ARCN International Journal of Sustainable Development
ISSN: 2384-5341. Volume 14, Issue 1, (December, 2024) pages 255 – 268
DOI: 2726-4-573-1-1435
arcnjournals@gmail.com
https://arcnjournals.org

ENTREPRENEURIAL OPPORTUNITIES ARISING FROM MAGNETIC SURVEY OF MADAGALI HILS AND ENVIRONS, NORTHESTERN NIGERIA

[1*]Major, I.B., [2]Kolomi, A.U., and [3]Dawa, S.A.
[1,3*]Department of Physics, Umar Ibn Ibrahim El-Kanemi College of Education, Science and Technology, Bama, Borno State, Nigeria
[2]Department of Agricultural Education, Umar Ibn Ibrahim El-Kanemi College of Education, Science and Technology, Bama, Borno State, Nigeria

Abstract: *The study area lies within the basement terrain of NE Nigeria between longitudes 13^0 30^1E and 13^0 41^1E, and latitudes 10^0 47^1N and $11^0$00N. Magnetic survey was carried out in order to reveal valuable Mineralization potentials that could lead to opportunities in mining, exploration, and related industries. The identification of the mineral resources may attract investment in infrastructure, creating business opportunities in construction, transportation and logistics. The data were obtained along twelve (12) traverses at a station interval of 1.85 km (1^1) using geometric -856 proton precision magnetometer. Out of one hundred and sixty-eight (168) stations, only one hundred and twenty-one (121) stations were accessible and occupied. The field data were diurnally corrected and the international geomagnetic reference field (IGRF) computed online using 2010-2015 value. The qualitative analysis indicates that, the area consists of basics rocks, granitoids and metamorphic rocks while the quantitative analysis shows that the average depth to the magnetic source is 0.625km. The field studies and rose diagrams revealed that the dominant structural trends in the area NE-SW, NNE-SW, NW-SE, N-S, and minor E-W. The NE-SW and N-S trends are the most dominant, and are attributed to pan African orogeny. The results of the analysis also indicate no appreciable Mineralization in the area and this could be attributed to unfavorable structural disposition, inadequate leaching and insufficient traps.*

Keywords: *Entrepreneurial, Structural trends, Magnetometer, geomagnetic, Structural disposition.*

INTRODUCTION

The study area, Madagali is located in the extreme Eastern part of the geologically less explored Hawal basement Complex of northeastern Nigeria. The area is covered by topographic map sheet 136 Madagali NW, produced on a scale of 1:120, 000 by the United State Geological Survey (USGS) in 2006 (fig.1)

Madagali area is part of Mandara Mountains which together with the adjacent Hawal and Adamawa massifs form the northeastern sector of the Nigerian basement complex. The Madagali hills form prominent parallel and elongated topographic highs in the study area. The hills are dominated by granitic rocks while the plains are underlain by metamorphic rocks.

The magnetic properties within a rock type can be quite variable (Carmichael, 1989) depending on chemical inhomogeneity, depositional and/or crystallization and post-deformational conditions.

The mineral contribution to the magnetic susceptibility of a rock has been widely given in literature (Thompson and Old field, 1986; Lowrie, 1990; Schon, 1996). The values of magnetic susceptibility depend on the grain size, the presence of minute crystal lattice, such as dislocations, lattice valencies, impurities etc. and the amount of iron ore in a sample.

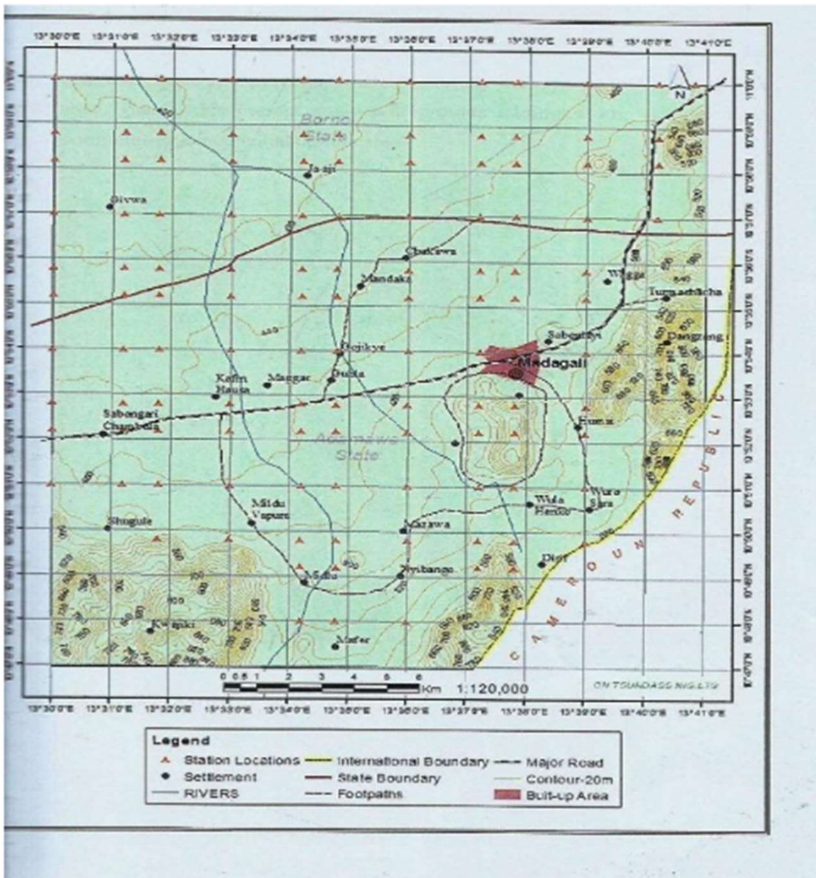

Fig.1: Topographic Map of the Study Area
(After US Geological Survey, 2006)

