# DEPTH ESTIMATION FROM THE POWER SPECTRUM OF POTENTIAL FIELD DATA OVER AMAR AND ENVIRONS, NORTH EASTERN NIGERIA

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**ABSTRACT**
*Two- dimensional Spectral analysis of Aeromagnetic data over Amar and Environs has been carried out in order to determine the average depth to magnetic sources .The analysis indicate two source depth which varies from 500 m to 2772 m for deeper sources and 300 m to 450 m for shallower sources which are attributed to near surface intrusion and probably low-lying river valleys in the study area. The results obtained compares favourably with the previous work done in Upper Benue Trou*gh.
*The investigation involves analysis of aeromagnetic data over Amar and Environs. The residual magnetic data shows NE-SW, NW-SW, N-S and E-W trending lineaments. These lineaments may be possible host for secondary mineralization in the study area.*

**Key words;** Mineralization, Aeromagnetic data, Spectral analysis, Lineaments, Intrusions**.**

## INTRODUCTION.

Spectral analysis of magnetic data has been used extensively to derive the depth to certain geological feature such as magnetic basement. Spector and Grant (1970) stated that the depth factor invariably dominate the shape of the radially averaged power spectrum of the magnetic data. Depth estimation from potential field using power spectra requires a realistic assumption of the statistical properties of the source distributions (Stefan et al. 1996). The study area falls within the Upper Benue Trough, which lies between latitude 7$^{o}$ 00'' and 8$^{o}$ 00'' N, and Longitude 10$^{o}$ 00'' and 11$^{o}$ 00'' E. The Benue Trough is a linear NE-SW trending rift system whose development is closely associated with the separation of Africa from South America and the opening of the South Atlantic Ocean during the Cretaceous (Nur 2000). The study area is dominated to the South- East by basement complex rocks comprising of migmatites, gneiss, dolerite dykes, and basaltic rocks of the Eastern arm of the Cameroon Volcanic line. The cretaceous sediments of the Benue Valley dominate the North-western part of the study area.
The estimation of depth to magnetic sources and delineation of structures that are possible host for secondary mineralization in the study area are the aims of this paper.

### Geology of the study area

The geology is made up of the Precambrian basement complex rocks which is considered to be undifferentiated basement complex (Mc Curry 1976) mainly gneisses, granites, Schist, metaconglomerate, basaltic rocks of Cameroon volcanic line and Cretaceous Sediments of the Benue Trough which dominate the North Western part of the study area this conforms to the bank of Benue Valley (Fig.1).

