INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

The Use of Magnetic Survey in Engineering Site Characterization

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Abstract:
Engineering site investigation using magnetic geophysical survey was carried out in Rufus Giwa Polytechnic, Owo, Ondo State, Southwestern Nigeria, with aim of investigating subsurface geology on the basis of anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks. The ground magnetic survey was carried along twenty-six traverses with the use of GSM-8 Proton Precision Magnetometer taken at regular station interval of 10 m. After the taking readings along each traverse, the final base station reading and time for that traverse are also recorded and drift, the drift constant and the drift correction were applied to the data collected. The magnetic field intensity over the study area is generally noisy (multiples anomalous zones) of thin magnetic anomalies. The relative magnetic intensity across the study area varies between -16090 and +1741 nT. Although this variation of values is not unusual in the crystalline basement terrain. The magnetic profiles show a low magnetic anomaly which could be associated with joint, fault or weathered materials. Also, pockets of sharp thin negative anomaly suspected to be thin dykes and 'W-shape' like magnetic anomaly typical of thick dyke. There are multiple anomalies observed along some profiles which suggest an inhomogeneity within the subsurface materials.

Keywords: *Magnetic, anomaly, intrusion, weathered material, inhomogeneity*

1. Introduction

Magnetic method involves measurements of the earth' magnetic field or its components at a series of different locations over an area of interest, usually with the objective of locating concentrations of magnetic material or of determining depth to the magnetic basement (Sheriff, 1991). The field measurements are easily acquired compared to the other geophysical techniques and corrections to readings are easily applied (Telford *et al.,* 1990). Besides, magnetic field anomalies are invariably diagnostic of metallic objects, mineral and regional structures.

1.1. Basic Theory of Magnetic Method

The magnetic flux density B (i.e. flux per unit area) also called the magnetic induction is expressed as:

$B = \mu H$ …………………………………………………………………………...….1

Whereμ is the absolute permeability of the medium and H is the field strength.

When the medium is a vacuum, then $\mu = \mu_o$and a field strength H, will create in a vacuum a magnetic flux density

$B_o = \mu_o H$ …………………………………………………………………..……2

For a medium other than a vacuum, then $\mu = \mu_r \mu_o$, so that equation 1,

$B = \mu_r \mu_o H$ …………………………………………………………………………3

By factorization, equation 3 becomes:

$B = \mu_o H + \mu_o(\mu_r - 1)H$ …………………………………………………………4

By simplification, equation 4 becomes:

$B = \mu_o H + \mu_o K H$ ……………………………………………………………………5

Where $K = \mu_r - 1$ (where K is the magnetic susceptibility). The ratio μ/μ_o is a dimensionless (pure) number called the relative permeability μ_r of the medium. Water air and all other non-magnetic, including vacuum, have $\mu_r = 1$ and $K = 0$.

Equation 6 can be expressed as:

$B = \mu_o (H + M)$ ………………………………..…………………………………7

Where M, the intensity of magnetization (magnetic polarization) is defined as:

M = KH…………………………………….…………………………………..8

1.2. Geomagnetic Field

The geomagnetic field is conceptualized as composed of three parts, namely the main field, the external field and variations of the main field (geomagnetic anomaly). The main field has an internal origin. To a very close approximation, it can be represented formally as the field of a geocentric dipole with its magnetic moment pointing towards the Earth's geographical south (Parasnis, 1986). For a complete definition of its magnitude and direction at any point on the Earth's surface, three elements are required: the magnetic flux density vector and its horizontal and vertical components, which are symbolized as B_l, B_h and B_z , respectively (Fig. 1).
Alternatively, the geomagnetic elements can be expressed in spherical polar coordinated (*B, D, I*) where *B*, *D* and *I* are respectively the magnetic flux density vector, the declination (angle between the magnetic meridian and the geographic north) and the inclination (angle at which the magnetic vector dips below the horizontal). These are the variations of the geomagnetic that are generated by near-surface variations of magnetic mineral (corrected for temporal variations) concentration in rocks, and $\mathbf{B}_R$ is the reference field (as given by the International Geomagnetic Reference Field (IGRF)). If $\boldsymbol{B}_{obs}$ is the measured total field intensity at the site of measurement, then the magnetic anomaly ($\Delta\boldsymbol{B}$)is given by $\Delta\boldsymbol{B} = \boldsymbol{B}_{obs} - \mathbf{B}_R$ (Sharma, 1997).