GEOLOGY OF THE STUDY AREA

Madagali hill is part of Hawal basement which is one of the three massifs in the northeastern Nigeria that share a long border with the Republic of Cameroun. The area is underlain mainly by migmatite-gneiss, intruded by large volumes of pan- African granitoids, schist and minor tectonites. Out-crops are restricted to the eastern and Southern part of the study area as the northern and Western sides are characterized by ponds and flood plains (fig. II). The Pan-African granitoids of the extreme northeastern tip of Nigeria, north of the Benue Trough was described by Islam and Baba (1997) as alkaline and of mixed origin. Baba et. al., (1996) described the Liga hill granites (north of the study) as being products of anatexis of crystal material. Bassey, (2006a) studies the structures of Madagali hills NE Nigeria from airborne magnetic and satellite data and showed that the lithological units in the area are gneiss, schist and granites. He concluded that the magnetic satellite and field studies have thrown some light on the geology and structure of this part of Nigeria's basement complex that has been relatively understudied. The major lineaments observed have been accounted for in terms of faults, foliations, joints, shear zones, dykes and veins. The lineaments have regional extensions into Niger, Chad and Cameroun. The Chad basin evolution involved interplay of NW-SE, NE-SW, N-S and possibly E-W tectonics. Major drainage channels in the area are structurally controlled. The study has revealed E-W structures as the youngest which is different from observations elsewhere in the Nigerian basement (Bassey, 2006a).