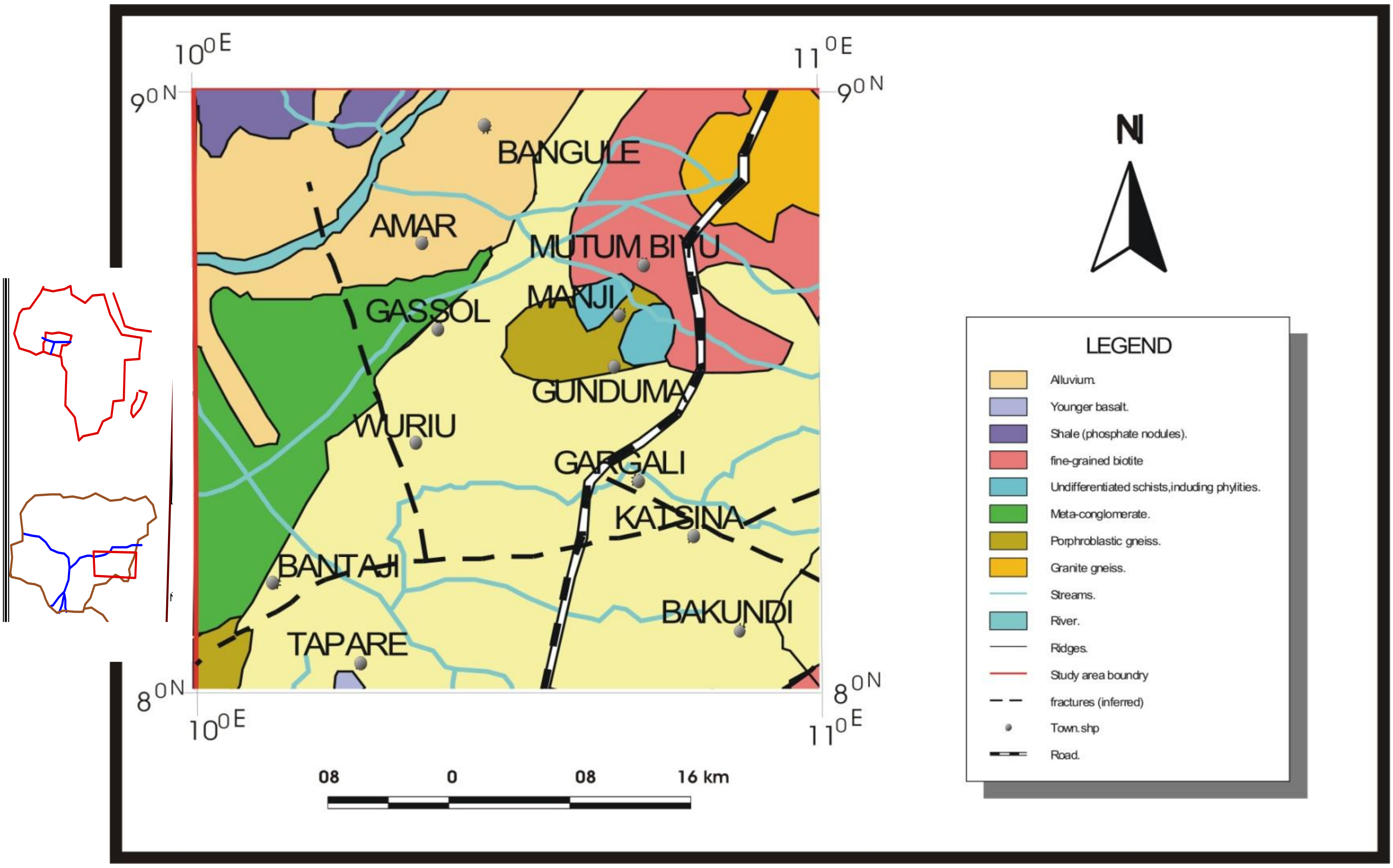

Fig.1. Geological map of study area (after GSN 2006)

The study area is characterized by a variety of lithological units, where it includes many types of igneous, metamorphic and sedimentary rocks, Fig.1. Indicates shale and alluvium deposit of marine origin and weathered rocks (Alluvium) dominating the bank of Benue Valley, these represent the first middle Albian transgression into Benue Valley North-western part of the study area. ( Nur et al, 1994). These rocks form the Yolde formation which marks the transition from continental to marine sedimentation. This Formation contains ammonites of Lower Turonian age (Nur, 2000). Fig.1, also indicate younger basalt belonging to the Cenozoic volcanic rocks of tertiary age. The Volcanic rocks basically the basalts trachytes in the study area resulted from eruption on the active Cameroon Volcanic line which extend down to Ngoundere Plateau in Cameroon (Eastern arm) and Biu Plateau Nigeria (Northern arm). The basement rocks are represented in the Southern part of the studied area as a part of the Northern-Eastern Basement complex of Nigeria, where these rocks outcrops on the surface.

