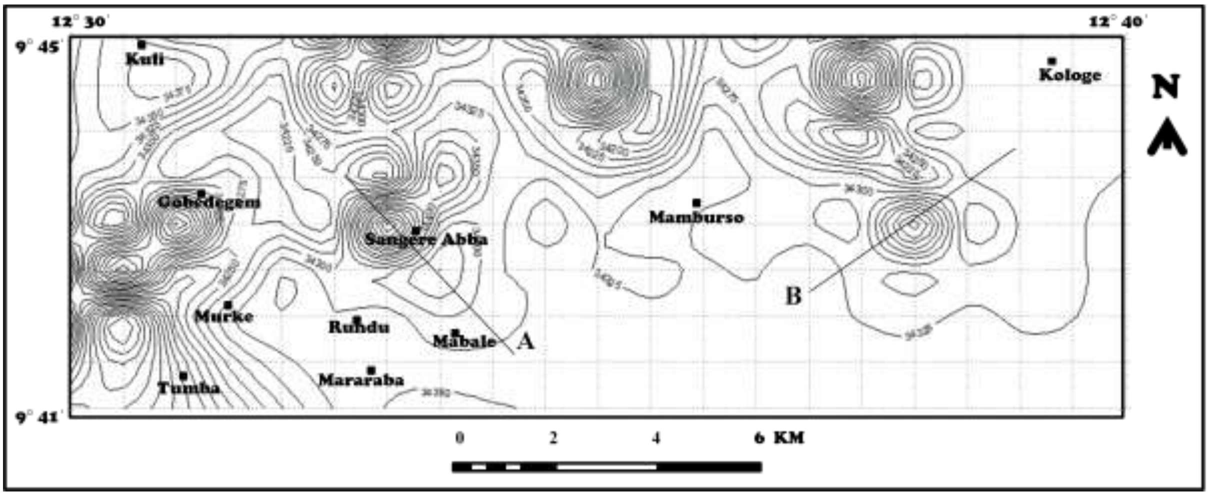

Fig. 2b. Total Magnetic Intensity contour map of the study area

Field Structures

The most prevailing planar structures encountered on the field are fractures and foliations. The data were plotted on frequency – azimuth rose diagram (Fig. 3a) using *GEOrient* package, and the results shows a composite direction of fracture clusters in the NE-SW direction which is the dominant structural trends in the area, and with minor N-S and NW- SE trends. Foliations trend mostly in the NW-SE with minor NE-SW directions (Fig. 3b), with surfaces having moderate dips (20° to 60°) predominantly to the west. One of the structures observed in the field is a NE-SW dextral strike slip fault on porphyroblastic gneiss shown in Plate 1.

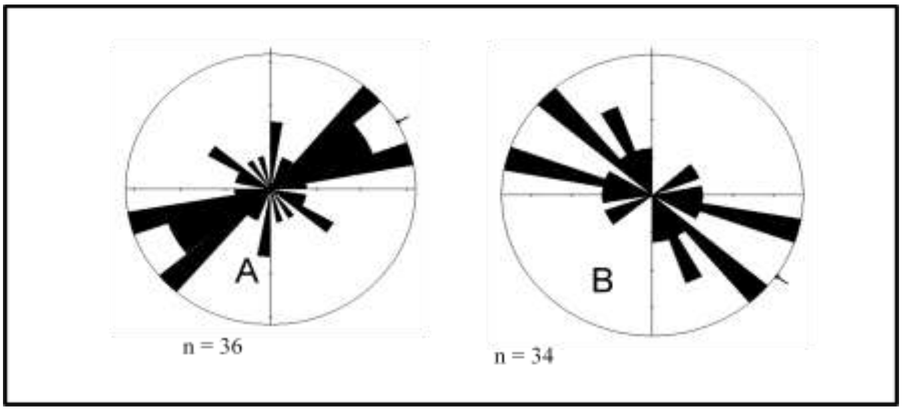

Fig.3. Rose diagram plots of fractures (A) and foliations (B) in the study area

Plate I Typical NE dextral strike-slip fault system of the study area.

Lineament Patterns Of The Area

The TMI map (Figure 2a) shows belts of NE–SW and NW-SE trending positive and negative anomalies. Their orthogonal patterns are reflective of mapped structural directions as expressed in Figure 2. Based on the alignment of anomalies, a magneto-lineament map was produced and is shown as Figure 4. A similar pattern of anomalies is observed in the first vertical derivative magnetic map (Figure 5)

The lineaments are identified as L1, L2, L3 and L4 based on their trends. L1 have NE - SW trend and are between 4 and 8 km in length. L2 have NW - SE trends and are between 1 and 4 km while the L3 have N-S trend and L4 NNW trend. The lineaments (L1) of NE – SW trend correlate with the direction of the Benue Trough (Fig.1), and also correlate with some mapped basalt outcrops along Mayo Balma and other rivers such as like Mayo Bollore, and Mayo Dauchi (Figure 1b). Lineaments (L2), with northwesterly trend follow the flow direction of Mayo Loko (Figure 1b). These lineaments (L1 & L2) were caused by deep seated regional structures [6], even though others correlate with mapped basalt in the western part of study area (Figure 1b) and by implication, the basalt emplacement in the area is controlled by seated basement faults.