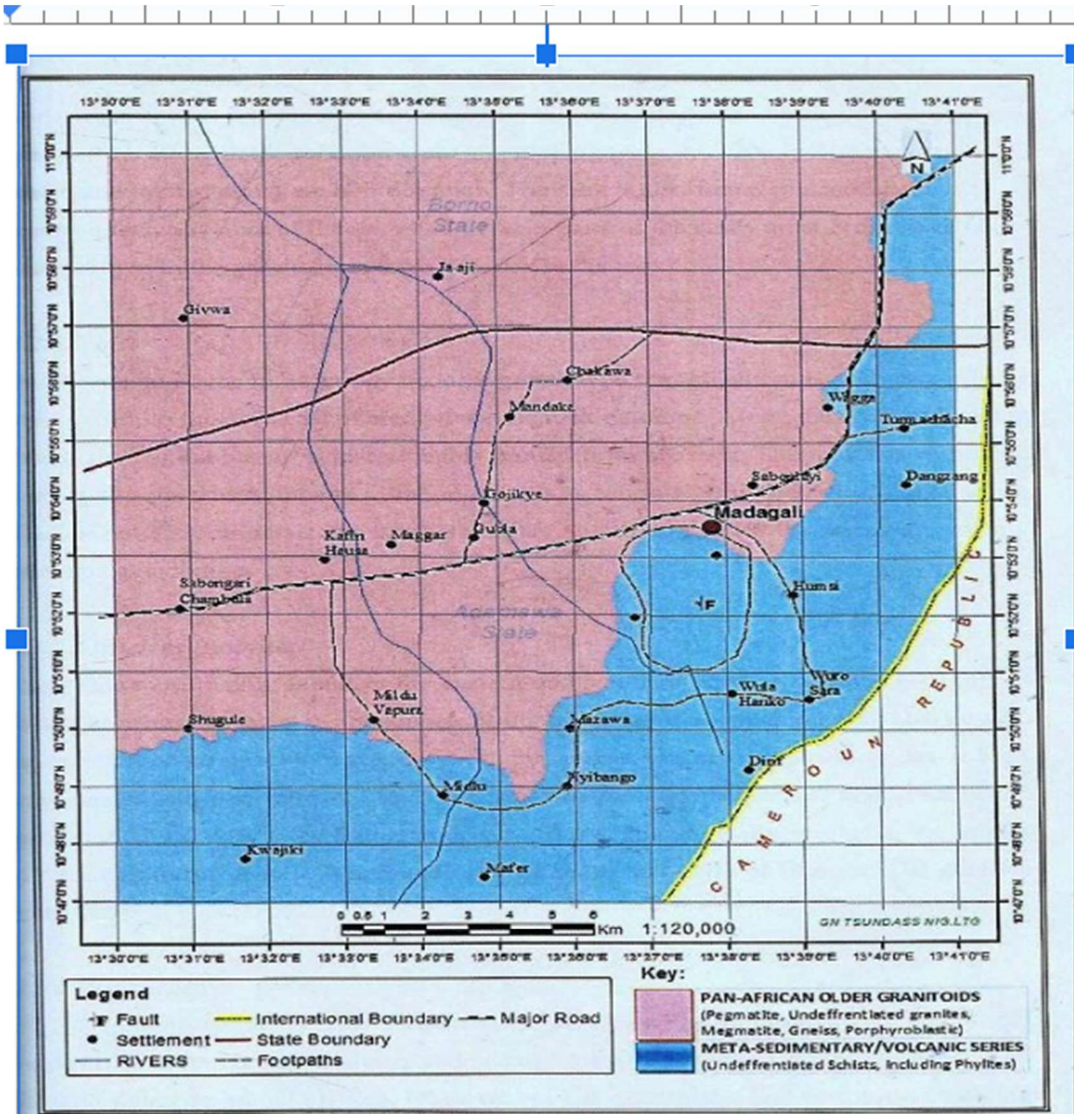

Fig. 2: Geological Map of the Study Area
(Modified after Nigerian Geological Survey
(NGS), 2006)

METHODOLOGY

The topographic map of the study area was gridded to produced one hundred and sixty-eight (168) grids. Out of which only one hundred and twenty-one (121) data were measured. The grid size chosen was 1 minute (1^1) interval approximately 1.85km. This interval was chosen as it made stations to be moderate in number and field work completed within available time. Traverses were established perpendicular to the strike direction (i.e. N-S). All the traverses were taken in straight lines either along the roads, footpaths or through bush. The lines were marked at convenient intervals (Station intervals) with red permanent marker for easy identification of stations.

DATA ACQUISITION

The data were acquired along twelve (12) traverses in the N-S direction at station interval of 1.85km using the geometrics-856 proton precision magnetometer, which measures the total intensity of the earth's magnetic field. Readings were not taken within the vicinity of metallic objects such as motorcycles cars, tarred roads, fencings, houses which might perturb the local magnetic field. For similar reason, operator of magnetometer should not carry any metallic object.

The magnetic instrument has a resolution of one (1) nanotesla (1nT). A base station was set up about a few meter from the survey area where the magnetometer records the magnetic readings at a time interval of less than two hours (2hrs) using a looping techniques. Reoccupation of the base station was done to check for diurnal variation of the earth's magnetic field. Each of the 24km long traverses has a station interval of 1.85km determined using a global positioning system (GPS). Three magnetometer readings were taken at each station and the average taken. The time (period) at which readings were taken were recorded for each station. The co-ordinates of each station of each traverse line were recorded by GPS. On the whole, one hundred and twenty-one (121) measurements were obtained.

DATA PROCESSING

The magnetic data obtained were corrected for diurnal variation (i.e. for positive drift; it was subtracted from the field data while for negative drift; it was added to the field data). The earth's normal (true) magnetic field of the study area was calculated using the international Geomagnetic Reference Field (IGRF) of 2010 – 2015 and subtracted from the diurnal corrected values to produce the total magnetic field intensity (TMI) map (Fig. 3). The TMI map was then processed by subjecting it to regional – residual separation (polynominal fitting), low pass filtering, first horizontal order first vertical derivative polynomial filting, and downward continuation.