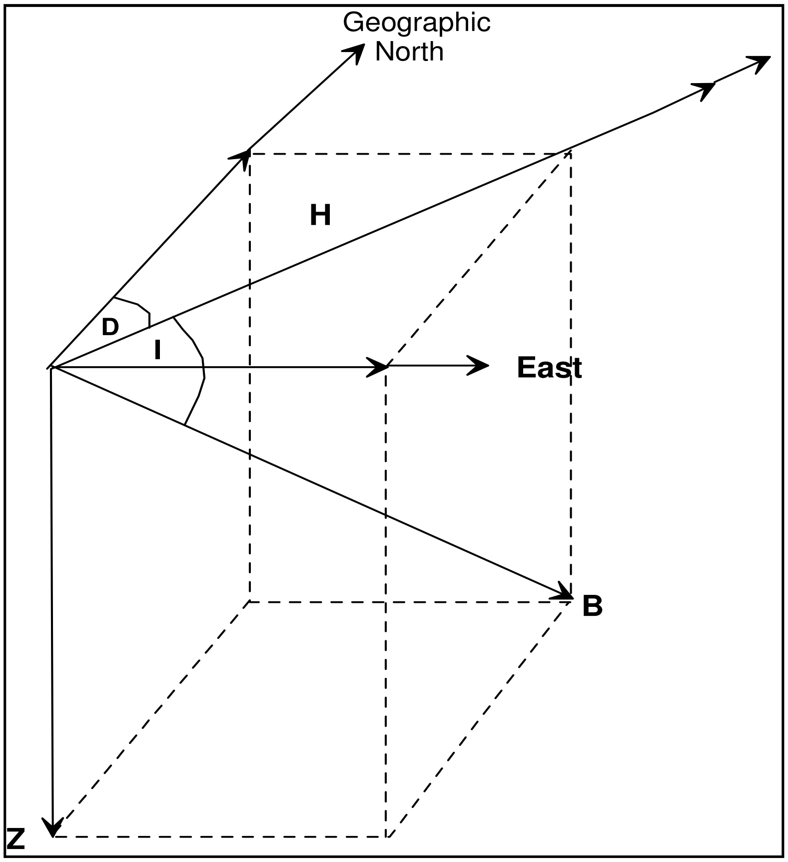

Figure 1: Elements of the Earth's Magnetic Field

1.3. Description of Study Environment

The research environment is Rufus Giwa Polytechnic, Owo, Ondo State, is located in Owo, which is within the south western part of Nigeria. The institution (Fig. 2) is situated in Owo local Government of Ondo State. It lies within longitudes $6^{\circ}00^{l}$ E and $5^{\circ}30^{l}$ E and latitudes $7^{\circ}30^{l}$ N and $7^{\circ}00^{l}$ N. The study area is easily accessible by roads like Ikare – Owo highway, Benin – Ifon highway and Akure – Owo highway.

The area lies geographically within the tropical rain forest belt of hot and wet equatorial climatic region characterized by alternating wet and dry climate seasons (Iloeje, 1981), which is strongly controlled by seasonal fluctuation in the rate of evaporation. The available rain data shows that mean annual rainfall ranges from 1000 mm - 1500 mm and mean temperature of 24˚C to 27˚C. There is rapid rainfall during the month of March and cessation during the month of November. June and September are the critical month when rainfall is usually on the high side.

The vegetation is of tropical rainforest. The area is underlain mainly by rocks of the Migmatite - Gneiss Complex predominantly by quartzite, granite and granite gneiss (Fig. 3). Quartzite is the most dominant rock; which mineralogically contains quartz dominating mineral, other minerals such as muscovite, tremolite, microcline and biotite are common as well. Quartzites which are prominent as ridge vary in texture from massive to schistocity due to the presence of flaky minerals like mica.

