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Pre – Construction Site Investigation of an Area within the Federal Polytechnic Ede Campus, Using the Magnetic Method

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Abstract: Physical infrastructure including roads, bridges and, buildings have a base that may necessitate some type of adjustment of the ground before constructing them. The magnetic method of geophysical exploration has the capacity for subsurface structure delineation and when applied in addition to routine geotechnical surveys arms construction workers with a good knowledge of the site upon which they intend to erect a structure. A building site pre – construction investigation was carried out on a portion of land within the Federal Polytechnic, Ede, North campus, using the ground magnetic method. The aim was to delineate subsurface structures which could be inimical to the stability of a proposed building. A GEM GSM – 19 T proton precession magnetometer was used to gather data along about five 80 m long traverses with about 10 m separating them. A station interval of about 5 m was used along individual traverses. The acquired data were processed using Excel, Surfer 10, and Oasis Montaj 8.4 software applications. Base station readings were employed to mitigate diurnal variations and the data were subjected to International Geomagnetic Reference Field correction to muffle the influence of the main magnetic field. The Reduce to Equator filter was deployed to focus anomalies over their sources. Lineament delineation filter namely, the Second Vertical Derivative was used to map fault structures. Additionally, spectral depth method was used to determine basement depths across the study area. Results were presented on profiles and maps. It was determined that fault structures within the subsurface might affect the proposed building adversely.

Keywords: Building, Delineate, Magnetic, Pre – construction, Subsurface, Structure

1.0 INTRODUCTION

Common problems experienced with buildings within south-western Nigeria include water seepage, cracks on walls, and subsidence ([6]; [3]). Certain buildings close to the study area are particularly known to be bedeviled by cracks which may be an early sign of a subsidence problem. Many of these problems occur as a result of a failure to conduct a proper pre – construction site investigation.
The design and construction of the foundation structure requires an understanding of the local geological and groundwater conditions, as well as an appreciation of the various types of problems that can occur ([4]).

Usually, borehole sampling and, test pit excavations are ways to gain a good understanding of the subsurface geology. And while these methods will always be important, geophysics has the capacity to provide enough indirect evidence and thus minimize environmental impacts ([13]; [14]; [9])
The zone of interest on/beneath the surface usually includes, soil, groundwater, unconsolidated sediments, weathered rock, and competent bedrock. Typical parameters of importance are thickness and extent of layers, physical properties of layers and any variability within them, and any structures within the ground. Having an understanding of what lies beneath before breaking ground can save significant costs to a construction project ([10]).

Geophysical methods provide useful information regarding the early detection of potentially dangerous subsurface conditions. The sources of hazards in construction work result essentially from undetected near-surface structures, such as cavities and/or in homogeneities in the foundation geomaterials ([18]).

In this study, the magnetic method which measures variations in the earth's magnetic field resultant from the varying susceptibilities of crustal materials and structures has been applied to map possible near surface lineaments, and estimate the depth to basement values within a portion ear - marked as a building site within the Federal Polytechnic, Ede.

2.0 STUDY AREA

The study area is located some 30 m away from the Geological Technology Department complex within the North campus of the Federal Polytechnic, Ede, Osun, Nigeria (Figure 1). It is bounded by Longitudes 4°25' to 4°26' E and Latitudes 7°43' to 7°44' N (Figure 2) covering an area of about 5000 m^2.

Figure 1: Google Satellite Map showing the Study Area ([8])