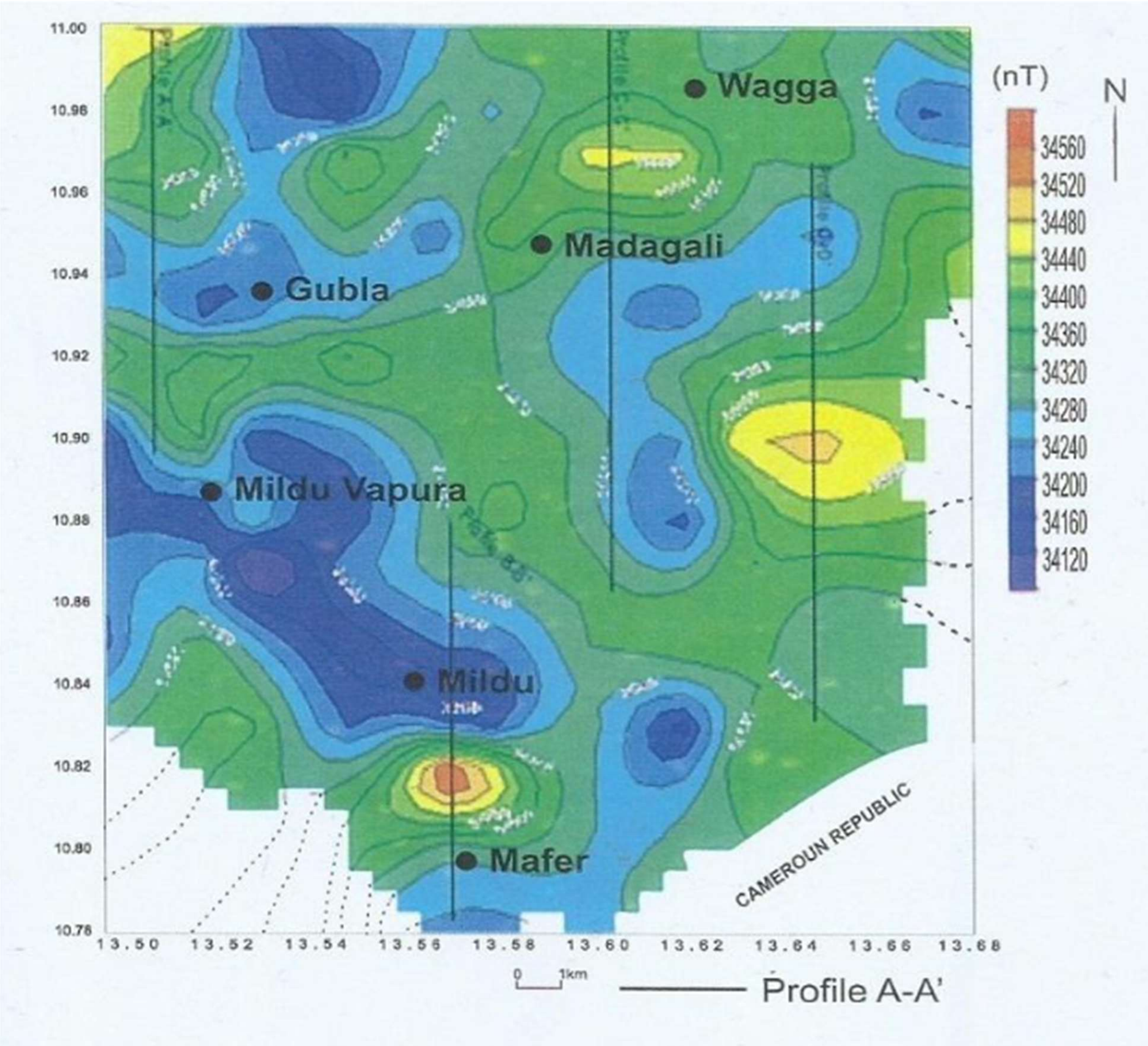

Fig 3: Total Magnetic Field Intensity (TMI) Map.
(Cont. int. 40nT)

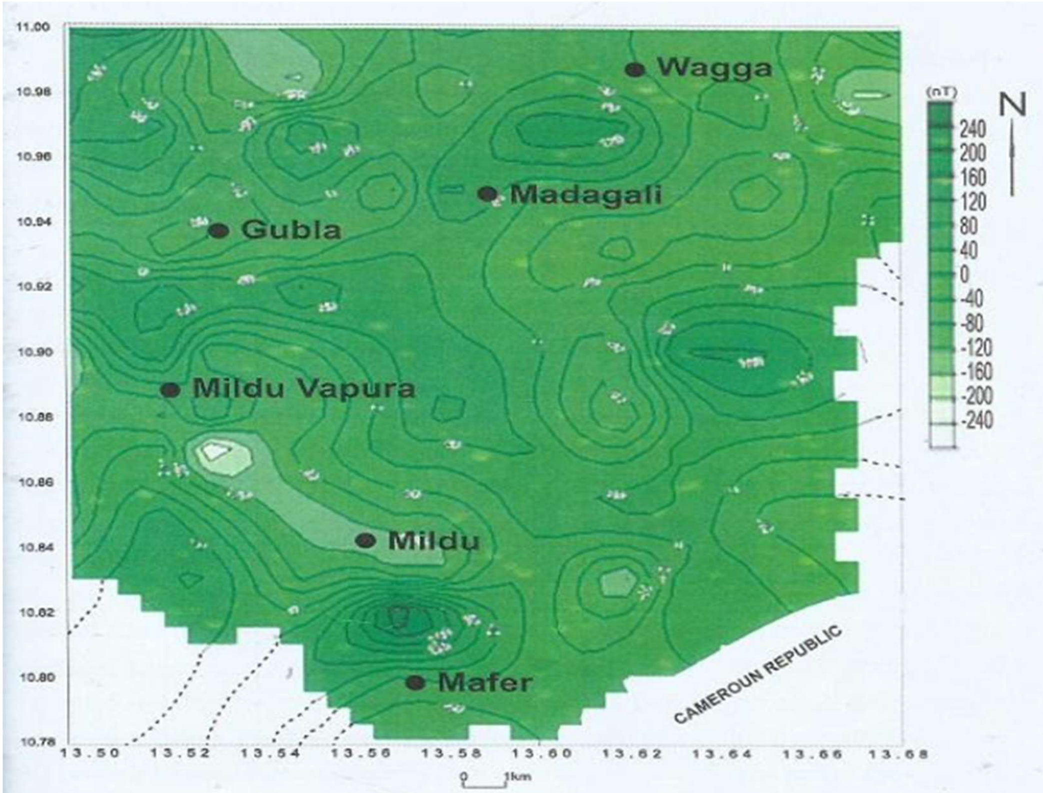

Fig. 4: Residual Magnetic Map of the Study Area
(Cont. Int. 40 nT)

QUALITATIVE ANALYSIS

DATA INTERPRETATION

The total magnetic field intensity (TMI) map of the area (fig.3) showed that the area is characterized by both high amplitude and short wavelength, and low amplitude and long wavelength anomalies. The high amplitude and short wavelength magnetic anomalies are attributed to near surface (Shallow) features while the low amplitude and long wavelength anomalies are attributed to deep seated features.

From the total magnetic field intensity map and residual magnetic map (fig. 4), it can be seen that, the area is characterized by both high and low frequency anomalies. On the residual magnetic map, it is seen that, the magnetic anomalies amplitude ranges from a minimum of -160nT to a maximum of 320nT.