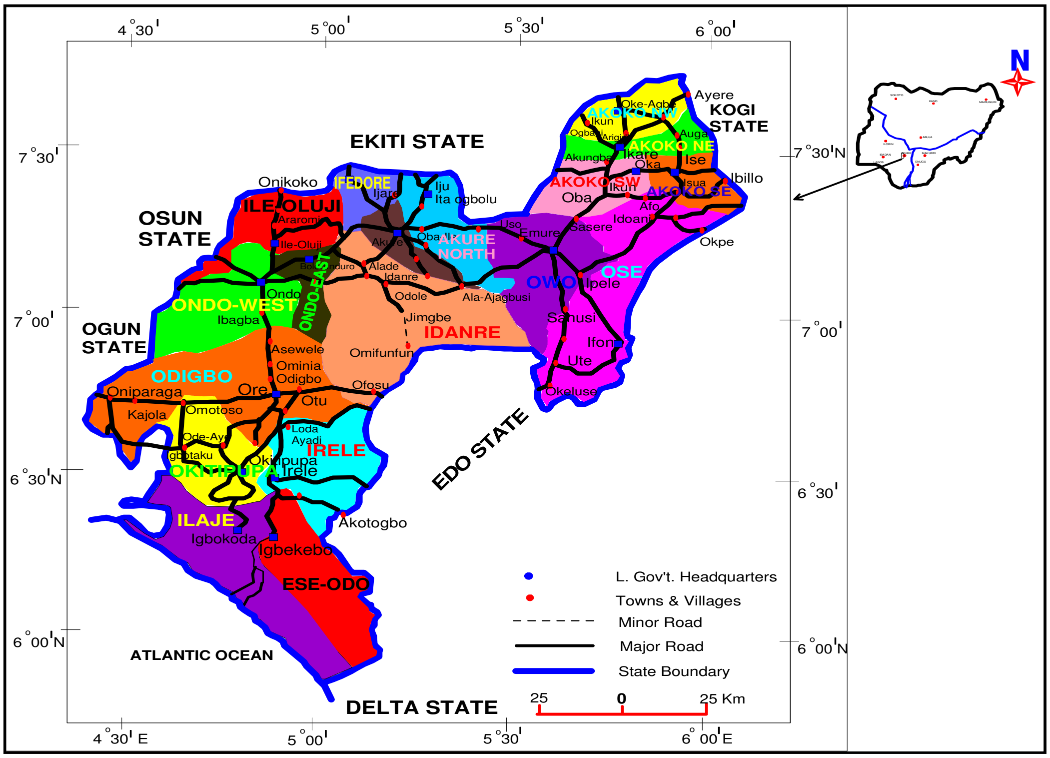

Figure 2: Road/Administrative Map of Ondo State

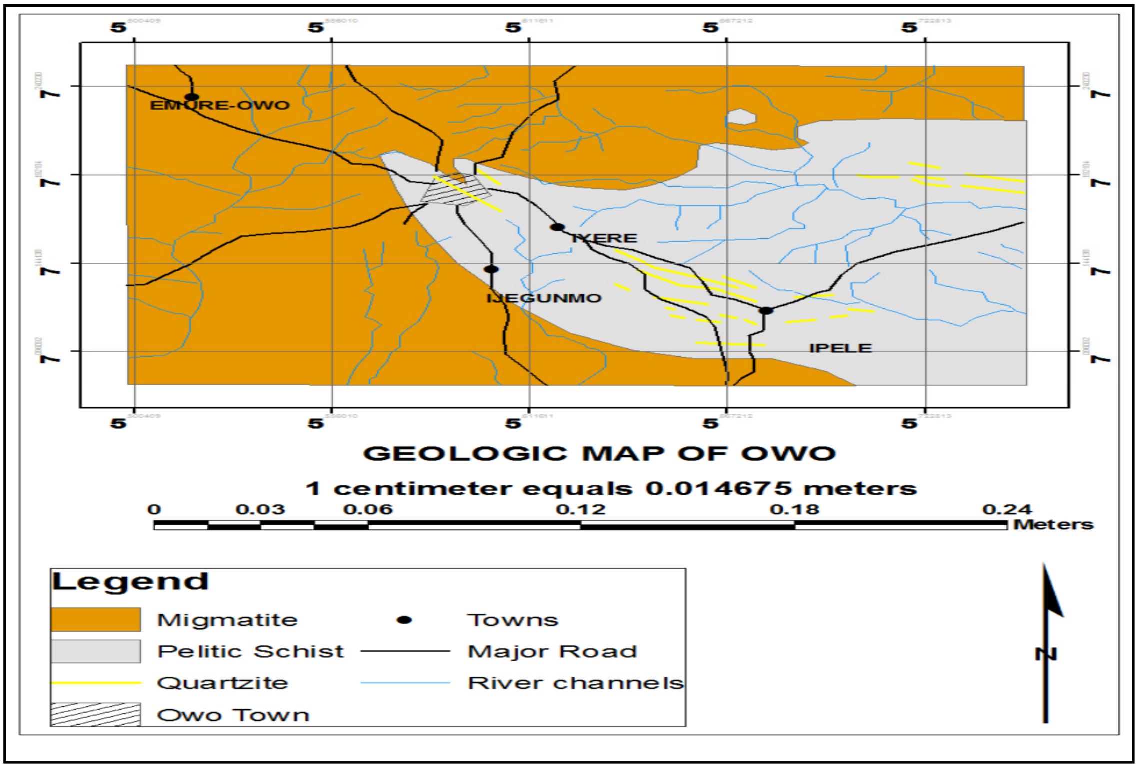

Figure 3: Geological Map of Owo and Environs, showing the Study Area (Modified After Geological Survey of Nigeria, 1984)

2. Method of Study

The ground magnetic survey was carried along twenty-seven traverses (Table 1) with the use of GSM-8 Proton Precision Magnetometer. At the start of the survey, a base station was established in the study area for every traverse. The magnetic reading and time were first recorded. Subsequently, after the base station reading, the traverse was now occupied, with readings taken at regular station interval of 10 m (Fig. 4). After the taking readings along each traverse, the final base station reading and time for that traverse are also recorded respectively, so as to calculate the drift, the drift constant and the drift correction.

The acts of processing magnetic data are essential aspect before interpretation. This is necessary to remove all causes of magnetic variation from observations other than those arising from magnetic effects of the subsurface. The reduction carried out to the magnetometer measurements in the study area was the drift correction. The changes in magnetometer reading with time are caused by the time-dependent variation of diurnal variation.

The magnetic data obtained are presented as plots of relative magnetic reading against station position. The interpretation technique adopted is qualitative interpretation; which involves visual examination of profiles and maps with the aim of obtaining information about the target, such as location, geologic dip direction and nature of the target.

Traverse	Length (m)	Compass Orientation
1	580	W - E
2	120	W - E
3	160	W - E
4	160	W - E
5	180	W - E
6	200	W - E
7	220	W - E
8	230	SW - NE
9	210	SW - NE
10	110	SW - NE
11	160	SW - NE
12	120	SW - NE
13	280	W - E
14	370	W - E
15	410	W - E
16	280	W - E
17	400	W - E
18	150	W - E
19	520	W - E
20	270	W - E
21	920	W - E
22	190	W - E
23	240	W - E
24	670	W - E
25	500	W - E
26	690	W - E
27	400	W - E