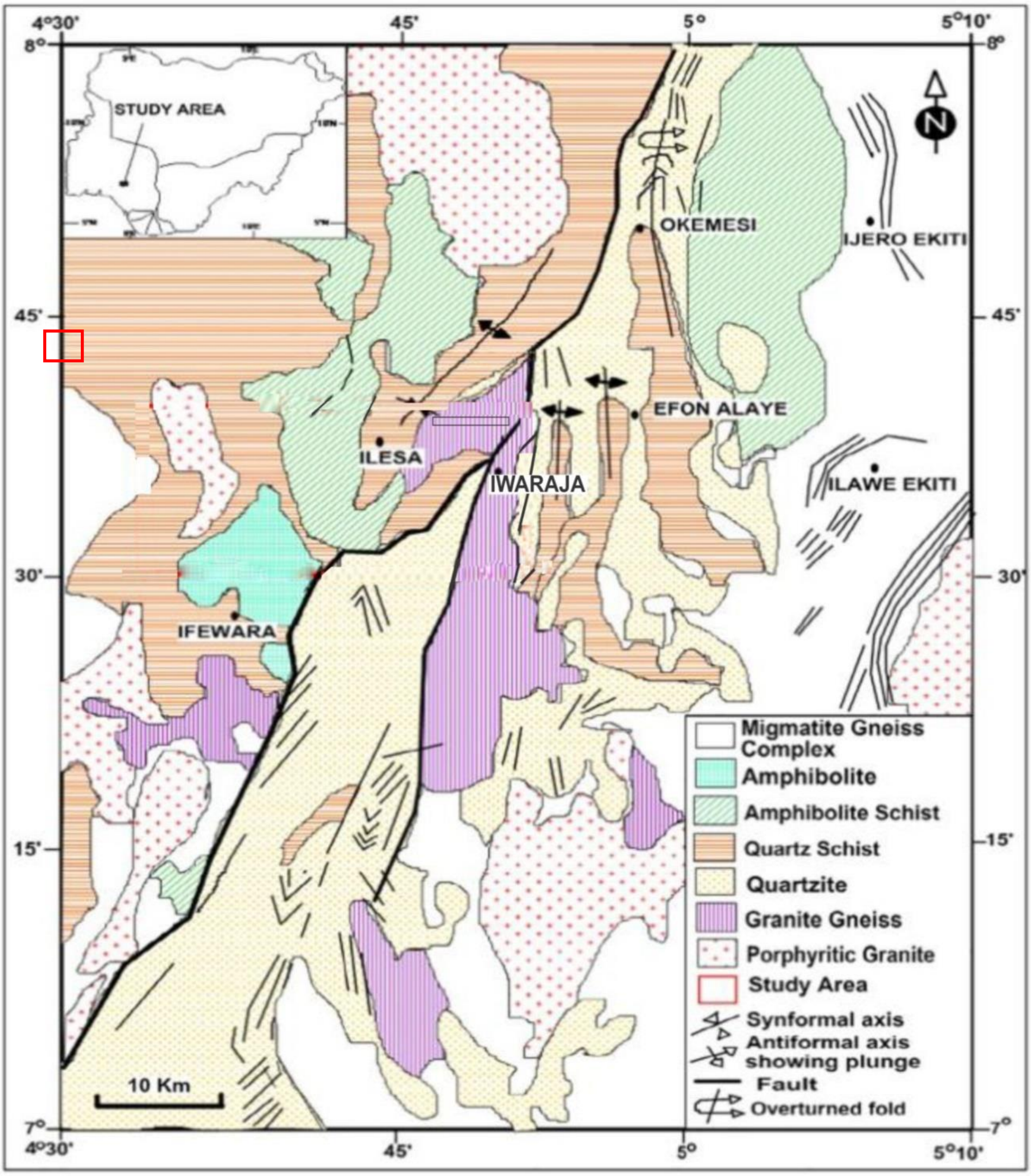

Fig. 2: Geological Map showing Study Area (After [12])

Located in Osun state, Southwestern Nigeria, it is underlain by Precambrian basement rocks that are characterized by foliated and non – foliated rocks. Some of the named rocks include, migmatite gneiss, quartzite, pelitic schist, biotite granite, charnockite, granite gneiss and porphyritic granite ([5]; [16]; [7]; [1]).

3.0 METHODOLOGY

The aim of this study is to delineate subsurface structures which could be inimical to the stability of a proposed building. The study followed the pattern of progression (Figure 3) of geophysical methods which involves acquiring data, processing data and interpreting them. A GEM GSM – 19 T proton precession magnetometer was used to gather data along about five 80 m long traverses with about 10 m separating them. A station interval of about 5 m was used along individual traverses. The acquired data were processed using Excel, Surfer 10, and Oasis Montaj 8.4 software applications. Base station readings were taken as references and used to correct diurnal variations and the data were subjected to International Geomagnetic Reference Field correction to muffle the influence of the main magnetic field. The Reduce to Equator filter was deployed to focus anomalies over their sources. Additionally, spectral depth and Euler Deconvolution methods were used to determine basement depths across the study area. Second Vertical Derivative filter helped to visualize possible presence of fault structures. Boundary delineation filter namely Analytic Signal was used to map edges and contacts.