The areas of positive anomalies occur in the southern, eastern, extreme north, northwest and part of the central part of the study area. These areas can be interpreted in terms of occurrences of basic rocks.

This can be explained in the light of available regional geological reports on the Mandara hills, and the adjoining basement regions (Adamawa massif in Nigeria and the northern Cameroun basement). According to the reports, these regions have widespread occurrence of basalts, trachyte and trachybasalts (Avbovbo et al., 1986; Fitton, 1987; Moraeu et al., 1987; Toteu, 1990; Bassey et al., 1999; Bassey, 2005). The positive residual anomalies are attributed to these basic and intermediate rocks.

Areas of occurrence of low residual anomalies in the study area are interpreted in terms of the presence of granitoids and metamorphic rocks in the area. They may also be due to susceptibility variations in lithologies or a combination of both.

QUANTITATIVE INTERPRETATION

The quantitative interpretation of the magnetic profiles (fig. 5) using wing link modeling software enables the calculation of their magnetic response from geological models.

The methods used in estimating the depth to basements such as local spectra suffers from various constraints in that, they cannot accurately map the undulation in the basement as they give only the average depths. Therefore, there is a need to construct forward magnetic models that accurately represent basement topography. Thus, to confirm the depth to basement surfaces and to delineate basement tectonic framework in the area under study, four profiles were modeled. These profiles were taken in direction perpendicular to the prominent trends/structures. These profiles were traced out from the total magnetic field intensify (TMI) map.

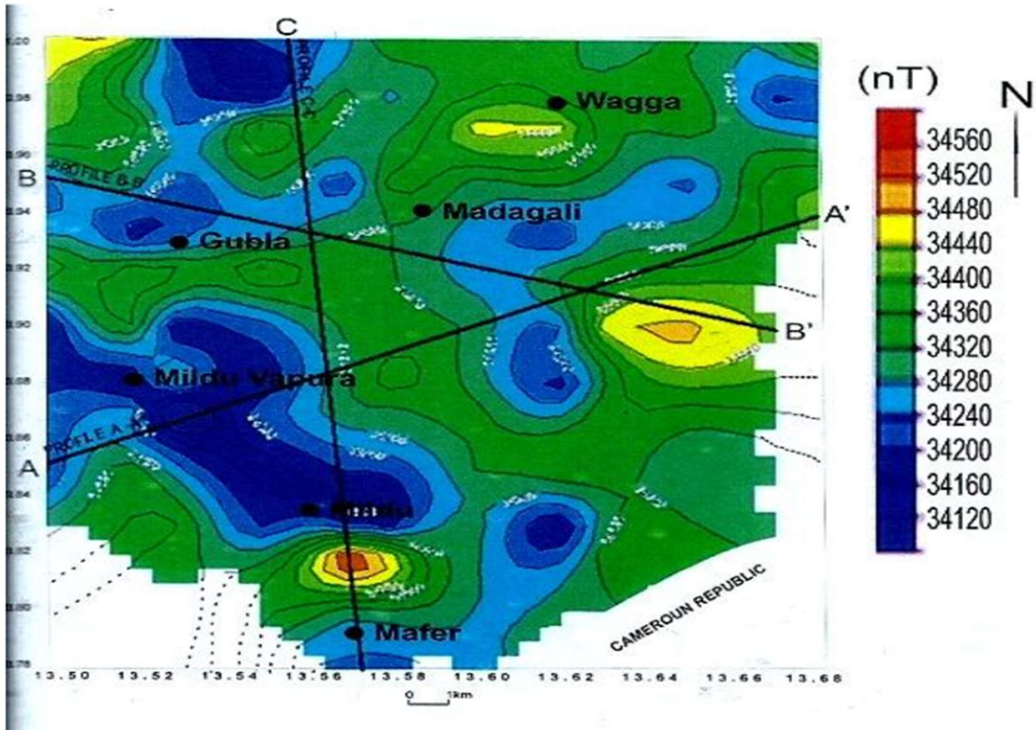

Fig. 5: Magnetic Profile AA'-CC' Map (Cont. Int. 40 nT)

Profile A-A[1] is a north-south profile drawn across a west east trending anomaly located in the western part of the map around river Yamtake (Mayo Yamtake) (fig. 6). The profile length is about 9.5km. It shows a good fit between the observed and the calculated anomaly. The maximum depth to the magnetic basement (Source) of 0.004 km below the ground surface is obtained within the graben at the northern end of the model. The shallowest (minimum) depth of 0.003km is observed over the horst rock (basic intrusion) at the center of the profile.

