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A QUALITATIVE INTERPRETATION OF AEROMAGNETIC MAP OF TAKUM (SHEET 273) THROUGH IMAGE – BASED DISPLAY AND DEPTH CALCULATIONS.

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ABSTRACT

*A qualitative interpretation of aeromagnetic map of Takum (sheet 273) of the lower Benue, Nigeria through image-based display and depth calculation was carried out at a scale of 1:100,000. The study area is located within longitudes 9 30'E-10 00'E and latitudes 7 00'N-7 30'. The principal purpose of this work is to recognize and delineate anomaly that may be related to structure and their relationship to metallurgy as well as visualizing the structural features within the study area. The technique of image processing was employed. A 1' by 1' cell size was used to display the magnetic field values as colour rasters. A total of 900 grid cells which represents the 900 digital numbers of aeromagnetic data were geographically registered on a base map and contoured to produce the required total field aeromagnetic map of the study area. Depth calculations made use of peter's maximum slope method. The range of anomaly depths is about 90m to 2850m. The susceptibility values range from (0.5 - 4.8) * 10-4 c.g.s. The prominent strike direction is the NE-SW trend. Ten possible major faults were identified and mapped out. The anomaly trends conform to the susceptibility trend. Visualization and quantification of subsurface geology were enhanced. The basement is of non-uniform magnetization. It is characterized by short wavelength anomalies which are probably caused either by susceptibility changes within the basement or near surface intrusive. Differing colours in visual display show areas of varying ruggedness which are useful tools in demarcation of lithologic structures and boundaries.*

Keywords: Aeromagnetic, Anomaly, Contour, Susceptibility, Delineate, Basement, Structures

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1.0 INTRODUCTION

Geophysical exploration is the making, processing and interpreting measurement of the physical properties of the earth with the objective of practical application of the findings. The physical properties and effects of subsurface rocks that can be measured at distance include density, electrical conductivity, thermal conductivity, magnetic, radioactivity, elasticity and other properties (Spector and Grant, 1970).

As an earth science which largely makes use of instruments to make direct or indirect measurement of the parts of the earth being studied, a number of principles apply to most of the different types of geophysical explorations. Occasionally, prospective features can be mapped directly by their magnetic effects, but most features are studied indirectly by measuring the properties or the geometry of rocks that are commonly associated with certain mineral deposits. The magnetic method can be used to delineate surfaces of dissimilar properties such as the basement and sedimentary surfaces. Estimation of depth to basement as well as mapping the surface can be achieved through this means (Maged Marghany and Mazian Hashim, 2010). The fault zones are known to be associated with repeated circulation of fluids from different origins within the earth crust (Zong, J., 2017). The faults zones are also areas in which mineralization mostly occur. This allows for the formation of potential economic ore deposits. In many conceptual models of the formation of ore deposits, fault zones are important structural features acting as collecting points of fluids and related metals, (Micklethwaite, S., 2010).

Ordinarily, one looks for an anomaly that is a departure from the uniform geologic characteristics of a portion of the earth. The primary objective of a survey is usually to determine the location of such departure. This gives idea of the natural resources abound underneath and points towards the economic importance. The exploration will reveal if the possible deposits are in commercial quantity or not. This study considers the details in the magnetic method. The available aeromagnetic map of Takum, a town within the Benue trough of Nigeria was digitized and the total magnetic intensity acquired. Many parameters of interest in connection with the magnetic contents were identified. The low pass filtering method to was employed to remove noise and spurious signals. The Peter's rule of thumb technique was used to calculate depth to basement or top of anomaly. An attempt of estimation of the different rock types was done by determining the susceptibility contrast of the rocks, Olowofela et al (2012). The process of faults identification was followed.

2.0 LOCATION AND GEOLOGY OF THE STUDY AREA

The study area covers sheet 273, Takum in the lower Benue of Ngeria. It is bounded by longitude ($9^{\circ}30'$-$10^{\circ}00'$) E and latitude ($7°00'$-$7°30'$) N, Figure 1. The area is about 200m above sea level. It is a basement complex within the Benue trough and it is .The study area is part of the South Eastern. The basement in the South Eastern part of Nigeria is folded with Northerly (NNE to NNW) axis. An extensive area (Ca.260Km), west of Obudu is underlain by massive to faintly gneissic hypersthenic quartz diorite (enderbite of Orajaka, 1964). The enderbite is immediately surrounded by meta-sediments in which hypersthenes, sillimanite, brown hornblende, garnet and cordierite are stable. Surrounding these high grade terrains are medium grade gneisses, migmatites with minor occurrences of schists. The metamorphic terrains were invaded by igneous bodies.