**Analysis of magnetic data**

The aeromagnetic data used for this paper was obtained as controlled maps of total magnetic intensity on a scale of 1:100,000 compiled by Geological survey of Nigeria (GSN). It consists of sheets 213, 214, 234, and 235. The relevant survey was conducted along a series of NW-SE profile with a spacing of 2 km. A nominal tie line spacing of 20 km and an average flight elevation above terrain of 150 m. the geomagnetic gradient was removed using the international Geomagnetic Reference field formula (IGRF) of the 1$^{st}$ January, 1974. The magnetic map was digitized at an equal interval of 2cm x 2 cm in the N-S and E-W grid lines giving a data matrix of (56 x 56). The points sampled on the square grid were contoured using a Computer software (surfer 8.0) and this represent the total intensity magnetic map(Figure 2).

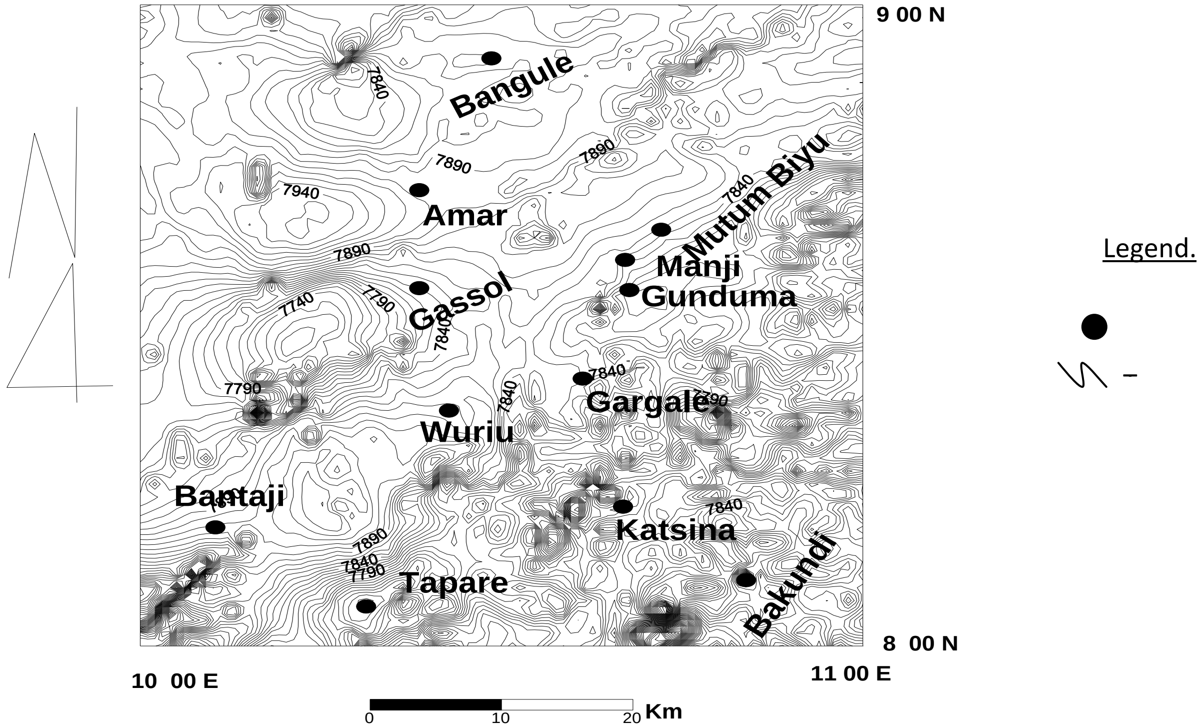


**Fig.2. Total intensity aeromagnetic map of the study area (Contour interval of 10nT)**

To obtain the residual, the regional field was calculated using a simple computer programme (visual basic) which was then subtracted from each observed data point and the resultant residual field was contoured with (surfer 8.0) at an interval of 20nT(Fig 3).