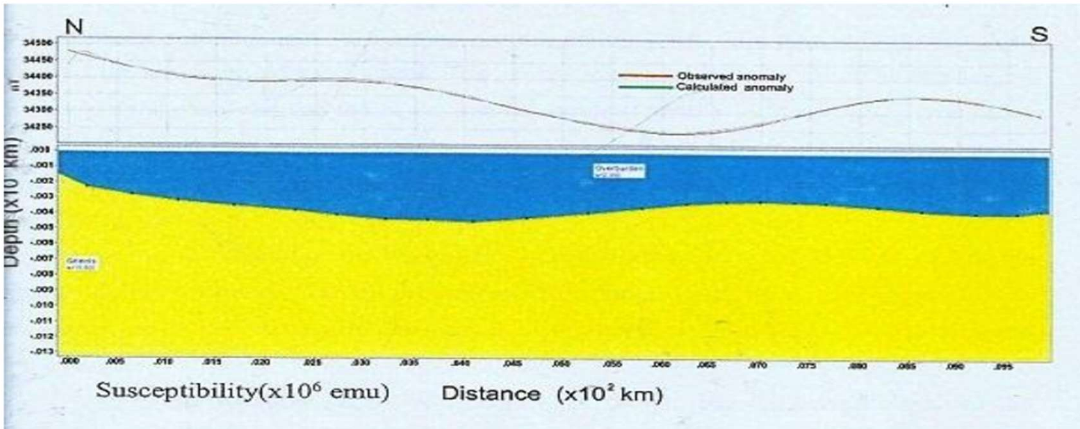

Fig. 6: Profile Model A – A[1]

Profile B – B[1] is a north-south profile drawn across a west- east trending anomaly located in the Southern part of the map around mildu town (fig. 7). The profile cuts across the width of the basement complex rocks. The profile length is about 10km. It shows a close fit between the observed and the calculated (computed) anomaly.

The maximum depth to the magnetic basement (Source) of 0.003km below the ground surface is obtained within the graben in the central part of the model. The shallowest depth of 0.01km is observed over the horst block towards the Southern end of the model.

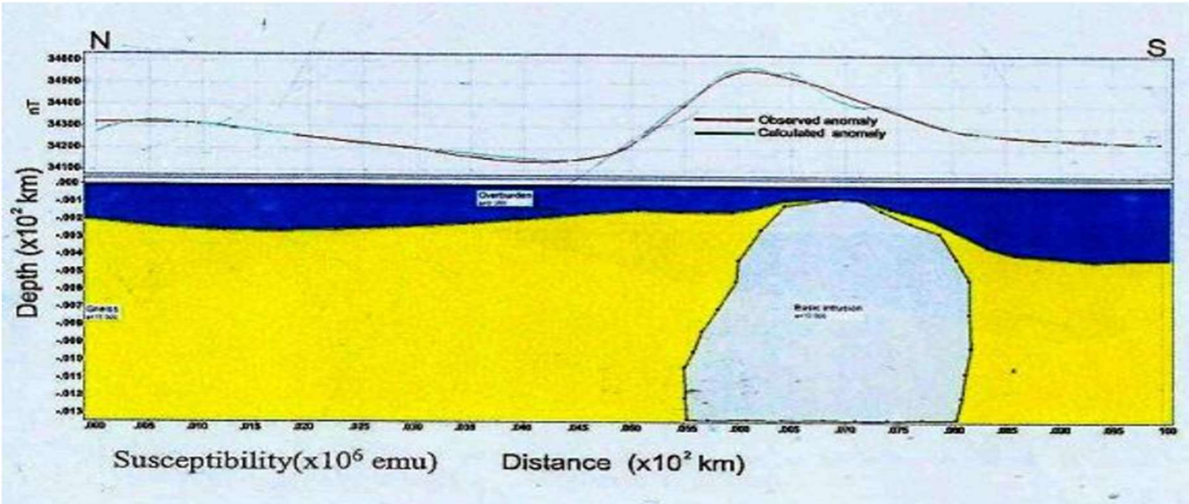

Fig. 7: Profile Model B – B[1]

Profile C-C[1] is a North-South profile drawn across a North-South trending anomalies located in the northern and central part of the map. The profile length is about 13.5km. The maximum depth to the magnetic basement (Source) of 0.009km below the ground surface is obtained within the graben at the central part of the model while a shallowest depth of 0.0km is observed on the northern end (horst block) of the profile (fig. 8).

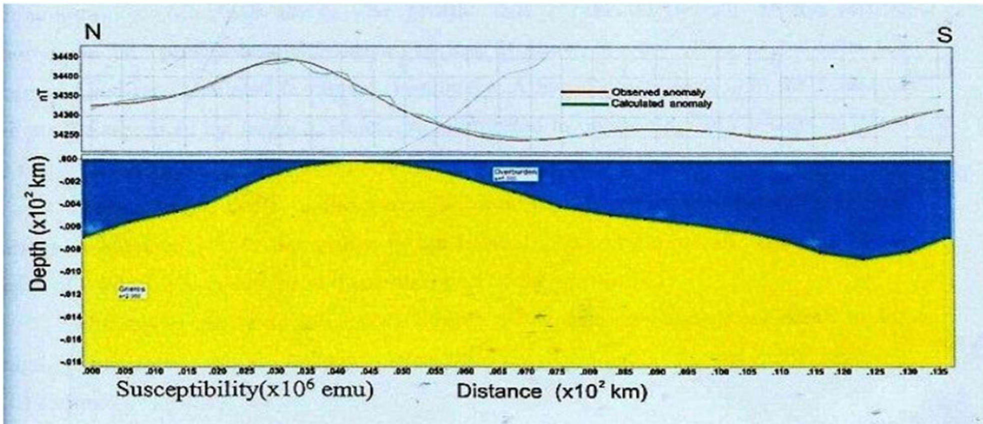

Fig. 8: Profile Model C – C[1]

Profile D – D[1] is a North-South profile drawn across a north-south trending basement anomalies located in the extreme northeast and eastern part of the map east of Limankara and Madagali town (fig. 19). The profile cuts across the length of the anomalies.