Figure 1: Geologic Map of the Study Area

3.0 METHODOLOGY

The aeromagnetic maps used for the study were obtained from the Geological Survey of Nigeria. The data were acquired and compiled by FAIREY SURVEYS LTD during an airborne geophysical survey between May to December, 1975. The nominal flying altitude above the terrain was 500 feet (approximately 152m) with flight line and tie-line spacing of 2km and 20km respectively. However, the flight and tie line direction is150˚/330˚ 60˚/240˚ respectively. The regional correction of the magnetic data was based on IGRI (Epoch date 1 January, 1974). The aeromagnetic total intensity field maps were on a scale of 1:100000 were digitized by noting the coordinates (X and Y) and the magnetic values Z at the point where the contours intersects the NW-SE flight lines. This is continuously done at the intervals of 1cm on the flight-lines. This produces X, Y, Z as text files. These are then run on the a2xyz program of the United States Geological Service (USGS) Potential Field method (Version 2.2 software) and Surfer Software to convert the binary numbers to post files called PST files. The Detour program, a Fortran 77 program is launched to view the data on screen to check errors The Detour program produces the minimum and maximum values of X, Y, Z and shows the contour intervals. Geocon program a screen viewing shows the contouring interval. Then finally the contour program plots the Command (cmd) file to produce a total magnetic intensity map. This process was adopted to produce a total intensity field map of the aeromagnetic maps of the study area. This map is shown in Figure 4.

4.0 RESULTS AND DISCUSSION

4.1 Low Pass Filtering, Total magnetic intensity (TMI) and Residual Anomaly Identification

The aeromagnetic data used were filtered using a low pass filter. The nature of filtering applied to the aeromagnetic data in this study was chosen to eliminate certain wavelengths and to pass longer wavelengths. The result is displayed as filtered total aeromagnetic intensity (TMI) map of the area, Figure 2. A total of 41 anomalies were identified, and they are either circular or elongated in shape.

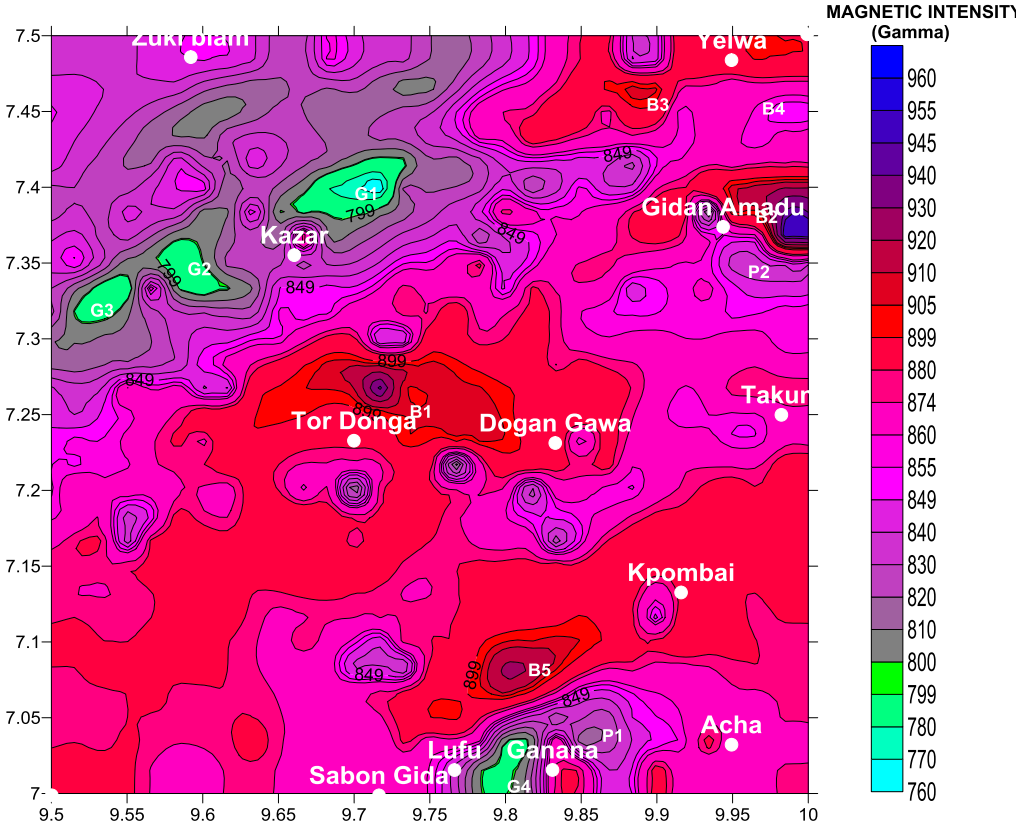


FIGURE 2: FILTERED TOTAL MAGNETIC INTENSITY MAP OF TAKUM

Figure 2: The Filtered total magnetic intensity map of the Study Area

The fitting of polynomials to observed geophysical data is used to compute the mathematical surface giving the closest fit to the data that can be obtained within a specified degree of details. This surface is considered to approximate the effect of deep seated or regional structures if it is low degree. The function that generates this surface is called the trend for that specified degree and the consequent analysis of this constitutes the trend surface analysis. The fitting surface which represents the regional is a surface which will have both positive and negative deflections from the observed data points with the residuals balanced between positive and negative areas. (Nettleton, 1976) The regional gradients were removed by fitting a plane surface to the data by multi- regression least squares analysis, Figure 3. The residual magnetic values show numerous contact points as revealed by zero contours, Figure 3. The

boundaries between different colours especially regions of brown and green are in the range of -4gammas to 4gammas.