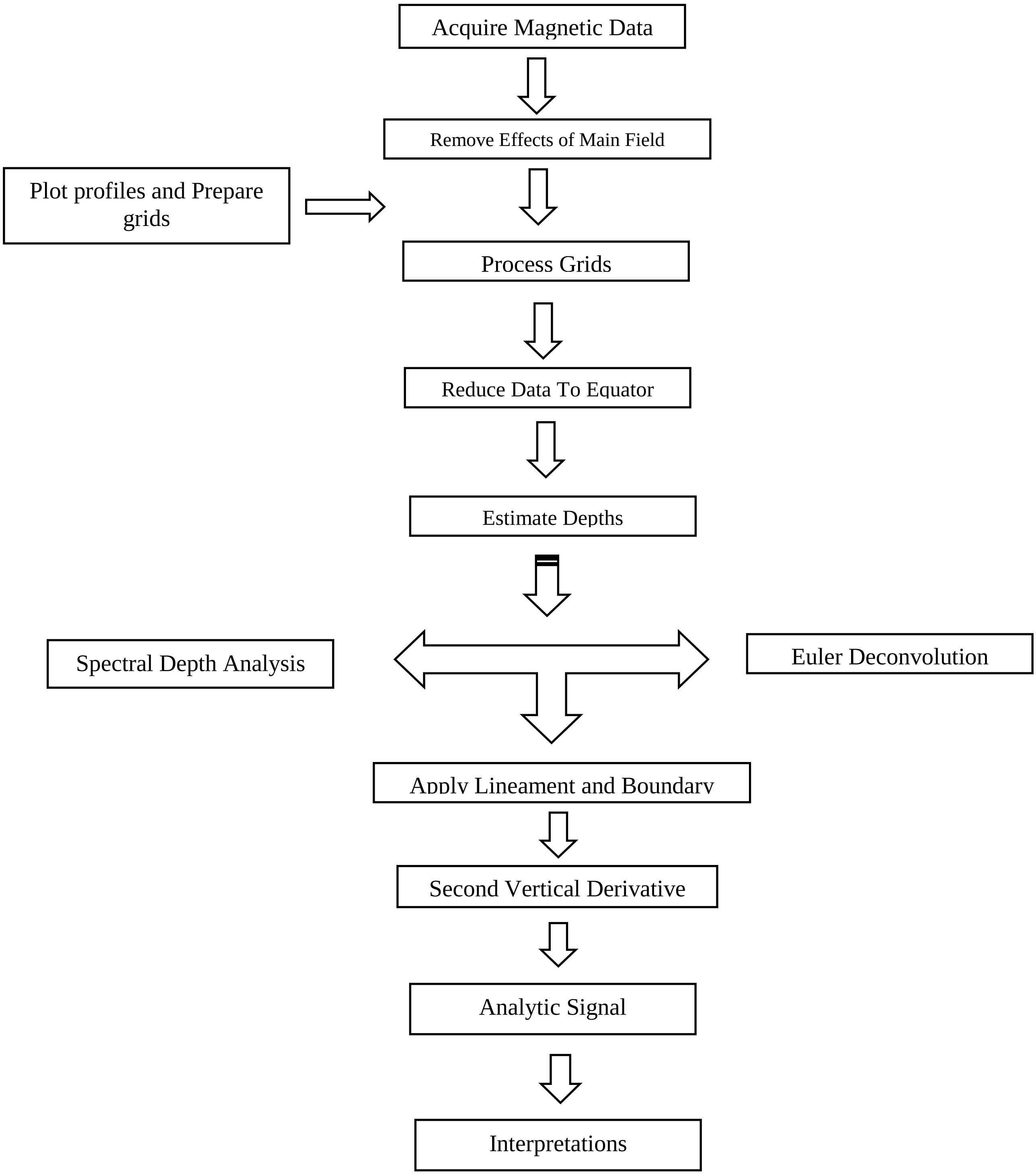

Figure 3: Flow Chart Highlighting Methods

4.0 RESULTS AND DISCUSSION

The elevation data collected from the study area are plotted into topographical maps. The results from the processed and enhanced magnetic data are presented as profiles and anomaly maps which show contrast in susceptibility over the study area in order to map out various lithological units and structural features.

4.1 TOPOGRAPHICAL MAP

The study area is essentially a flat plane as can be seen from the topographical map (Figure 4). The elevation values vary from 304 to about 308.6 m. The most elevated is within the South-southwestern portion of the study area.

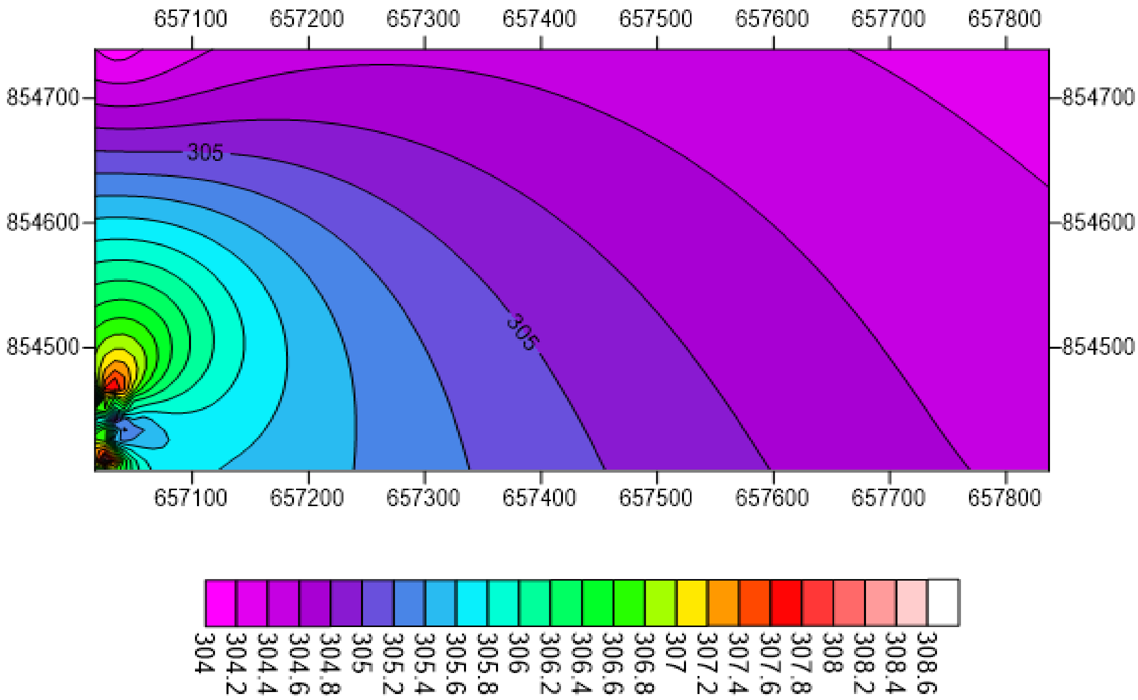

Figure 4: Topographical Map of the Study Area

4.2 RESIDUAL MAGNETIC INTENSITY PROFILE

The magnetic intensity data across the study area is here presented as a profile plotted against station points (Figure 5). The profile shows at a glance that the magnetic intensity values are mostly negative suggestive of the presence of an extensive weathered zone. Its near horizontality could also be suggestive of the presence of an almost flat basement surface underlying the study area.