Table 1: The Details of the Traverses Established in the Study Area

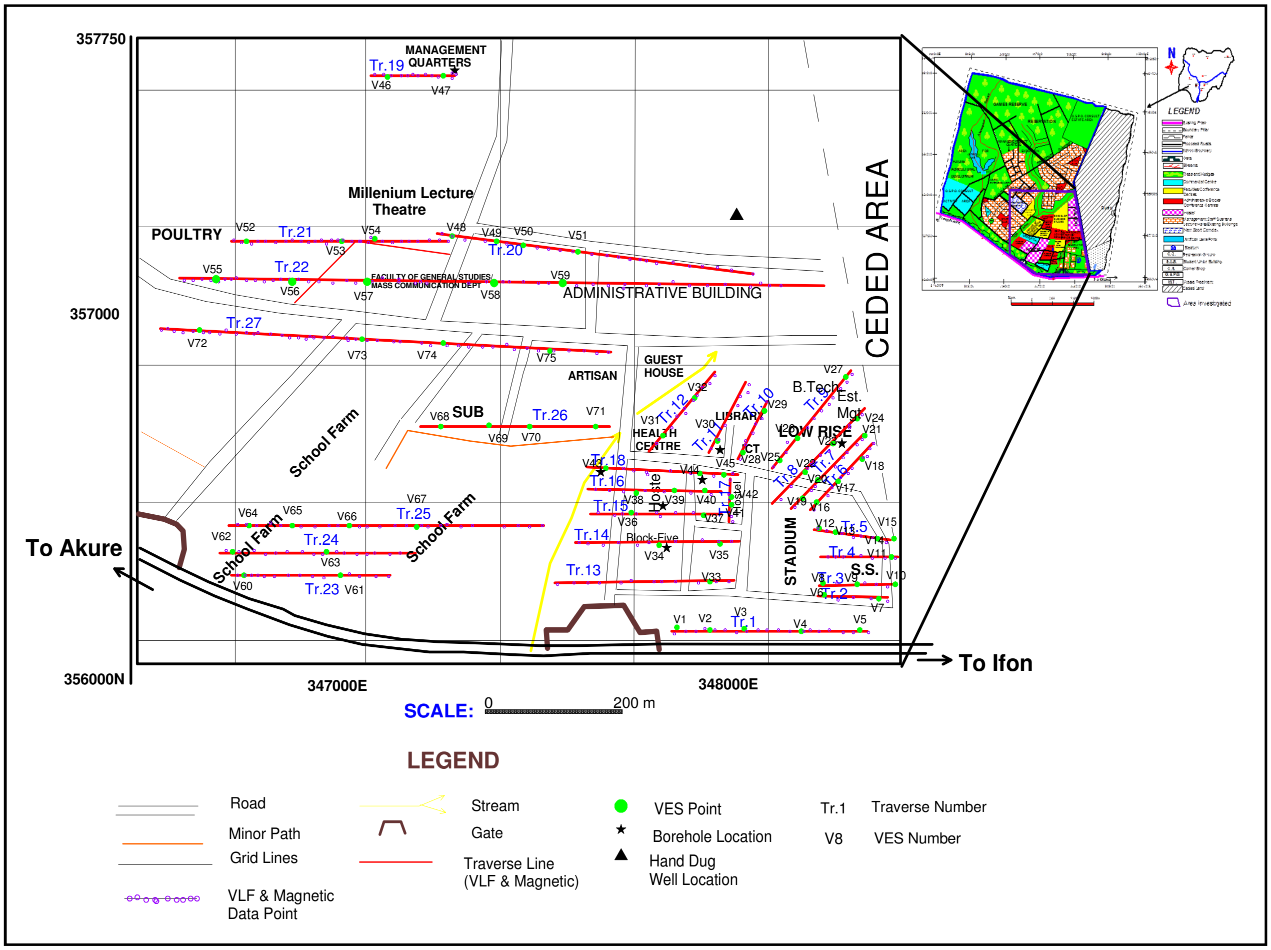

Figure 4: Data Acquisition Map of the Study Area showing the Magnetic Profiles

3. Results and Discussions

The relative magnetic field intensity profiles along Traverse 1 to Traverse 5 are (Fig. 6 – Fig. 9) show amplitude variations of between -284 and +228 nT, -391 and +114 nT, -987 and +191 nT, -199 and 856 nT, -111 and +530 nT, respectively. These ranges of values are not unusual in a crystalline basement terrain (Telford *et al.,* 1990). They are characterized by a relatively flat anomaly, which can be considered as magnetically homogeneous except for minor intrusions or thin dyke of positive amplitude at distances 100 and 120m, 290 and 380m and, 540 and 580m along Traverse 1, 20 and 50m (negative amplitude) along Traverse 2, 60 and 110m along Traverse 3, 80 and 100m along Traverse 4, and, 70 and 90m along Traverse 5.