The chain of magnetic lows characterize the contact of the basement with the sedimentary Basin (Benue trough) (Ofoegbu 1983), traceable from latitude 7°15′N-7°30′N and longitude 9°30′E of the study area, Figure 3.

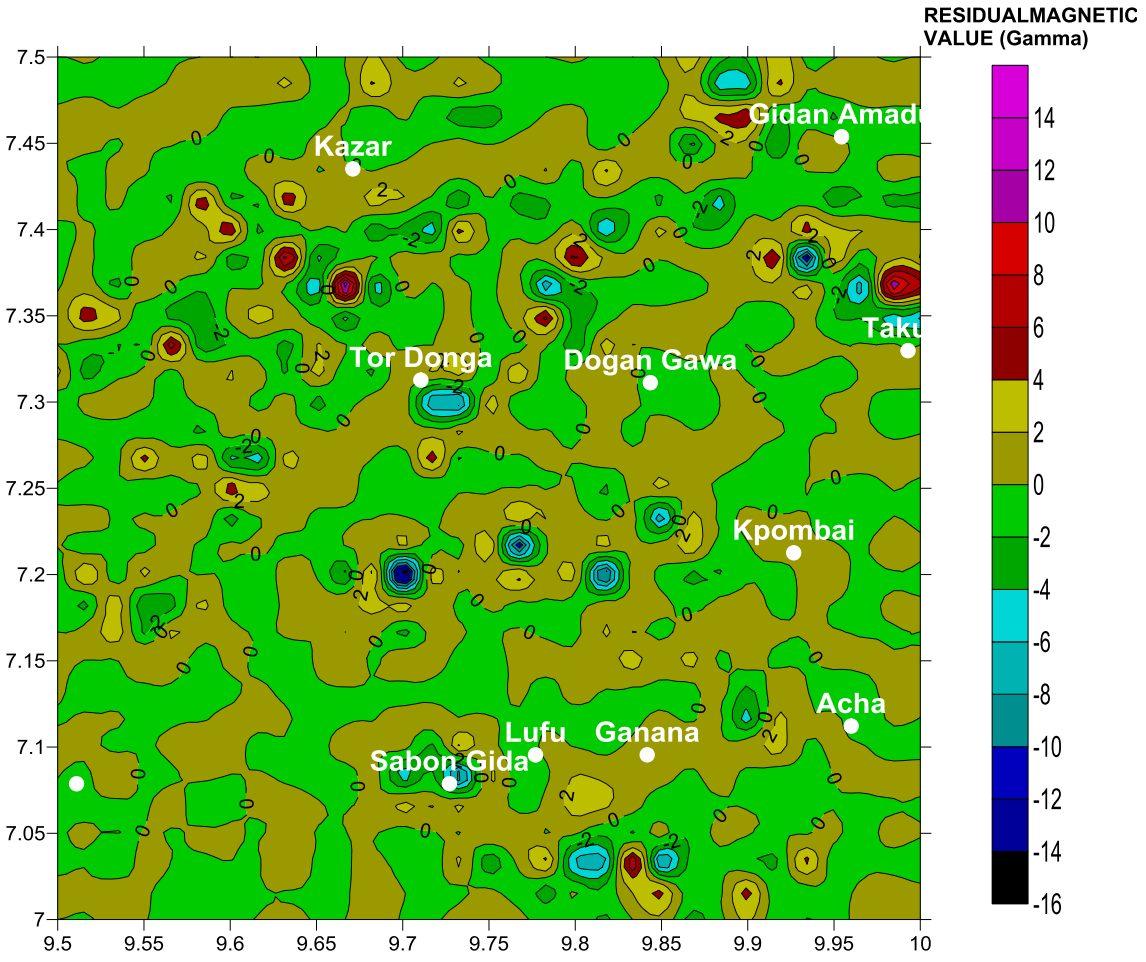


FIGURE 3: THE RESIDUAL MAGNETIC INTENSITY WITHIN THE STUDY AREA

4.2 Anomalies and Strike Direction

The local magnetic anomaly reflects the main structural features within the study area. The strike, width, magnetic intensity and deflections of each of the 41 identified anomalies are presented in the four known directions. The major strike directions are NE-SW, E-W, NW - SE and N-S trends. Four anomalies identified lie in the N-S direction. The magnetic intensity varies from 825gamma to 900gamma, width sizes between 14mm and 35mm of which three are magnetic low and one is magnetic high, Figure 4. Twelve anomalies lie in the E-W direction. The intensity of magnetization is from 820 gamma-920 gamma with seven magnetic highs and five lows. A total of seven anomalies lie in the NW-SE direction of which two are magnetic lows while five are magnetic highs. The intensities and the