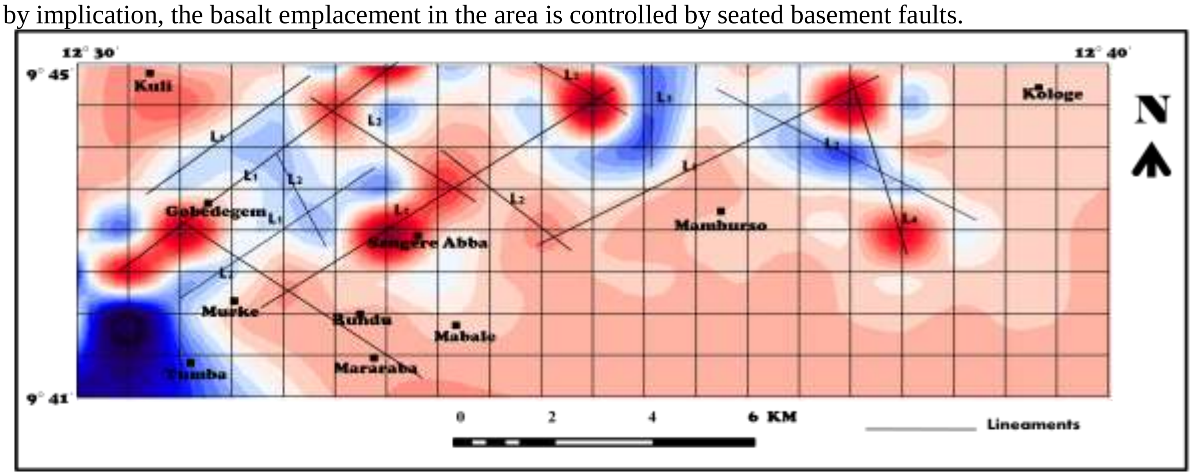

Fig.4. A schematic magneto-lineament map of the study area

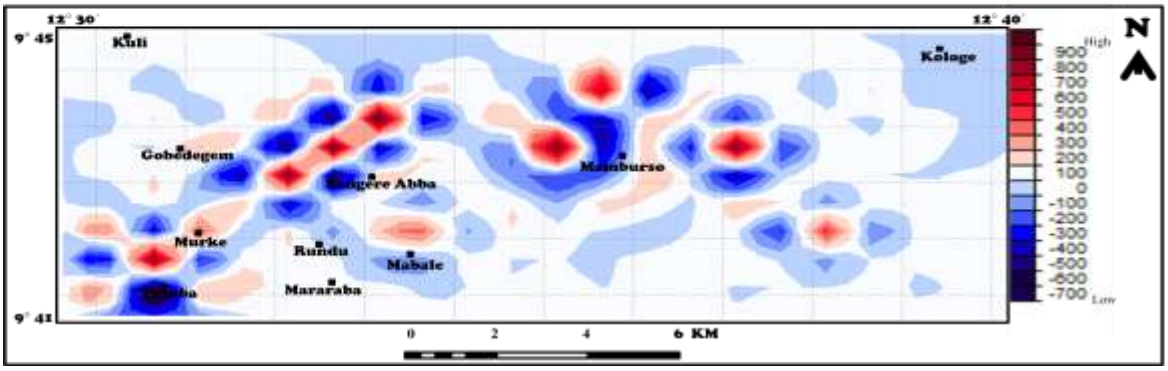

Fig.5. First vertical derivative map of the magnetic field of study area (note the NE-SW and NW-SE alignments of magnetic anomalies).

Generally, these lineaments patterns correlate with tectonic trends in Song area as reported by [7] and [8] who mapped faults, foliation, shear zones etc and found them to be in the NE, NW and N-S directions. Both lineament sets (L1 and L2) constitute part of conjugate pairs of lineaments which are abundant in the basement complex in the area. Based on distribution of outcrops of basalt in the area and occurrences of high amplitude anomalies (the latter are attributed to sub-cropping basic rocks). An attempt is made to present the distribution of both groups of rocks on a map (Figure 6). In this map, the two major (northeasterly and northwesterly) trends are evident and indicative of a possible fissure eruption in the volcanic activity that saw the emplacements of these basic rocks. Alignment of volcanic rocks along the northwesterly direction in Song area was observed by [9] in his analyses of distribution of basic and phonolite plugs in the Upper Benue Trough and adjoining basement regions.