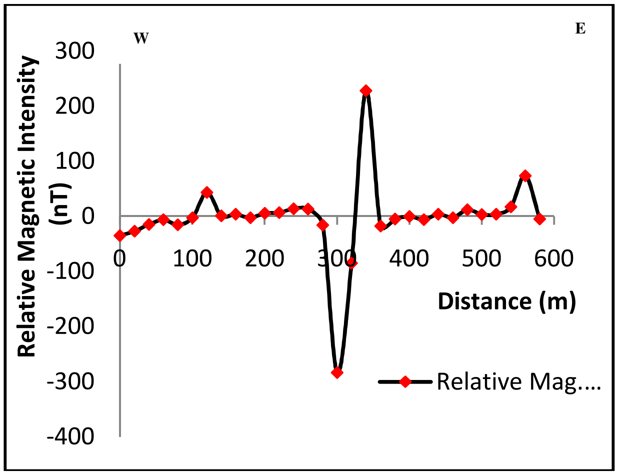

Figure 5: Magnetic Profile along Traverse 1

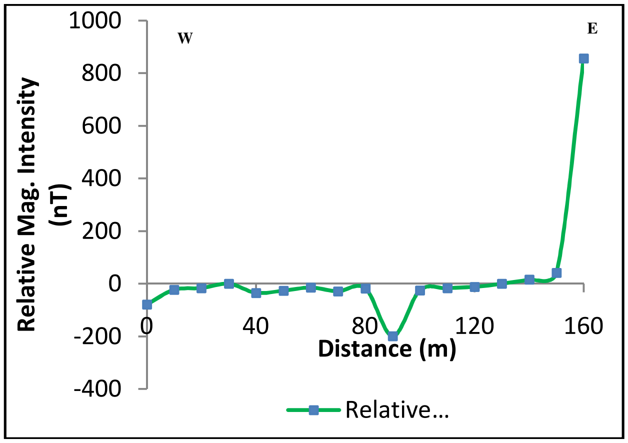

Figure 8: Magnetic Profile along Traverse 4

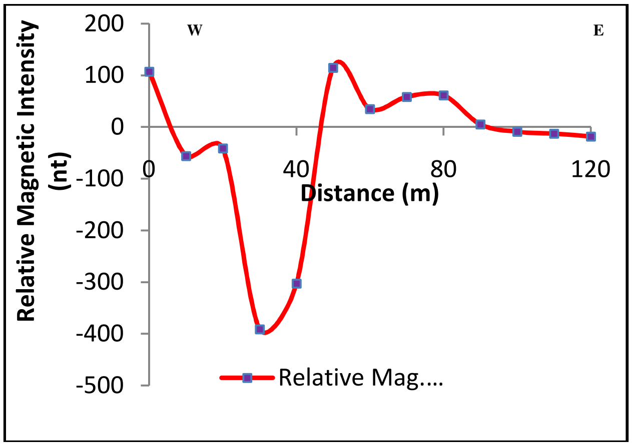

Figure 6: Magnetic Profile along Traverse2

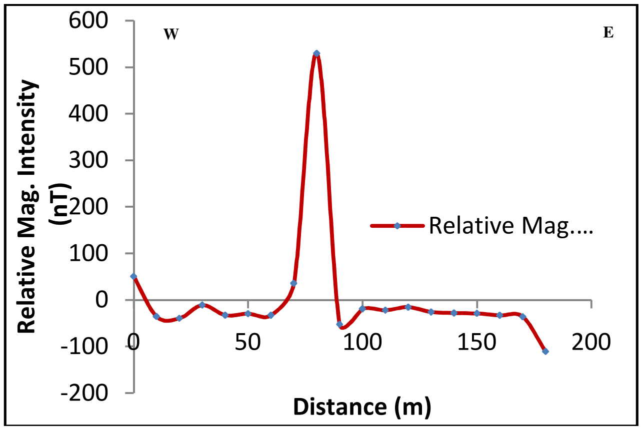

Figure 9: Magnetic Profile along Traverse 5

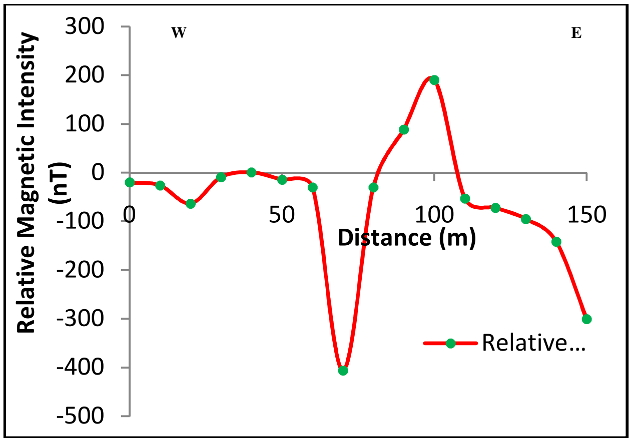

Figure 7: Magnetic Profile along Traverse 3

The magnetic profiles along Traverse 6 (Fig. 10), Traverse 7 (Fig. 11), Traverse 8 (Fig. 12), Traverse 9 (Fig. 13), Traverse 10 (Fig. 14), Traverse 11 (Fig. 15), Traverse 12 (Fig. 16) and Traverse 13 (Fig. 17), with amplitude variations between -214 and +890 nT, -341 and +537 nT, -327 and +237 nT, -59 and +690 nT, +29 and +555 nT, -210 and +588 nT, -857 and -495 nT, and, -33 and +1740 nT respectively. They show an uneven anomaly; indicating a magnetically noisy relatively inhomogeneous environment of a significant structural feature. The high anomaly intensity (Fig. 10) which may be a dyke that intruded the parent basement rock.

The magnetic profile along Traverse 14 (Fig. 18) has a magnetic field intensity that varies between -16090 and +1119. It is characterized by one magnetic low flanked on the eastern part by two negative troughs with central high (‘W-shape’ like magnetic anomaly) as shown between distances 160 and 210 m. The magnetic anomaly is typical of thick dyke.

The relative magnetic field intensity profiles along Traverse 15 (Fig. 19), Traverse 16 (Fig. 20), Traverse 17 (Fig. 21) and Traverse 18 (Fig. 22) have magnetic values that varied from-758 to +1422 nT, -631 to +1534 nT, -521 to +583 nT, and -254 to +520 nT respectively.The anomalies along these Traverses are generally noisy indicating a heterogeneous nature of the subsurface.

The magnetic profile along Traverse 19 (Fig. 23) has a magnetic field intensity that varies between -283 to +855 nT. It is characterized by one magnetic low flanked on the eastern part by two negative troughs with central high (‘W-shape’ like magnetic anomaly) as shown between distances 160 and 210 m. The magnetic anomaly is typical of thick dyke.

The relative magnetic field intensity profiles along Traverse 20 to Traverse 23 (Fig. 24 – Fig. 27) show amplitude variations of between -56 and +95 nT, -769 and +111 nT, -7 and +104