corresponding widths of contours are in the range of 810gammas to 945gammas and 4mm to 52mm. The low and high magnetic deflections show different magnetic materials with poles. The anomalies that lie in the NE-SW direction are sixteen, of which six are magnetic high and eight are low. The sizes of the anomalies vary between 16m and 164m wide and the highest intensity is 920 gammas. The largest anomaly is a magnetic high, anomaly 15. The anomalies in the N-S direction are 4, NW-SE, 7; E-W, 12; and 16 in the NE-SW direction, which is predominant, Figure 4. There are two prominent sharp gradients that trend in the NE-SW direction around Kazar and Kpombai. Kazar is located in the NNW section (longitude 9°30′E and latitude 7°15′ -7°25′N) and Kpombai in the SSE axis of the study area (longitude 9°45′E and latitude 7°15′N). The steep gradients form linear boundaries between areas of different magnetic relief, level or texture, Figure 1. This explains the number of magnetic highs and lows which is in the ratio of 17: 22.

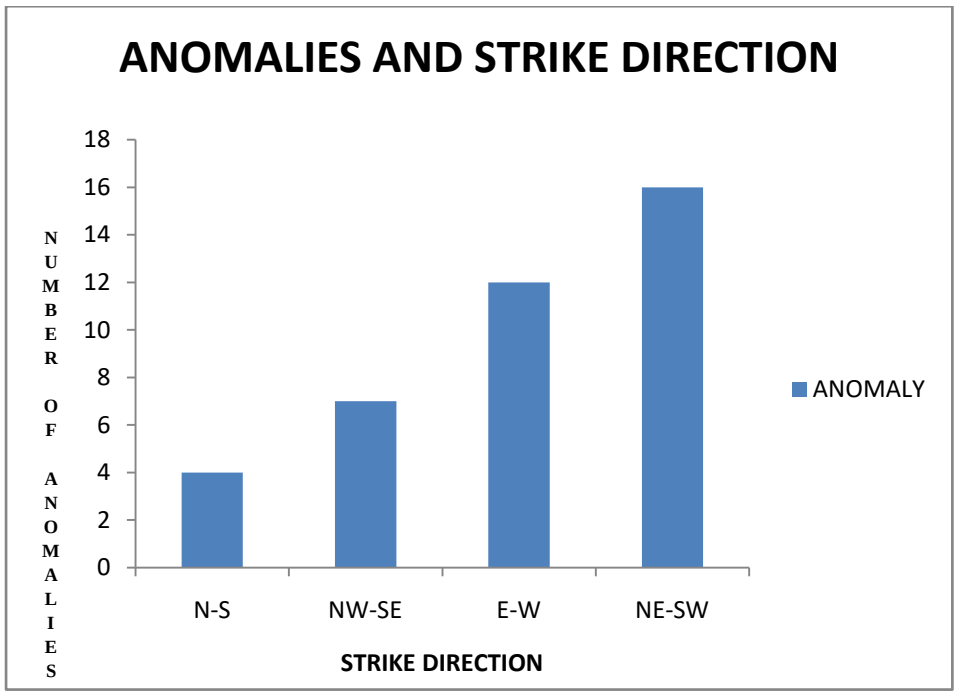


Figure 4: Anomalies and Their strike directions within the study area.

4.3 Depth Estimation

The Peter's maximum slope method was used to estimate the depths to anomalies with due considerations of flight height of 152 m, and tangents at points of inflections. The general view shows that anomalies are not deeply buried. The shallowest depth to the top of anomaly is 98m and the deepest is 2850m. Plots of anomalies1, 35 and 42 are shown in Figures 5, 6, and 7. Anomaly 1 and 42 are dipoles or dykes of similar rocks while Anomaly 35 is of different type.