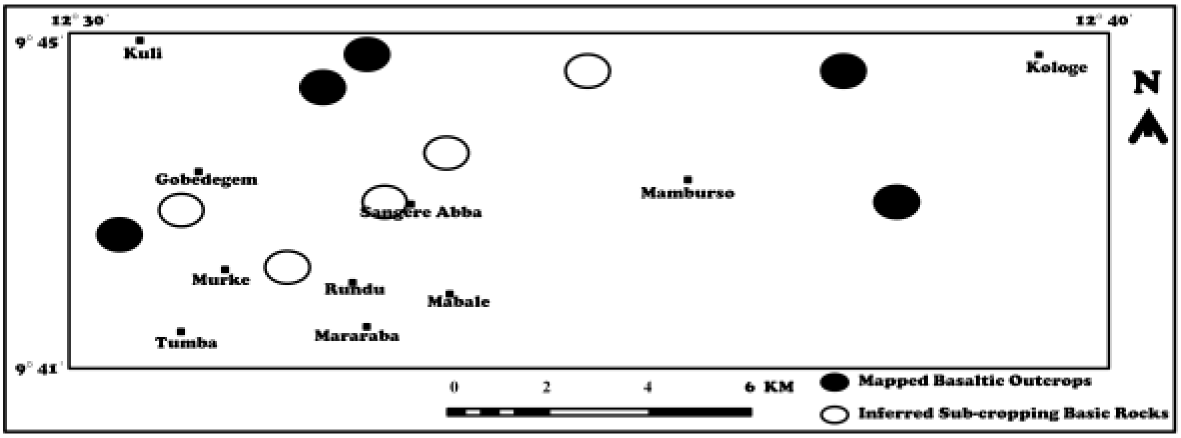

Fig.6. Map of distribution of basalt and subsurface basic rocks based on field geological observations and occurrences of high amplitude anomalies.

2d Modeling

The 2D modeling program of *WinGLink* is a graphically interactive, and modeling program designed for the interpretation of magnetic and other potential field data. In this study magnetic susceptibility values were imputed from the software (*WinGLink*) based on rock types found in the study area. Depths to the top of causative bodies that generate anomalies in Figure 3b are modeled.

The susceptibilities used in the modeling were adopted and varied until best fits between the observed and calculated magnetic curves were achieved (Fig. 7a and b). The 2D models show that the anomalies have their geological sources as basic intrusions. In Figure 7a the causality body lies at a depth of about 500 m, while in 7b the body lies at about 1200 m below the surface. There are no drill hole data from the area yet to confirm these depths. The author posit that basic intrusions and extrusions found in this marginal part of Hawal Basement Complex are part of basic igneous dykes diapirically injected into fault zones and other planes of crustal weakness by mantle plume activity during the formation of Yola Rift [10].

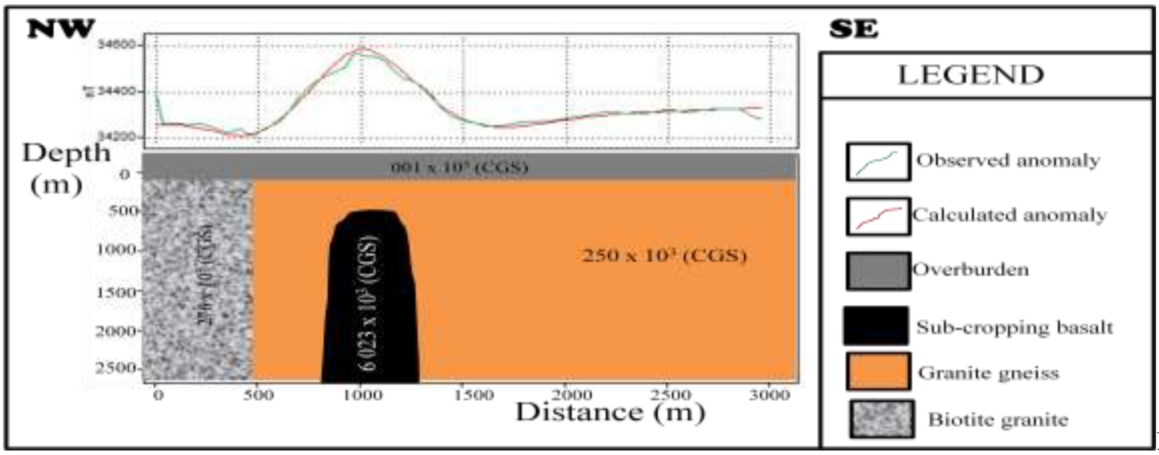

Fig. 7a: A modeled geomagnetic section along a profile A.