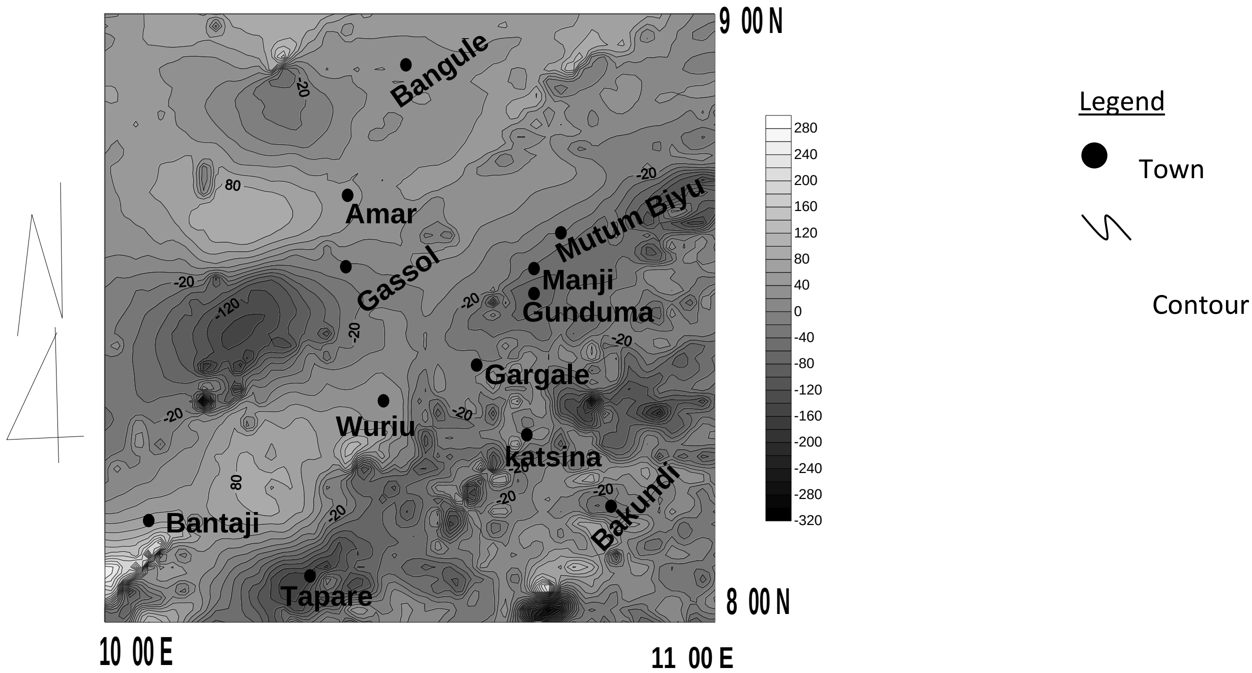


**Fig.3. Residual Magnetic Map of the study area (Contour interval 20nT)**

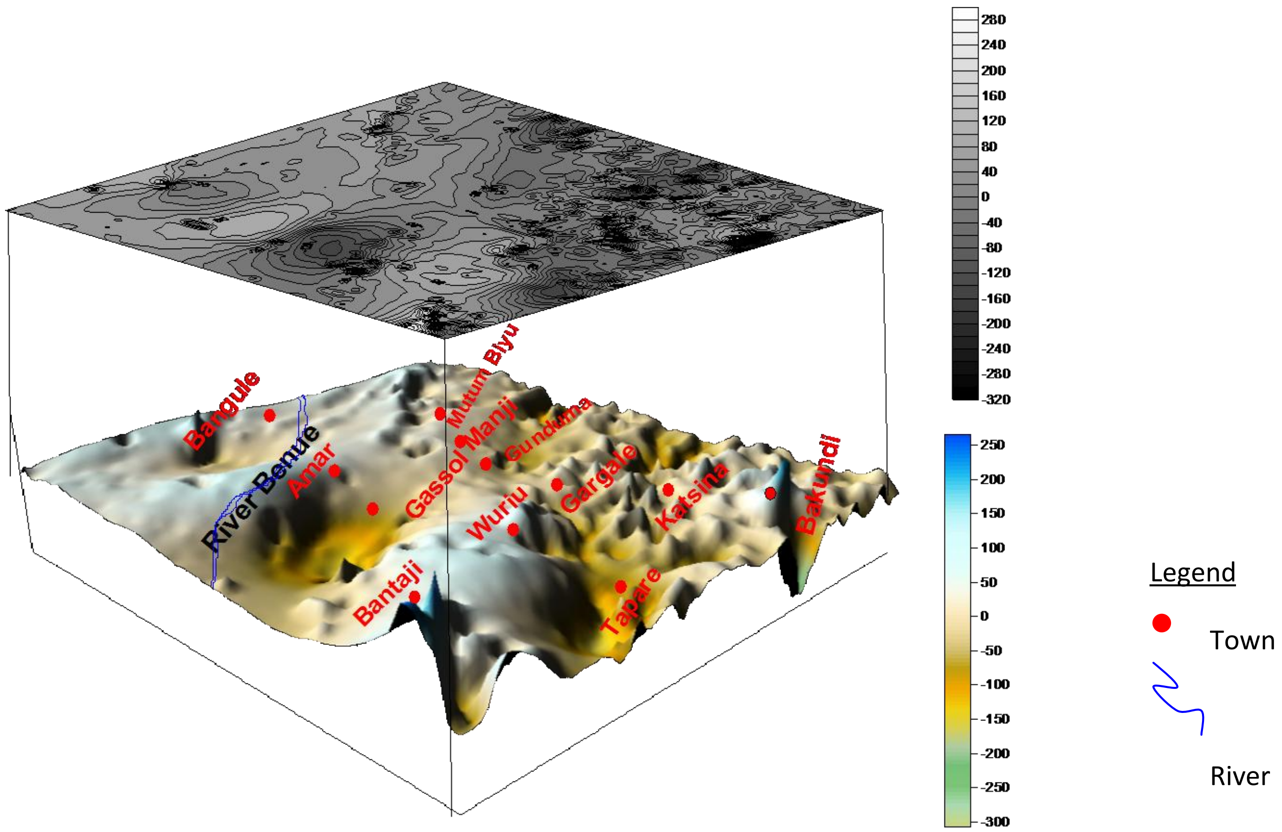


Fig.4. Residual Magnetic Map Superimposed on 3-D Residual

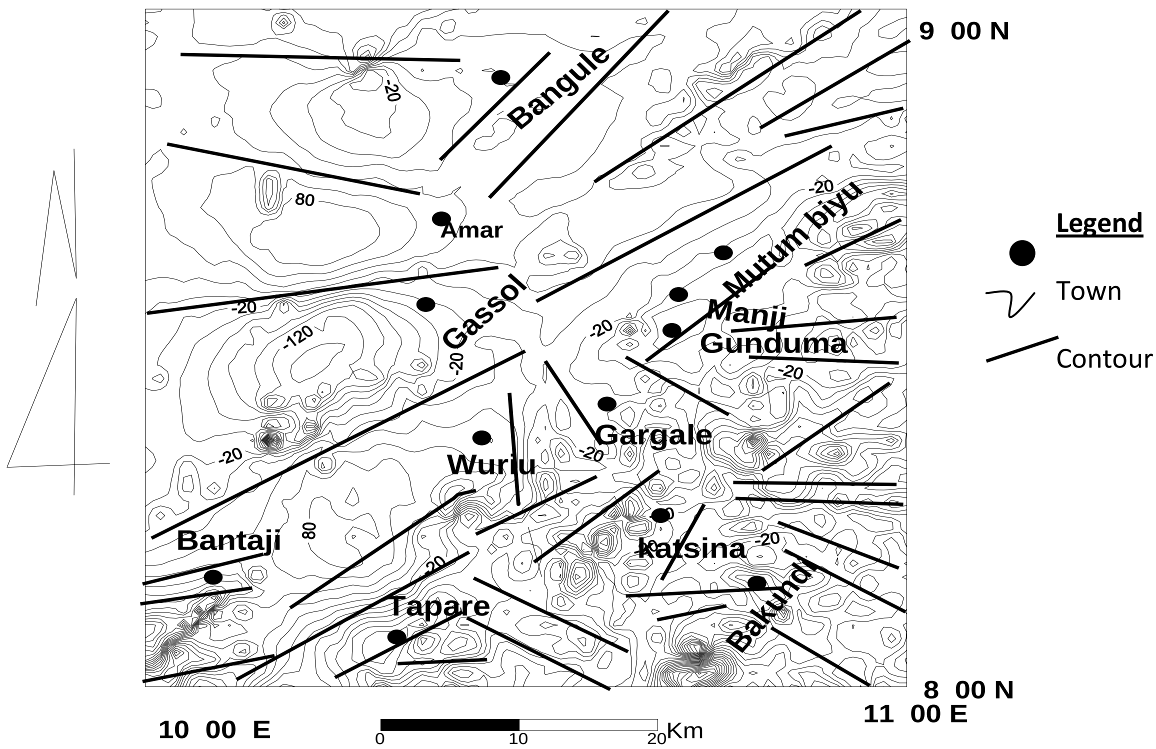


Fig.5. Lineaments on Residual contour Map of the study area

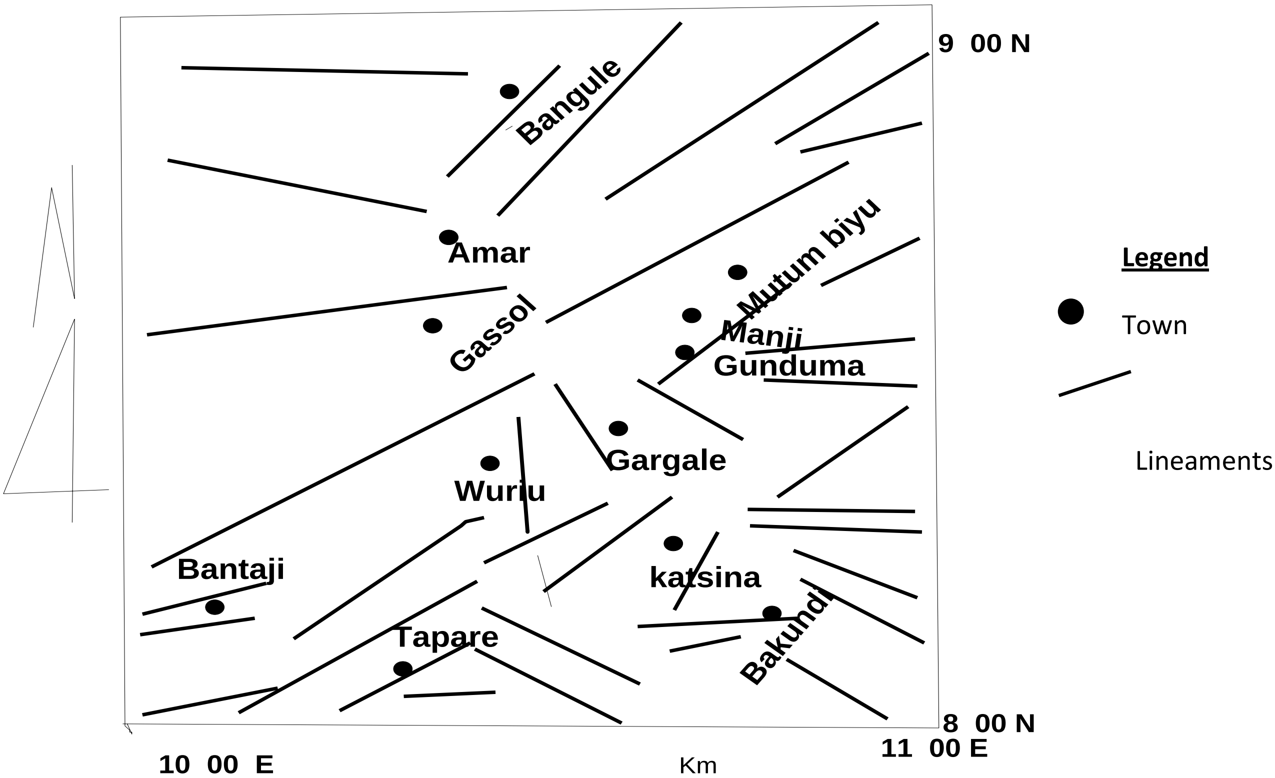


**Fig.6. Magnetic lineament map derived from anomalies 'closures and nosing' of Fig.5**

## Spectral Analysis

Two – dimensional techniques for Spectral analysis of magnetic data has been described by several Authors, Bhattacharyya 1966, Naidu 1969, Spector and Grant 1970, Ofoegbu and Onuha 1991, Ofoegbu et al 1992, Nur et al 1994, Nur, et al 1999, Nur 2000 etc. In this paper the approach of Markku P. (2009) was utilized to analyze magnetic data over Amar and Environs.