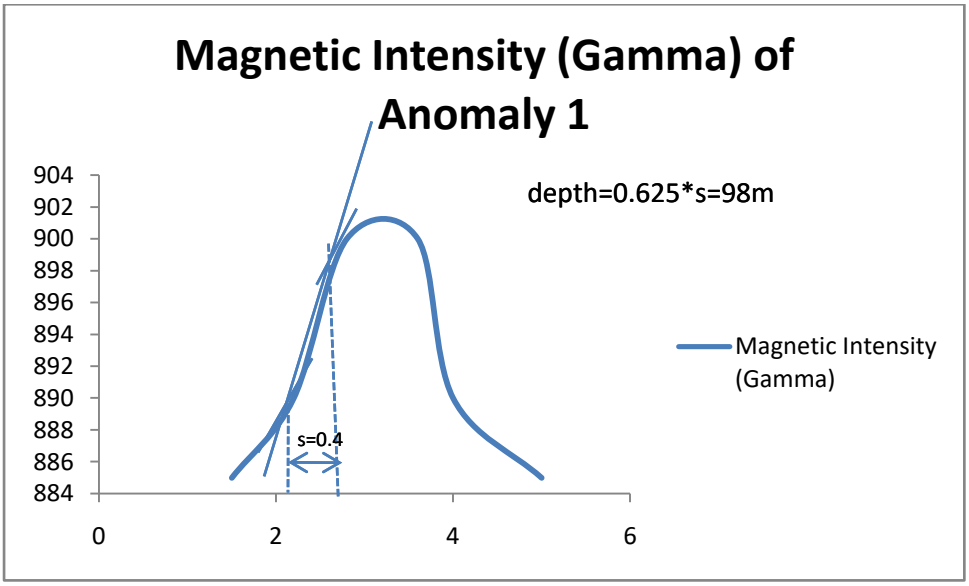


Figure 5: Plot of Anomaly 1 of the study area showing a magnetic high.