The model result deduced from fig. 9 is that, the shallowest depth to the magnetic basement is 0.005km and the deepest depth to the magnetic source is 0.0125km.

From the four (4) models, the average depth to the magnetic basement (Source) is calculated to be 0.625km.

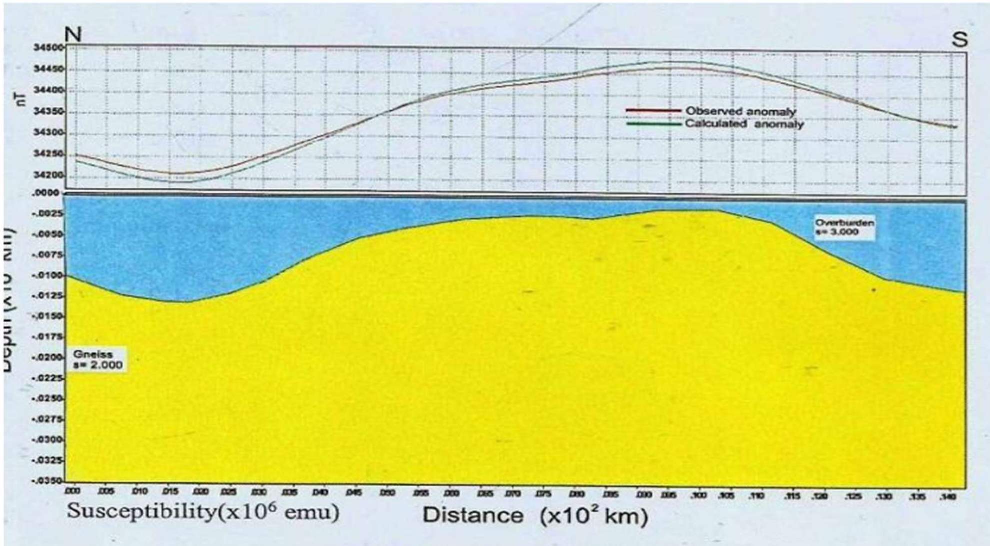

Fig. 9: Profile Model D – D[1]

DISCUSSION

The earth's magnetic field is a composite of anomalies of varying frequencies. The highest frequency events of interest are those created by geological conditions in the shallow subsurface and the lowest frequency events are caused by magnetic property contrasts at or beneath the basement surface while intermediate frequency events are created within a sedimentary section. Map by map interpretation showed different anomaly signatures which is indicative of the susceptibility contrast of the rock types and to certain extent, the effects of instructions, fissures and rock contacts (Kayode et al., 2010).

Generally, in this area, the magnetic field intensity varies from 34120 – 34580 nanotebla (nT), which is a measure of the magnetic mineral content present in the underlying rock units and on conditions near/ or far beneath the surface.

From the two maps (total magnetic field intensify, TMI and the residual magnetic map), four (4) areas of significant positive anomalies were identified in the study area. These areas are; south of Mildu town, east of Madagali town, South of Wagga and northwest of the study area. The highest positive anomaly occurs at Mildu town. This area showed a magnetic high of 34480 – 34580 nT. These areas of high magnetic susceptibility values are most likely to be regions of basic igneous rocks.

The lowest magnetic anomalies occur at areas north of Mildu town, east of Wagga, north of Gubla and around Mildu Vapura villages. These are most likely to be regions of acidic igneous rocks such as granites.

The positive residual anomalies can be explained in the light of available regional geological reports on Mandara hills and the adjoining basement regions (Adamawa Massif in Nigeria and the northern Cameroun basement). The regions have widespread occurrences of basalts, trachyte, and trachybasalts (Avbovbo et al., 1986; Fitton, 1987; Moreu et al., 1987, Toteu, 1990; Bassey et al., 1999; Bassey, 206). The positive residual anomalies are attributed to these basic and intermediate rocks.

Areas occurrence of zero or negative residual anomalies in the area are interpreted in terms of the presence of granites, gneiss and schist. They may also be due to susceptibility variations in lithologies or a combination of both (Bassey, 2006).

The magnetic and field studies showed that the area has experienced polyphase thermotectonic events involving magnetism, metamorphism and structural deformations.

From field structural data, the oldest deformational features trend NW – SE. These features are foliations, shear zones, and joints. These NW – SE lineaments are among the longest and invariably are of deep crustal origin (Odeyemi et al., 1999). Other geophysical evidences (gravity and Seismic) exist to show these lineaments continue beneath the Chad basin into Niger Republic where they have surface expression as the Tenere Rift (Lake Chad Basin Commission, 1973; Cratchley et al., 1984; Nur, 2001).

Some planar bodies have been emplaced along the NW structural direction as pegmatite and granite dykes (Bassey, 2006). Major streams in the area such as river Na'amtari Jambutu flow essentially NW – SE after taking their rise from the eastern hills. N – S structures observed are mainly normal faults resistant basement ridge, dykes and foliation. From this study, they are next in relative age to the NW – SE structures.