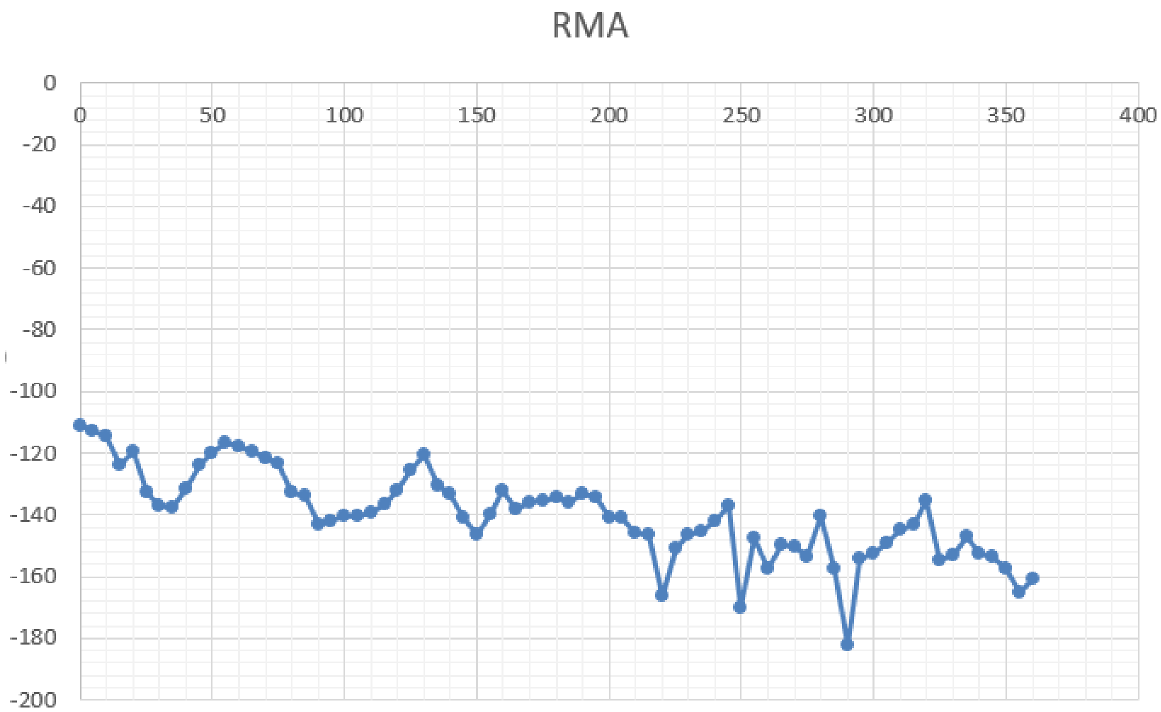

Figure 5: Magnetic Intensity versus Station point Profile.

4.3 RESIDUAL MAGNETIC INTENSITY MAPS

The Magnetic Intensity data that had been subjected to International Geomagnetic Reference Field corrections, Noise filtered and Residualized, were then plotted into maps. These maps are presented using both Surfer and Oasis montaj in figures 6 and 7.

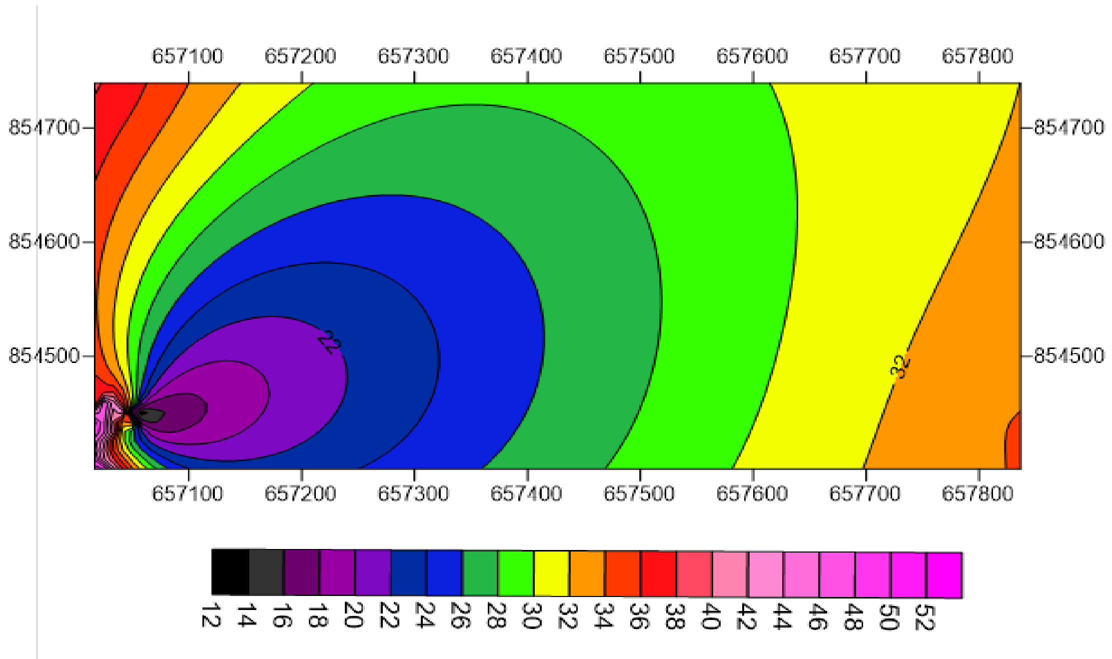

Figure 6: Residual Magnetic Intensity Map (Surfer 10)