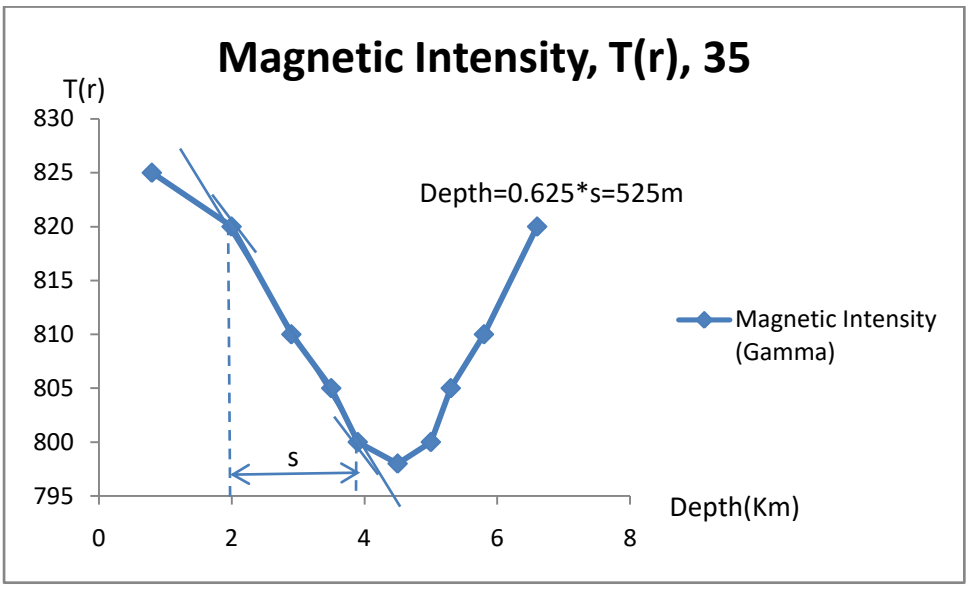


Figure 6: Plot of Anomaly 1 of the study area showing a magnetic low

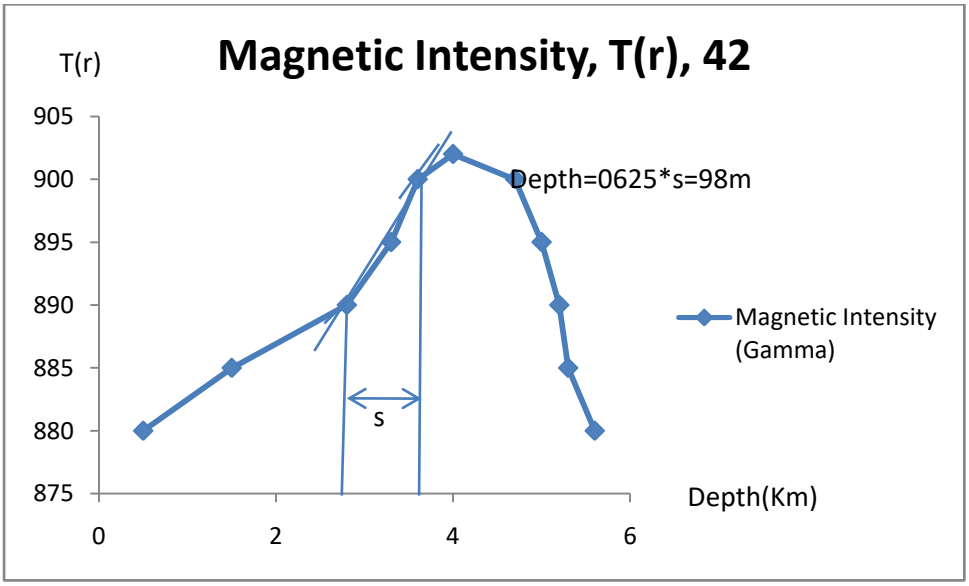


Figure 7: Plot of Anomaly 1 of the study area showing a magnetic high

4.4 Location of Lineaments

The multiple fragmentations, lineation and circular signatures are indicative of fractures and possible fault zones, Figure 4. The directions differ and can be observed as lines showing fractures or fault zones. The major lineaments run in the NE – SW, NW – SE and N –S directions (Ananaba and Ajakaye, 1987). The length of these lineaments vary in their various strike as some are located at the flanks such as longitude 9°30′ - 9° 40′ E and latitude 7°15′ - 7° 30′N; of the study area, The longest lineament extends to 55km and seem to pass through a longer stretch. The N –S fault zones run between 9.6°E and 9.65°E, 9.75°E and 9.85°E as well as 9.2°E and 9.3°E. The widths vary from 20m to 150m.

East of longitude 9°40′E is an area of magnetic high with steep gradient suggesting areas of possible fault which are structural features associated with magnetic minerals (north central and southeast of Takum). The low magnetic reliefs are indicative of negative susceptibility contrast and vice-versa, Figure 5. These spaces are not necessarily filled with magnetic substances but non magnetic minerals and metals that may be of economic value. Shear zones may be observed in- between a magnetic low and high which are indicative of low and high percentage of mafic minerals. There are other areas of lower susceptibility contrast but owing to lack of geologic knowledge of the undifferentiated basement complex these areas are not labeled. This suggests that boundaries should be readjusted to include them. Again it could be stressed that the multiple anomalies of average depth range of 800m is due to the highly fractured condition of the study area and faults are located at almost every 9.5km. The located faults on the filtered aeromagnetic map agree well with that superimposed on the unfiltered map by earlier researchers. The trend of faults confirms the structural trends in Nigeria Basement Complex which explains that the most prominent of the structural trends is the N-S planar structures but that the relicts of E-W, NE-SW and NW-SE structures are preserved, Anudu G. K. et al, 2014. It also agrees with the basement as being characterized by several sets of fractures with the North easterly and Northwesterly conjugate sets predominating (Oluyide, 1988).