Given a residual magnetic anomaly map of dimension L x L digitized at equal intervals, the residual magnetic values can be expressed interns of a double Fourier series expansion.

$T(x,y) = \overset{N}{E}\ \overset{M}{E}\ P_m^n\ (C^2TYL)(nx + m\text{-}p) + Q_m^n \text{ Sin } [(^{2\pi}/_L)(n_x + m_y)]$ ……………. (1)

Where L = length of the square side, $P_m^n$ and $Q_m^n$ = Fourier amplitudes,

and N, M = number of grid points along the X, Y directions.

The sum

$P_m^n \cos [(2\pi/L)(n_x + m_y)] + Q_m^n \sin [(2\pi/L)(n_x + m_y)]$ ……..…………….. (2)

Represent a single partial wave for which

$(P_m^n)^2 + (Q_m^n)^2 = (C_m^n)^2$ …………….. (3)

$C_m^n$ is the amplitude of the partial wave while the frequency of this wave is given as

$f^n{}_m = (n^2 + m^2)^{1/2}$ ………………….(4)

The Fourier transform of a section of a magnetic data digitized in a square grid therefore forms a square matrix of (56 x 56) which can be reduced to a set of average amplitudes depending on the frequency (Hahn et al 1976).These average amplitudes fully represent a spectrum form which the to magnetic sources can be estimated (Ofoegbu et al 1992)

To carry out Spectral analysis, the residual data of the Study area was divided into sixteen (16) blocks containing (16 x16 ) data points. This is to ensure no essential part of the anomaly was cut out by the blocks. The analysis was carried out using computer software FOURPOT, Version 1.0a. (Markku 2009)

The average depth estimated for the sixteen (16) blocks are shown on Table.1, below

**Table.1. Average Depth to Magnetic Sources in Amar and environs**

| | | | | | | |
|---|---|---|---|---|---|---|