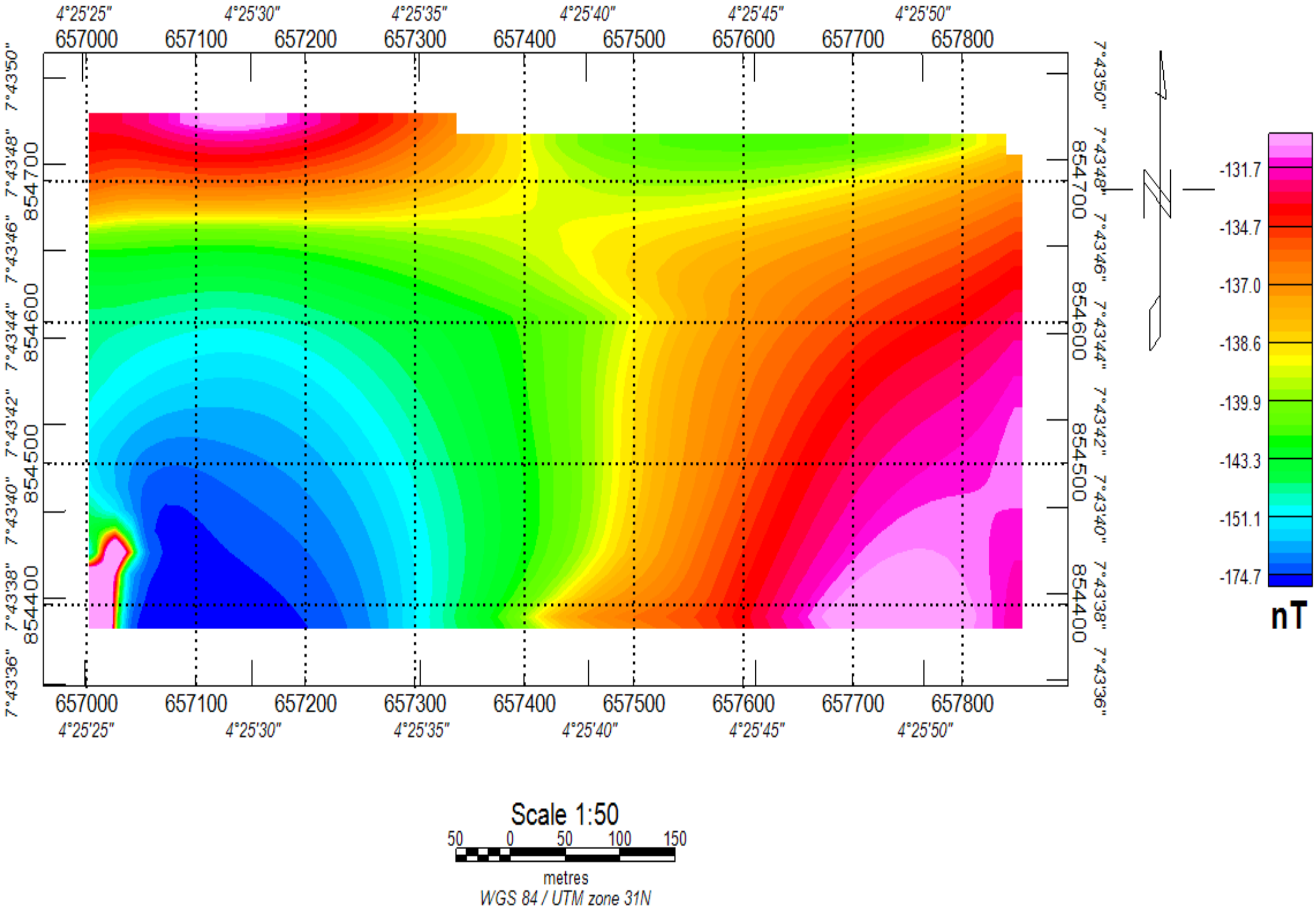

Figure 7: Residual Magnetic Intensity Map (Oasis Montaj 8.4)

Both maps agree to a large extent, revealing that the Southwestern, Southeastern and Northwestern portions of the study area have the highest magnetic intensity values.

4.4 REDUCE TO EQUATOR

The Reduce to equator (RTE) filter was applied to the magnetic intensity data to focus anomaly over the sources generating them to facilitate interpretation. Without this filter, magnetic data obtained at locations other than the Pole are characterized by some skewness. Therefore to remove this effect, this filter fitted for data collected close to the equator was deployed. This is presented in Figure 8 below. A shift is obvious in the anomalies showing their true position over their sources.