The N – S faults extend into the Chad Basin where they have affected the sediments (Avbovbo et al., 1986). NE – SW structures are next in relative age (Bassey, 2006). The structures are found to be faults and foliation. This structural direction is related to the West African Rift system made up of the North easterly Benue trough and Cameroun volcanic line (Fitton, 1983). By inference, it is also related to the north east (NE) trending Chad shear zone in Chad Republic. E – W lineaments are the youngest as they cross cut structures of other directions. They are mainly basement normal faults, while others are granites and pegmatite dykes. Comachia and Dars (1983) reported an ENE – WSW trend as a foliation direction produced by late pan African event.

REFERENCES

Avbovbo, A.A., Ayoola, E.O., and Osahon, G.A. (1986). Depositional and structural styles in Chad Basin of NE Nigeria. *A.A.P.G. Bulletin 70(12): 1787 – 1798.*

Baba, S., Emofurieta, W.O. and EL-Nafaty, J.M. (1996). Petro Chemistry of Liga Hills Granites, N.E Nigeria. *Borno Jour.Geol.1, 35 – 58.*

Bassey, N.E.(2006a). Structural Geological mapping and interprertation of landsat and aeromagnetic data over parts of Hawal basement Complex, NE Nigeria, *Ph.D. thesis (unpublished), Abubakar Tafawa Balewa University (ATBU), Bauchi.*

Bassey, N.E. (2006). Structue of Madagali Hills, N.E. Nigeria from Airborne Magnetic and Satellite Data, *Global Journal of Geological Sciences, 4(1), 47 – 57.*

Bassey, N.E. (2005). Selective Structural Geological Mapping and interpretation of landsat and aeromagnetic data over Hawal Basement complex, N.E., Nigeria. *Unpublished Ph.D Thesis (Submitted), Abubakar Tafawa Balewa University, Bauchi State.*

Bassey, N.E, Ezeigbo, H.I.,m and Kwache, J.B. (1999). Hydrogeological Study of Duhu area (Sheet 135), N.E. Nigeria on the basis of Ae.0romagnetic data, Water Resoutrces, 10;pp 560 – 577.

Lowries, W. (1990). Fundamentals of Geophysics, *Cambridge University Press, Low Price Paper Back Edition, 229 – 306.*

Carmichael, R.S. (1989) Practical handbook of Physical Properties of Rocks and Minerials, *CRC Press, Boca Raton Ann Arbor, Boston.*

Comachia, M. and Dars, R. (1983). Un tract structural majeurdu Continent Africa. Less lineaments Centafricans du Cameroun au gofled'adeu, Bull. *Soc. Frane, 7pp 101 – 109.*

Crastchley, C.R., Louis, P. and Ajakaiye, D.E., (1984). Geophysical and Geological Evidence for the Benue – Chad Basin Cretaccous Rift valley system and its tetonic implications. *Jour. Afr. Earth Sc. 2(2): 141 – 150.*

Fitton, J.G. (1983). Active versus passive Continental Rifting; evidence from the West African Rift System. *Tectono-physics, 94; 473 – b481.*

Geosystem, SRL (203). Winglink (Version 2.03.01) (Electronic Software).

Golden Software inc. (2012). Surface mapping system (Surfer version 11.0.642). (Electronic Software)

Islam, M.R., and Baba, E. (1997). The Geology of the Basement Complex of Northern parts of Mandara Hills Vii/ viii, 99 – 105.

Kayode, J.S., Nyabese, P. and Adelusi, A.O. (2010). Ground Magnetic Study of Ilesa East, South Western Nigeria. *Journal of Environmental Science and Technology. Vol. 4(3), p. 12 – 131.*

LAKE CHAD COMMISSION REPORT 1973: Survey for water resources of the Chad Basin for development Purposes. F.A.O Rome.

Moreau, C. Regnault, J.M, Deruelle, B., and Robineau, B (1987). A new tectonic model for the Cameroun line, Central Africa, tectonophysics 139, pp. 317 – 334

Nigeria Geological Survey Agency (NGSA), 206. Geological map of Nigeria.

Nur, A. (2001). Spectral Analysis and Hilbert – Transformation of Gravity data over South west of the Chad Basin, Nigeria. *Jour. Min.Geol. 37(2): 153 – 161.*

Odeyemi; I.B., Anifowose, Y.B. and Asiwaju-Bello, Y.A. (1999). Multi-technique Graphical Analysis of Fractures from remote Sensing images of basement regions of Nigeria. *Jour. Min.Geol. 35(1). 9 – 21.*

Schon, J.H. (1996). Physical Properties of rocks: Fundamentals and Principle of Petrophysics, In: Klaus, H. and Sven, T. (Eds): Handbook of Geophysical Exploration, Vol. 18, Pergamon Press, London. 583pp.

Thompson, R, and Oldfield, F. (1986). Environmental Magnetism. Alen and Unwin, London. 227pp.

Toteu, S.F. (1990). Geochemical Characterization of the main petro graphical and structured Units of Northern Cameroun: Implications for Pan African Evolution. *Journal of African Earth Science 10(4): pp615 – 621.*

US Geological Survey, (2006). Topographic Map Sheert 136 Madagali NW, Nigeria. Scale: 1; 120,000.