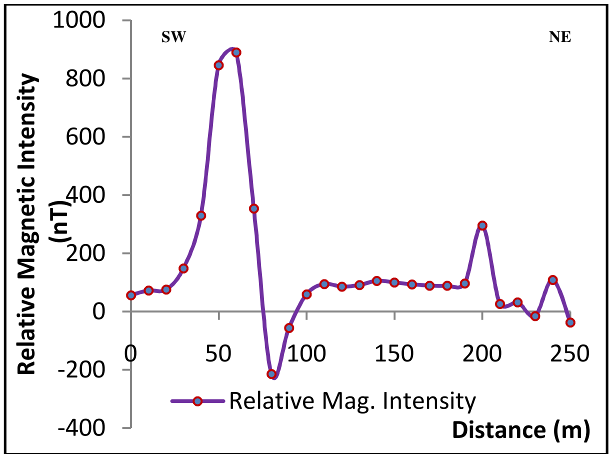

Figure 10: Magnetic Profile along Traverse 6

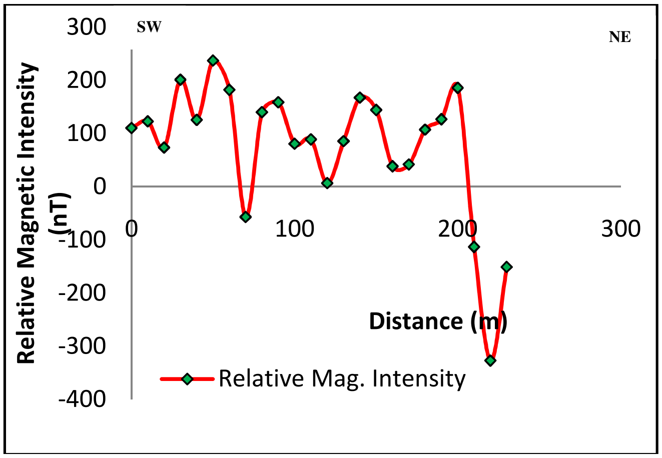

Figure 12: Magnetic Profile along Traverse 8

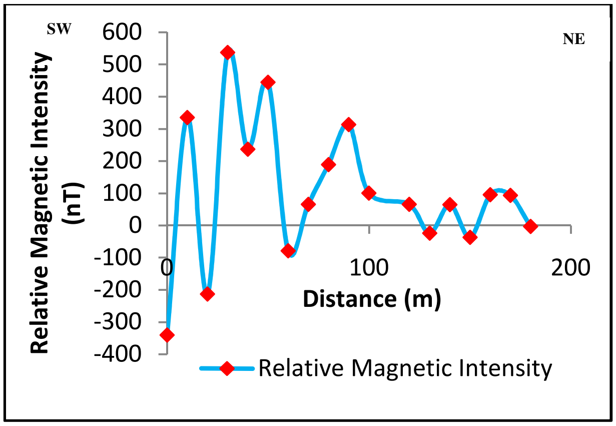

Figure 11: Magnetic Profile along Traverse 7

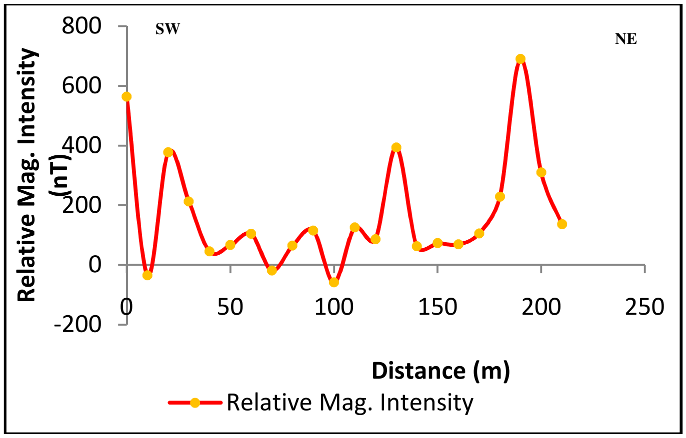

Figure 13: Magnetic Profile along Traverse 9

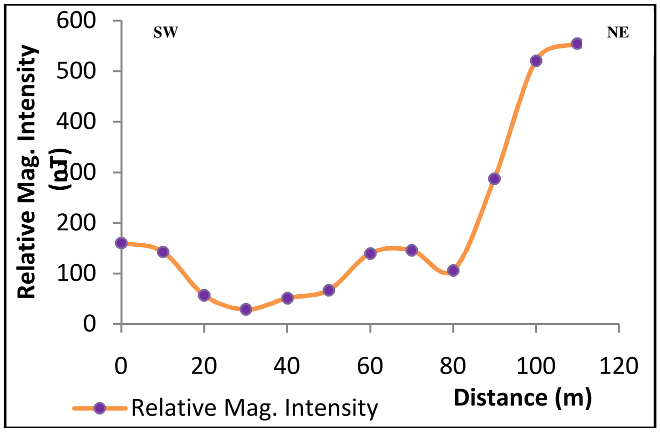

Figure 14: Magnetic Profile along Traverse 10

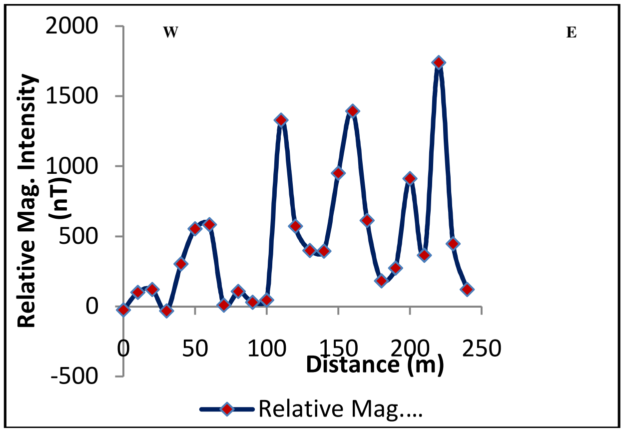

Figure 17: Magnetic Profile along Traverse 13

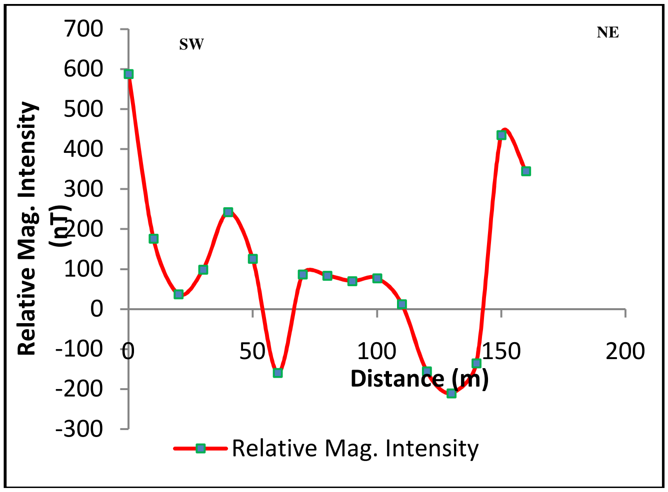

Figure 15: Magnetic Profile along Traverse 11

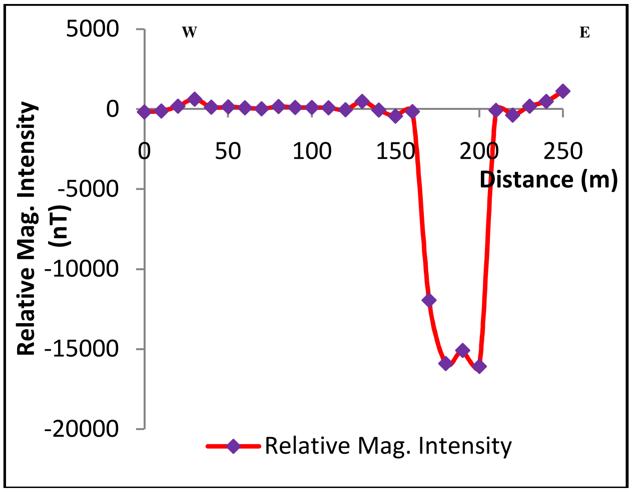

Figure 18: Magnetic Profile along Traverse 14

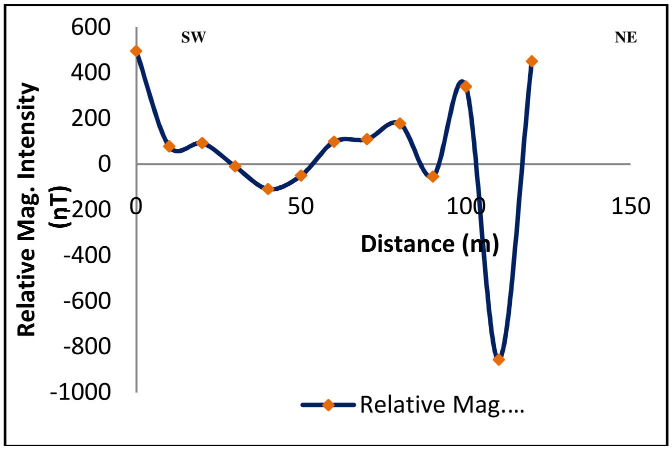

Figure 16: Magnetic Profile along Traverse 12

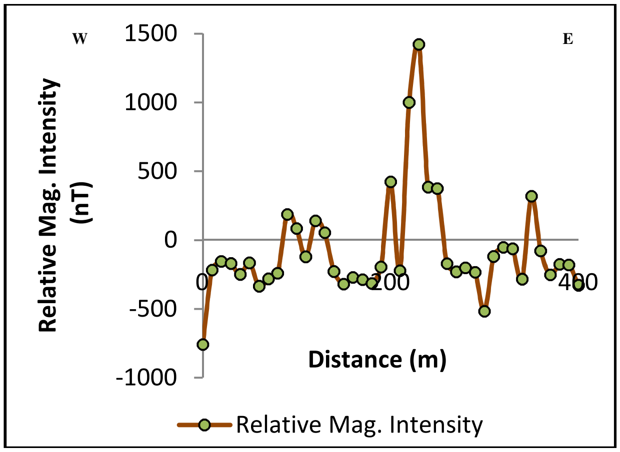

Figure 19: Magnetic Profile along Traverse 15

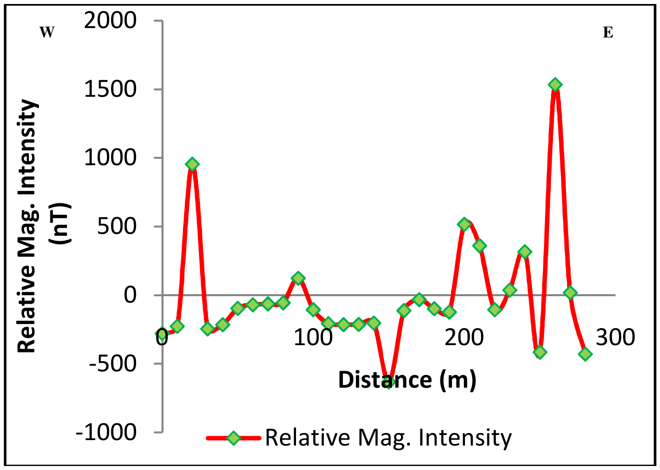