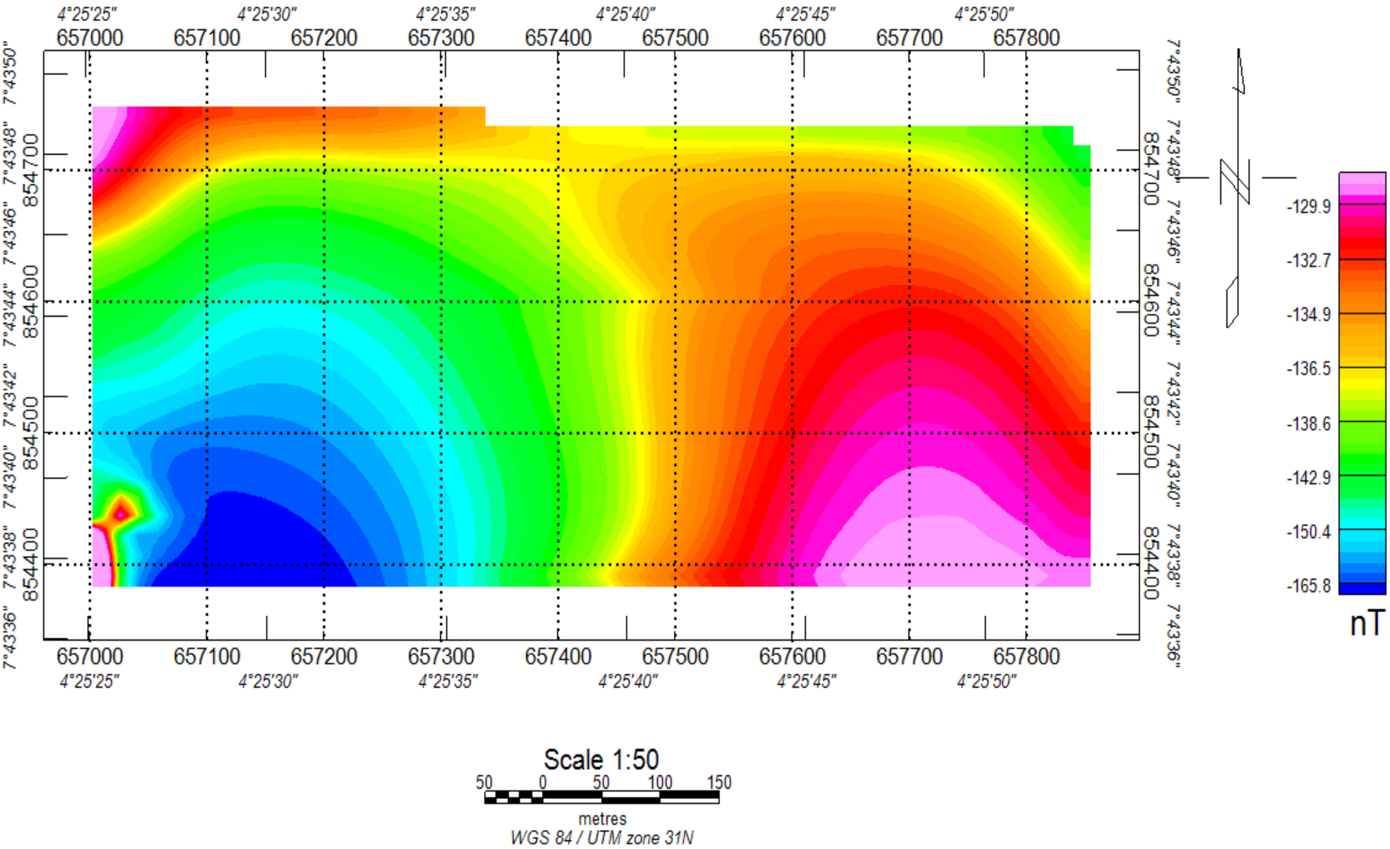

Figure 8: RTE for Residual Magnetic Intensity

4.5 EULER DECONVOLUTION

This method which is a depth determining technique relates magnetic field and their gradient components to the location of the source of an anomaly. Solutions were obtained by inverting Euler's homogeneity equation over a window of data at every grid point ([19]; [17]).

$$(x - x_o)\frac{dT}{dx} + (y - y_o)\frac{dT}{dy} + (z - z_0)\frac{dT}{dz} = N(B - T) \qquad 1.0$$

where (x_o, y_o, z_0) is the location of a magnetic source, whose total field magnetic anomaly at the point (x, y, z) is T and B is the regional field. N is a measure of the rate of change of a field with distance and assumes different values for different types of magnetic source. Equation (1.0) was solved by calculating the anomaly gradients for various areas of the anomaly and selecting a value of N = 1. The result is presented in Figure 9 below.

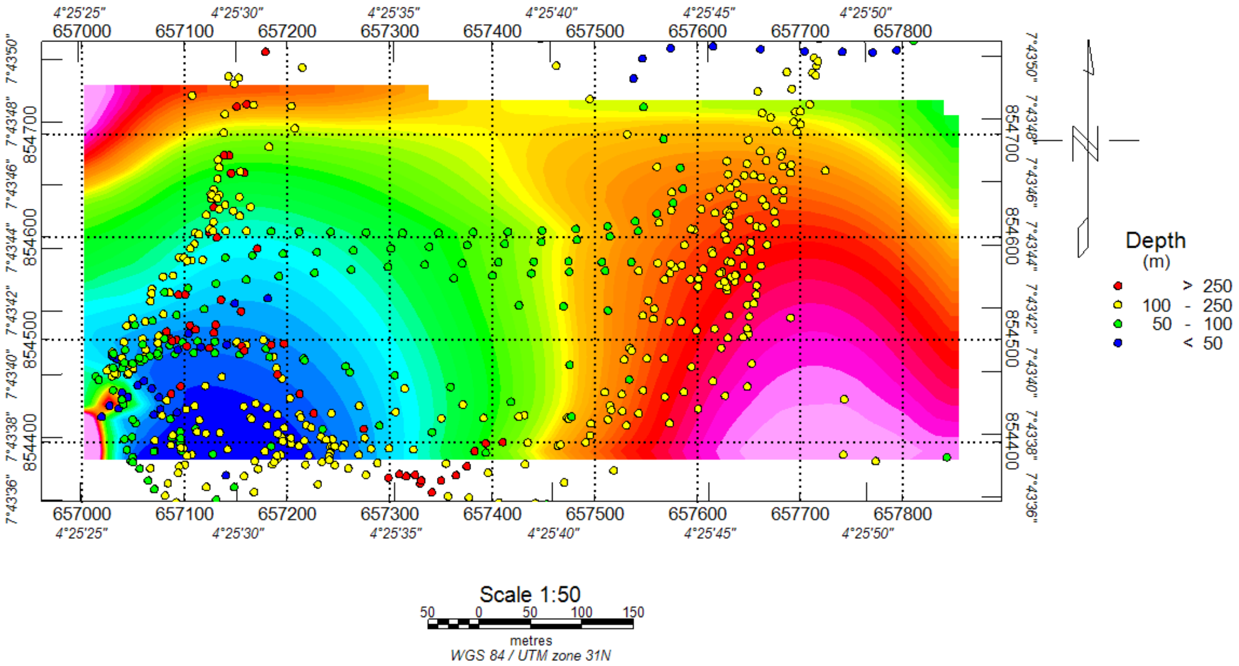

Figure 9: Euler Deconvolution

The shallowest depths within the study area are seen to be less than 50 m and the deepest ones just above 250 m.