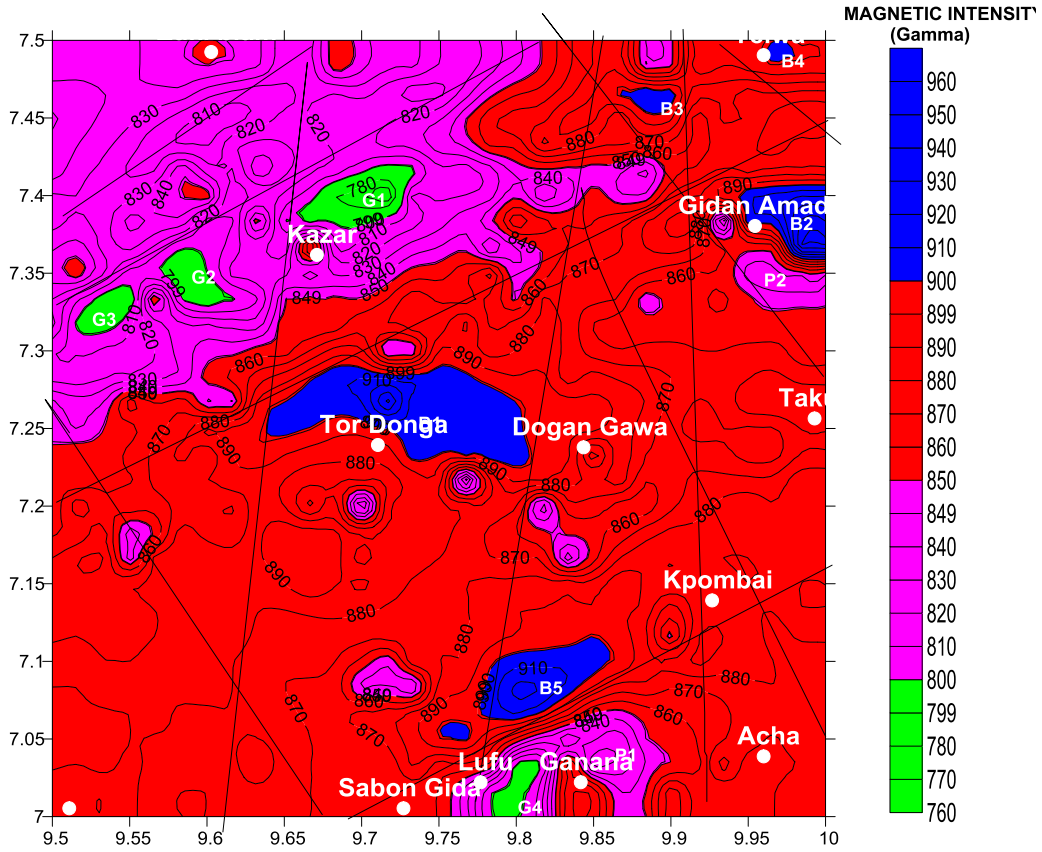


FIG. 6:FAULT LINES ON FILTERED TOTAL MAGNETIC INTENSITY MAP OF TAKUM

Figure 8: Fracture and Fault lines within the study area

4.5 Susceptibility Distribution

Susceptility is a measure of the degree of iron content within the country rock of a certain locality. Generally, the susceptibility contrast is highest in the NE-SW trend while it is lowest in the NW and SE regions.

The susceptibility contrast in the NW and SE areas is from .0.01 to -0.005cgs. It is denoted in black. From -0.005 to -1.73 cgs are around Kazar, Azukibiam, Acha and Lufu Ganana (Umeji, 1988). The areas of low to medium susceptibility are from -1.73 to 0.001 cgs. High values range from 0.004 to 0.008 cgs and they are in the NE region of Takum, Gidan Amadu and Gawa, Fig. 9.

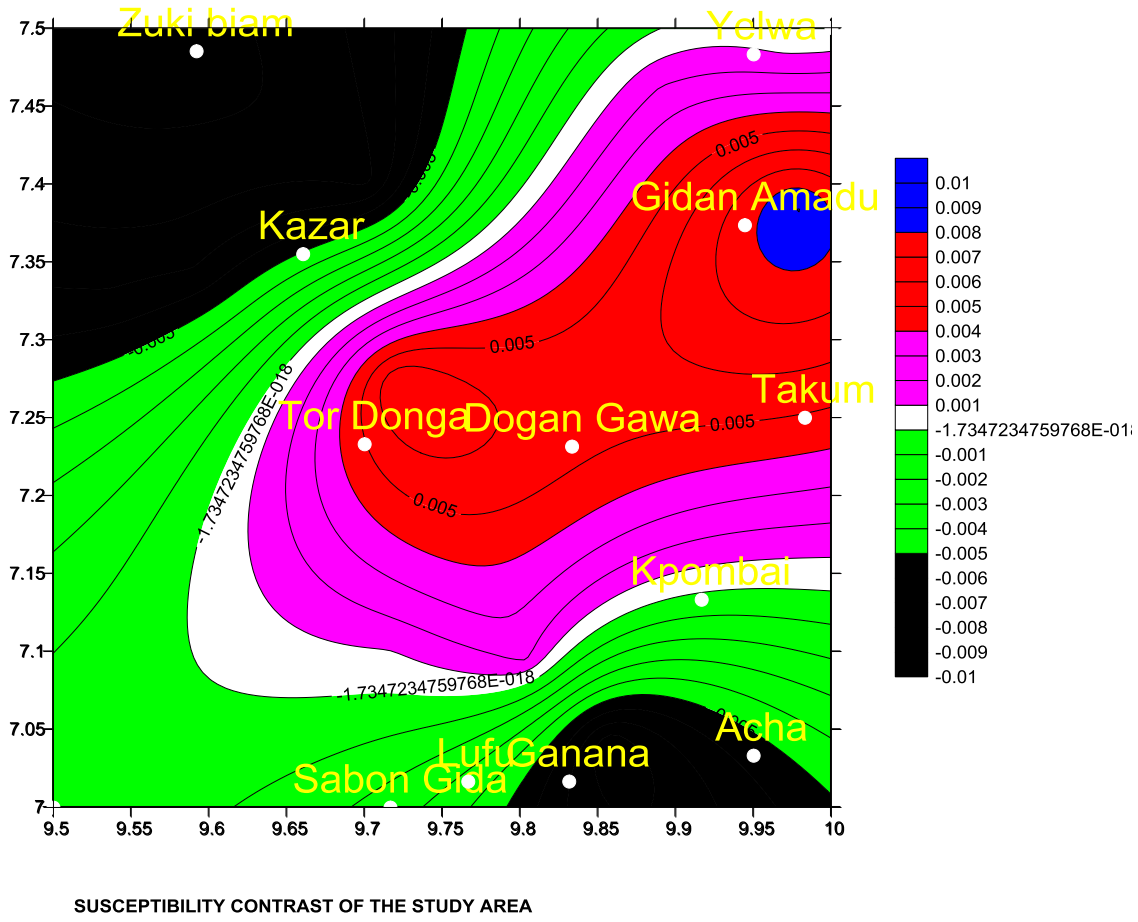


Figure 9: The susceptibility contrast of the study area

From the depth estimation, the range of depth to anomalous bodies is 90-2850m. The depth of anomalies increases with their widths. The depths to basement anomalies are very shallow.