| Block 1 | Block2 | Block3 | Block4 | Block5 | Block6 | Block7 |
| D1 = 0.647 | D1 = 0.793 | D1 = 0.944 | D1 = 0.734 | D1 = 0.396 | D1 = 0.720 | D1 = 0.624 |
| D2 0.219 | | D2 = 0.161 | | | | |
| Block8 | Block9 | Block 10 | Block 11 | Block 12 | Block13 | Block 14 |
| D1 = 0.942 | D1 = 1.499 | D1 = 0.609 | D1 = 0.810 | D1 = 2.330 | D1 = 1.257 | D1 = 0.851 |
| | D2 = 0.472 | | | D2 = 0.436 | D2 = 0.382 | D2 = 0.461 |
| Block 15 | Block 16 | Block 17 | Block 18 | Block 19 | Block 20 | Block21 |
| D1 = 464 | D1 = 0.679 | D1 = 0.365 | D1 = 0.747 | D1 = 0.891 | D1 = 1.859 | D1 = 1.640 |
| D2 = 0.215 | | | | | D2 = 0.385 | D2 = 0.477 |
| Block 22 | Block 23 | Block 24 | Block 25 | Block 26 | Block 27 | Block 28 |
| D1 = 2.733 | D1 = 2.231 | D1 = 2.183 | D1 = 1.363 | D1 = 1.437 | D1 = 1.953 | D1 = 1.798 |
| D2 = 0.947 | | D2 = 0.847 | | | | |