Figure 20: Magnetic Profile along Traverse 16

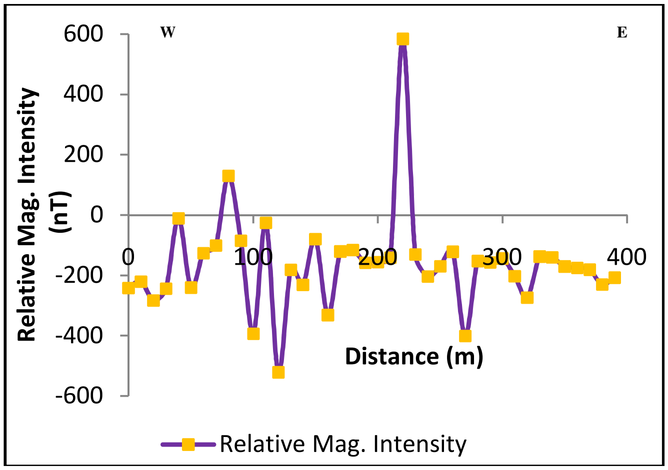

Figure 21: Magnetic Profile along Traverse 17

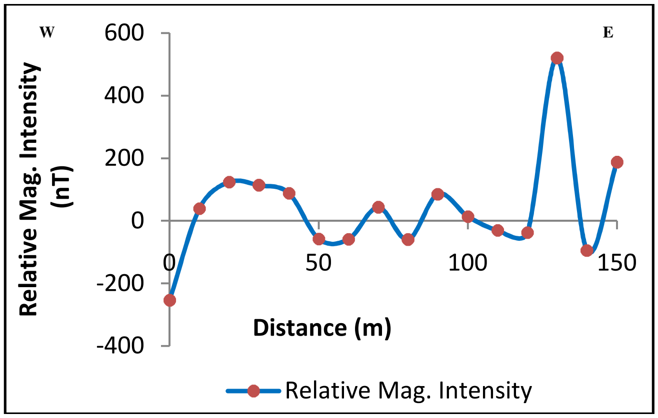

Figure 22: Magnetic Profile along Traverse 18

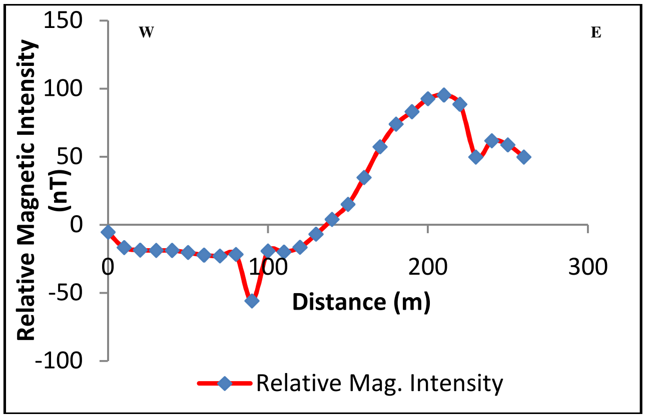

Figure 24: Magnetic Profile along Traverse 20

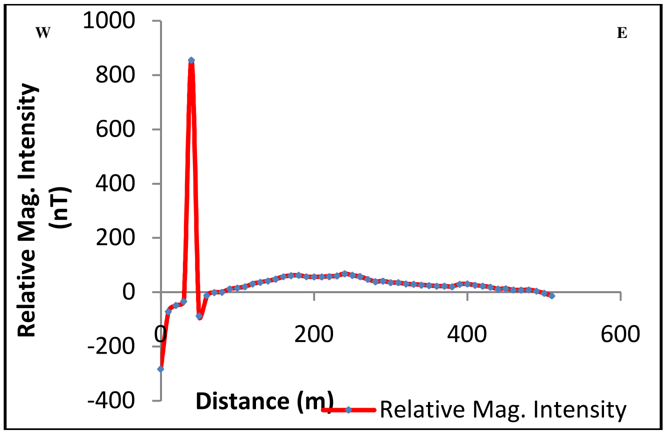

Figure 23: Magnetic Profile along Traverse 19

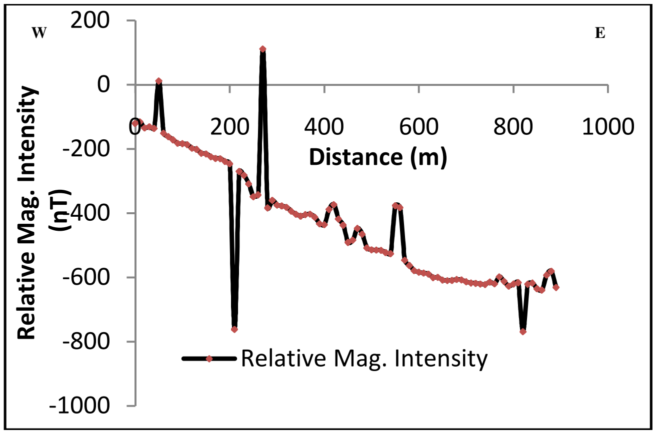

Figure 25: Magnetic Profile along Traverse 21

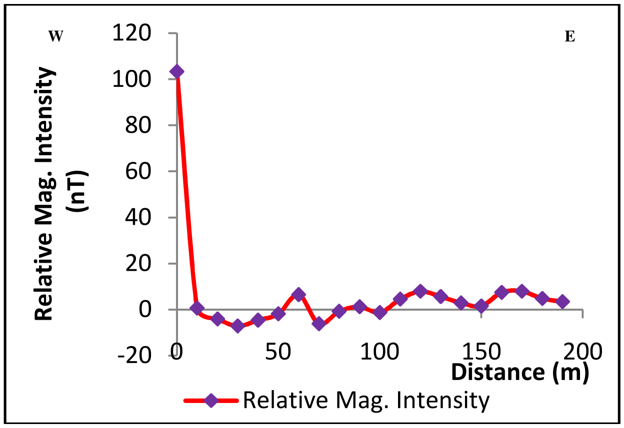

Figure 26: Magnetic Profile along Traverse 22

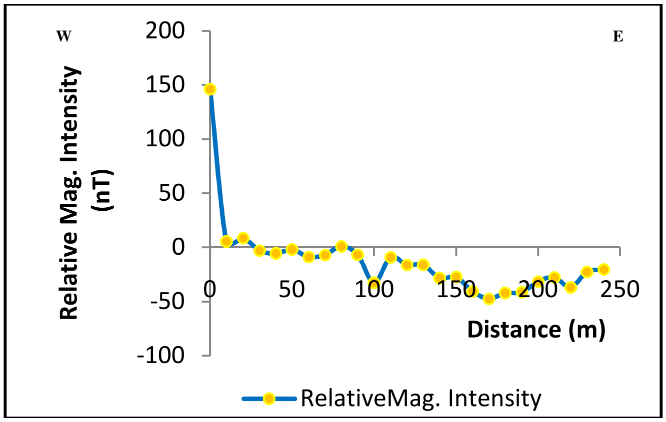

Figure 27: Magnetic Profile along Traverse 23

nT, -48 and 146 nT respectively. These Traverses are characterized by noisy magnetic anomaly, which are indicative of subsurface inhomogeneity.

Traverse 24 (Fig. 28), Traverse 25 (Fig. 29) and Traverse 26 (Fig. 30) show a relatively an even amplitude with magnetic field intensity that varied