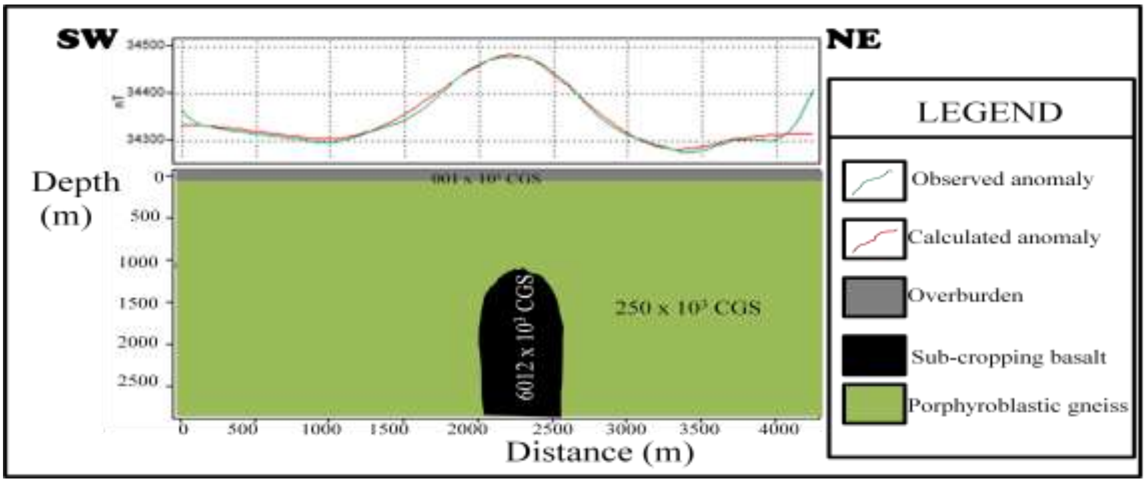

Fig. 7b: A modeled geomagnetic section along a profile B.

IV. Conclusions

The work has shown the relationship between ground magnetic anomalies and surface/subsurface occurrences of basic rocks. Field evidences suggest fissure eruption for basalt in the area. Alignment of anomalies shows two major patterns: NW-SE, and NE-SW which are consistent with major field structural direction. Field evidence also shows that E-W tectonics pre-date NE tectonics. A major finding of this study-emplacement of basic rocks in the study area is consistent with the diapiric injection mechanism of rift valley formation.

Reference

[1]. Goki, NG, Amadi, AN, Olasehinde, PI, Dada SS., Ikpokonte, EA, and Adekeye, J,D. Appraising the structural geology of Kakuri Sheet 144: Implications for the tectonic evolution of the basement complex. Jour. of Eng. and Tech. Research.2011; 3(2), 26-36.

[2]. Feumoe, A N S., Theophile N., Eliezer M., and JAMES DF, Delineation of tectonic lineaments using aeromagnetic data for the south-east Cameroon area. 2012 GEOFIZIKA 2012; (29) 176-192.

[3]. Athens, ND, Glen, J M G, Morin, R L. and Klemperer, S L,). ATV magnetometer systems for efficient ground magnetic surveying [computer software and manual]. From: The Leading Edge, 2011; 394 – 398.

[4]. SAMAILA, N K, ABUBAKAR, MB, DIKE, EFC. & OBAJE, NG. Description of soft-sediment deformation structures in the Cretaceous Bima Sandstone from the Yola Arm, Upper Benue Trough, Northeastern Nigeria. J. African Earth Sciences. (2006) 44; 66-74.

[5]. GIBSON, R I. and MILLEGAN, PS. Geology applications of gravity and magnetic: Case histories. Society of Exploration Geophysicist.1998; 170, 162. DOI:10.1190/1.9781560801832.

[6]. BASSEY, NE. Structural geological mapping and interpretations of LandSat and Aeronmagnetic Data over part of Hawal Basement Complex, NE Nigeria. PhD thesis (Unpublished) Abubakar Tafawa Balewa University Bauchi, Nigeria.2006

[7]. BASSEY, NE Mass wasting in Song area of the Hawal Basement Complex, NE Nigeria. Global Jour. of Environ Sci.2007;6 (1):65-70

[8]. BASSEY, NE. Statistical study of alignments of volcanic and sub-volcanic basic rocks in Hawal Basement Complex, northeast Nigeria US Open Environment and Earth Sciences Journal.2013; 10(1), 01- 13.

[9]. Benkhelil, J. Structure and geodynamic evolution of the Intracontinental Benue Trough (Nigeria). Doctoral Thesis, University of Nice, France, Elf Nigeria Ltd publication, SNEA.1986; 202p.

[10]. Haxy,WF, Turcotte, DL and Bird, JB. Thermal and mechanical evolution of Michigan Basin. Tectonophysic.1976; 36: (57).