**Discussion of Results**

The residual anomaly map obtained from Regional –Residual separation (Fig.3) indicate NE-SW trending structures which correspond to Benue Valley, a major tectonic feature in the North - Eastern crystalline basement. The 3-D residual magnetic map on which residual contour map was superimposed (Fig.4), shows that the basement configuration of Benue Valley is arched upward and trending NE-SW on which shallow depth to magnetic sources were obtained .This is interpreted as the crust is thin under the Benue valley in the study area. Other magnetic anomaly features indicated by closures and nosing's in the South –Eastern part of the Study area around Mutum Biyu, Manji, Gunduma, South and east of Gassol as shown on residual magnetic map (Fig.3) are interpreted as volcanic arcs resulting from younger basalts of Cameroon Volcanic line (CVL), as can be observed on 3-D residual magnetic map (Fig.4) Though these younger basalt only outcrops at Manji and Gunduma area. This coincides with the geology of the area.

Generally there would always be magnetic susceptibility contrast across a fracture zone due oxidation of magnetite to hematite , and / or infilling of fracture planes by dyke like bodies whose magnetic susceptibilities are different from those of their host rocks(Bassey, et al, 2000). Such geological features appear as thin elliptical closures or nosing on the residual magnetic map (Fig.3.). Bearing this in mind, prominent elliptical closures and nosing were identified on the residual magnetic map (Fig.5).These features represent geologic lineaments whose position are indicated by line drawn parallel to the elongation of the anomalies and they are presented on Fig.5 and 6. These lineaments trend, NE-SW, NW-SW, N-S and E-W corresponding to Pan –African and Pre-Pan –African deformational episode, and may be a possible host for secondary mineralization in the study area. Looking at the residual contour map superimposed on 3-D residual map (Fig.4.) the central and the North western part look different from the SE part of the study area, because at the SE part of the area; is a consistent sequence of varying anomalies coinciding with the basalts of Cameroon volcanic line which attributed to Precambrian Basement fractures which were initiated prior to formation of Benue Valley, Bassy et al (2000). In addition to that, in the study area where elongated zone of steep gradient without well-defined closures, it is quite possible that this pattern resulted from subsurface faulting, which has displaced magnetized rocks (Dobrin, 1976).

The result obtained from Magnetic source depth determination through Spectral analysis over Amar and Environs suggest two source depths. The deepest sources lies between 500m to 2772m while the shallow source ranges between 300m to 450m and could be attributed to intrusive bodies Table.1.

A comparison of the results obtained in the study area with those previously estimated from magnetic analysis shows a good agreement with what was obtained by (Nur, et al 2000). That the deepest source in upper Benue lies between 1500m to 2219 m, and the shallow sources lies between 330m to 414m

## CONCLUSION

Depths to magnetic sources have been determined for the Amar and environs from spectral analysis of aeromagnetic data over the area. The analysis indicate two depth source model, with the depth of deeper source varying between 500m to 2772m,while the shallow source depth varies between 300m to 450m. The shallow depth source model indicates the presence of intrusive rocks in the study area. The results obtained compare favourably with previous studies in Upper Benue Trough. The magnetic data over this area is characterised by presence of NE-SW, NW-SW, N-S and E-W lineaments which correspond to Pan –African and Pre- Pan –African deformational episode which maybe a possible host of secondary mineralization in the study area.

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