4.6 SPECTRAL DEPTH ANALYSIS

The rapid decay of potential anomalies with distance from source allows for basement depth estimation by computing their power spectra in the technique Spectral Analysis. This was done by plotting $\log_e P_k$ against wave-number k (Figure 10) in order to obtain average depth to the disturbing interface.

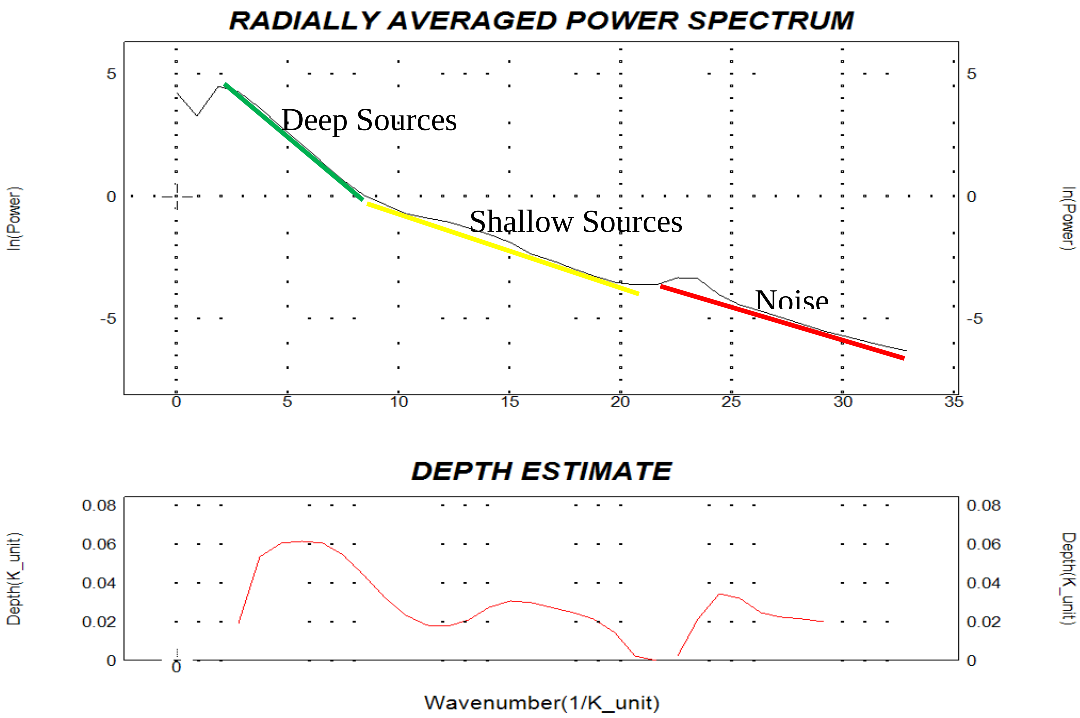

Figure 10: Spectral Depth Plot

Depth to shallow and deep sources were estimated using the relation (equation 2.0) below.

$$h = \frac{\Delta P}{4\pi\Delta k} = \frac{m}{4\pi} \qquad 2.0 \qquad ([2])$$

where m is slope. The average shallow depth is given to be about 20 to 35 m and deep depths ranged from about 400 to 600 m which is very much in agreement with the depth estimation from Euler Deconvolution.

4.7 SECOND VERTICAL DERIVATIVE

The Second Vertical Derivative (SVD) were obtained by operating the relation 3.0 below on the potential fields.

$$\frac{\partial^2 F}{\partial z^2} = -\left(\frac{\partial^2 F}{\partial x^2} + \frac{\partial^2 F}{\partial y^2}\right) \qquad 3.0$$