The top left flank NNW, longitude 9°30′ - 9° 40′ E and latitude 7°15′ - 7° 30′N is composed of sandstone and has low susceptibility contrast and a series of closed lows on the map which suggest the location of fractures or possible faults which may be di-magnetic, Figure 4.

4.6 Quantification and Visual Classification of the Rock Types

The visual display of the pixels agrees fairly with the rock types identified and the geology of the study area. The pie chart and histogram of the three main rock types reveal that 9.7% of the study area is covered with sandstone, 20.8% is granite while 69.55 is the gneiss-migmatite complex. This result confirms that the host rock is gneiss-migmatite complex.

The magnetic visualization technique reveals the subsurface- surface geologic relationship. The enhancement of the colour display may explain the basement area that is characterized by short wavelength anomalies which are probably caused either by susceptibility changes within the basement or by near surface intrusive, Figure 6.

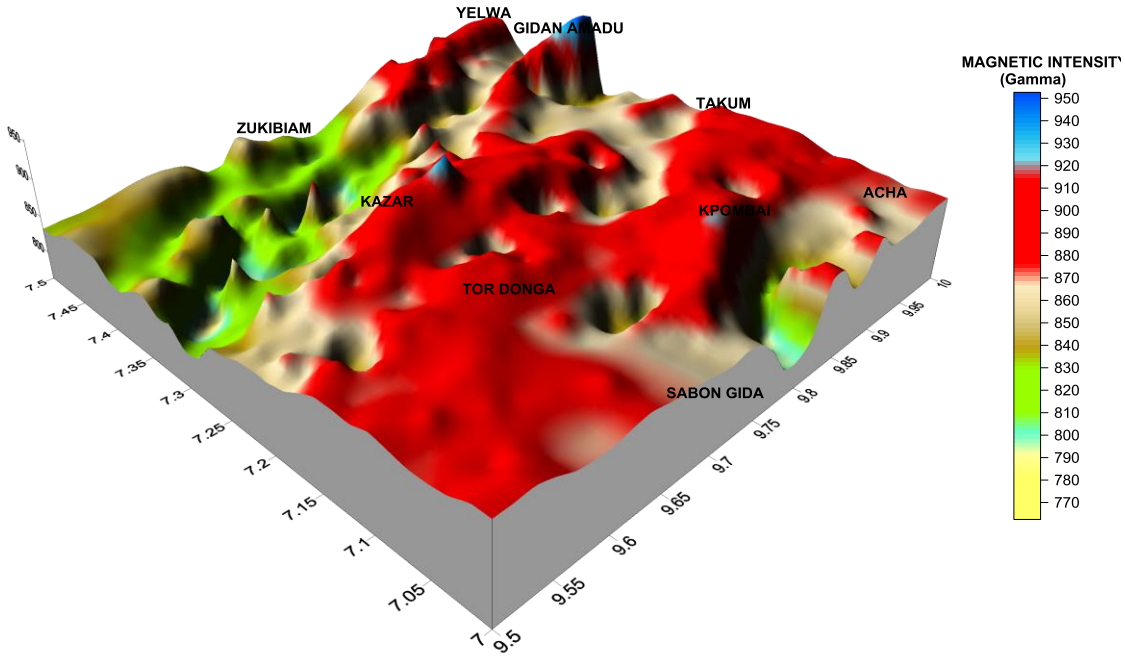


Figure 6: 3D magnetic relief of the study area

5.0 CONCLUSION AND RECOMMENDATIONS

The total field aeromagnetic map of Takum shows that such a potential field map, constitute invaluable tools for the better and clearer understanding of the geology of the study area.

The magnetic response show varying intensities in magnetic content of underlying rock units. The aeromagnetic anomalies are characterized by a series of magnetic lows and highs with steep gradients in some places.

The study area is highly fractured as reflected in abrupt susceptibility changes which agrees with the structural trends speculated by many researchers.

The basement is invaded by igneous intrusive which rise to anomalies of circular or near circular symmetry. Thickness range is between (90-2850) m. There are NE-SW trending anomalies with short inflection points which are indicative of transition zones of rock units.

Subsurface magnetic visualization enhances geophysical exploration. The areas of abrupt change in susceptibility and fracture zones are revealed with ease. Differing colours shows varying ruggedness and are useful tools in demarcation of lithological structure. The output image is a true formation of the suspected geology of the area. Harnessing of suspected minerals are easily and readily facilitated and quantified.

A detailed geological mapping is recommended, starting from photogeological interpretation followed by ground geological and geophysical works. Gravity work is also recommended as well to confirm through density variation and the interpreted magnetic anomalies. These may be related to mineralization.

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