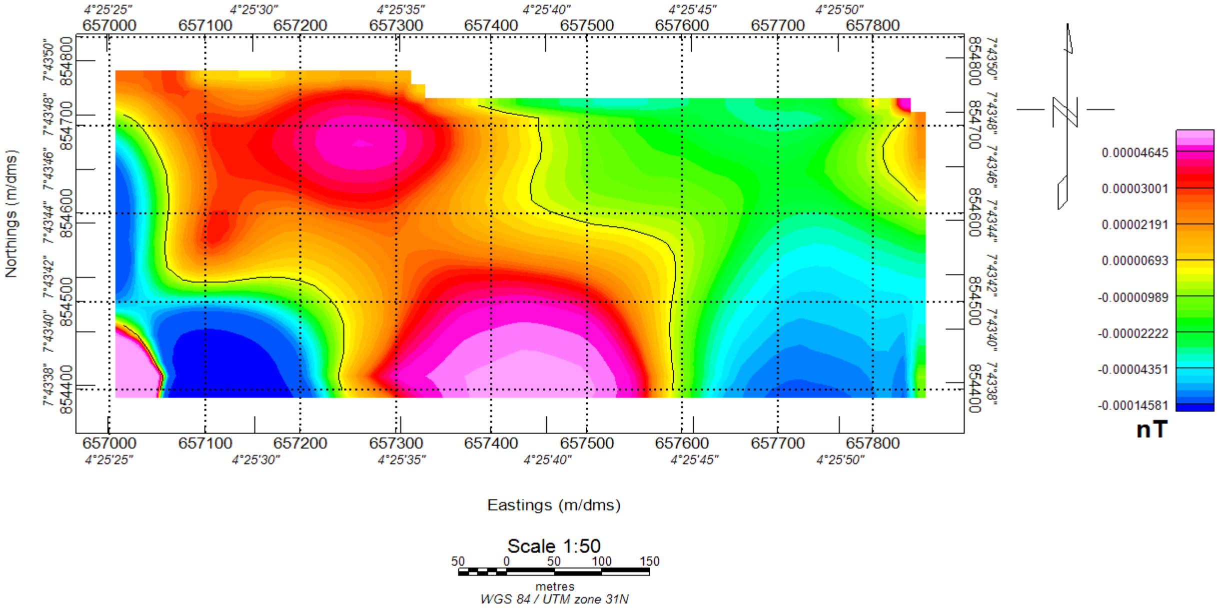

Figure 11: Second Vertical Derivative

where, F is the potential field (gravity or magnetic) while x, y and z are the directions of differentiation (Equation 3.0). The quantity 0 nT/m^2 gives the location of edges of geological features for magnetic data. SVD reveal the large curvatures are associated with shallow anomalies observable on the map. They generally trend in a NW – SE direction.

4.8 ANALYTIC SIGNAL

The Analytic signal solution is generated through a combination of horizontal and the vertical gradient (Equation 4.0) which combines all vector components of the field and transform the shape of magnetic anomaly from any magnetic inclination to positive symmetrical signature over the causative body ([11]; [15]).

$$|A_F(x,y)| = \sqrt{\left(\frac{\partial F}{\partial x}\right)^2 + \left(\frac{\partial F}{\partial y}\right)^2 + \left(\frac{\partial F}{\partial z}\right)^2} \qquad (4.0)$$

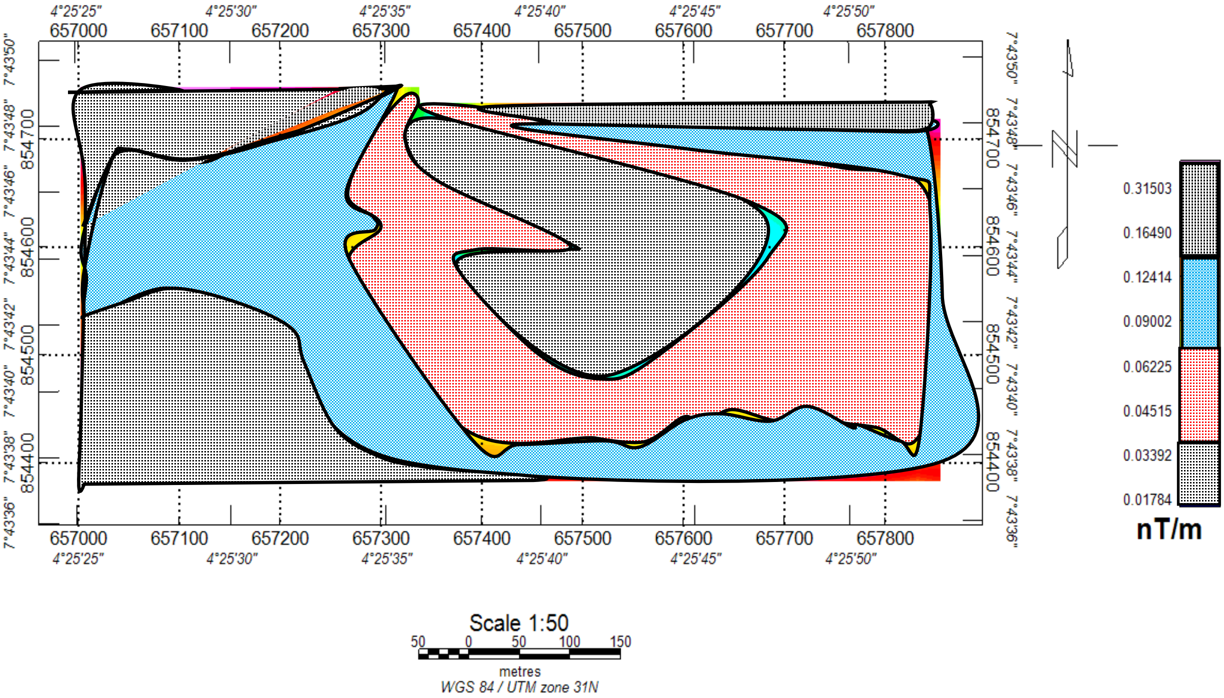

Figure 12: Analytic Signal

5.0 CONCLUSION

A building site covering an area of about 5000 m^2 has been investigated for its fitness for the erection of a building. The depth to basement values for near surface sources are less than 50 m and deep depth sources range from 250 and 600 m.

From the profile plot interpretation and spectral depth analysis, it is safe to assume that the portion of the subsurface within the < 50 m zone is made up of weathered materials. Geologically, the area is underlain by Quartz schist suggesting that the weathered material will be sand and gravel which are ideal for construction.

However, from the lineament mapping, faults are estimated to occur within the range of 50 – 250 m depth. The reactivation of such faults might eventually lead to cracks in any building sited here. These faults are probably regional and the cause of cracks in buildings situated within the area of interest.

As is the practice in the application of geophysics, it is recommended that Electrical Resistivity method be further deployed to generate geo – electric sections of the area of interest. This would help confirm the lithologic make up and their thicknesses.

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