from -54 to +559 nT, -208 to +1290 nT, and -416 to +339 respectively. Although pockets of sharp thin negative anomaly suspected to be thin dykes are observed at distances between 450 and 500 m along Traverse 26, and 90 and 100 m, 300 and 320 m, 350 and 380 m, but the anomaly is positive between 680 and 700 m along Traverses 26.

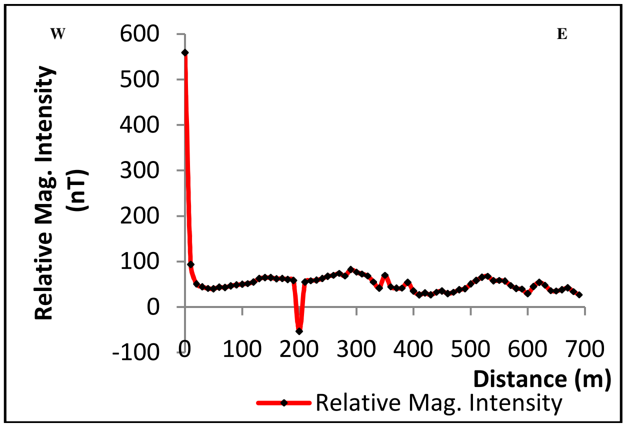

Figure 28: Magnetic Profile along Traverse 24

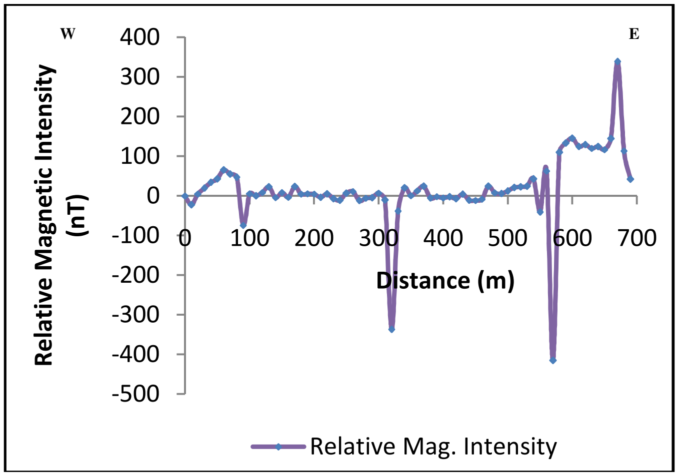

Figure 30: Magnetic Profile along Traverse 26

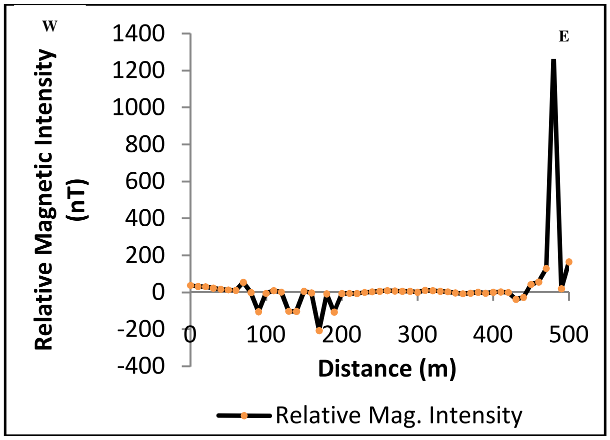

Figure 29: Magnetic Profile along Traverse 25

Figure 31 shows thedistribution of magnetic susceptibilityobtained within the study area. The map reveals closure oflow magnetic anomaly around the southeastern part of the study area which could be associated with fault, joints, etc. However, the area shows an uneven anomaly, indicating a magnetically noisy relatively inhomogenous environment.

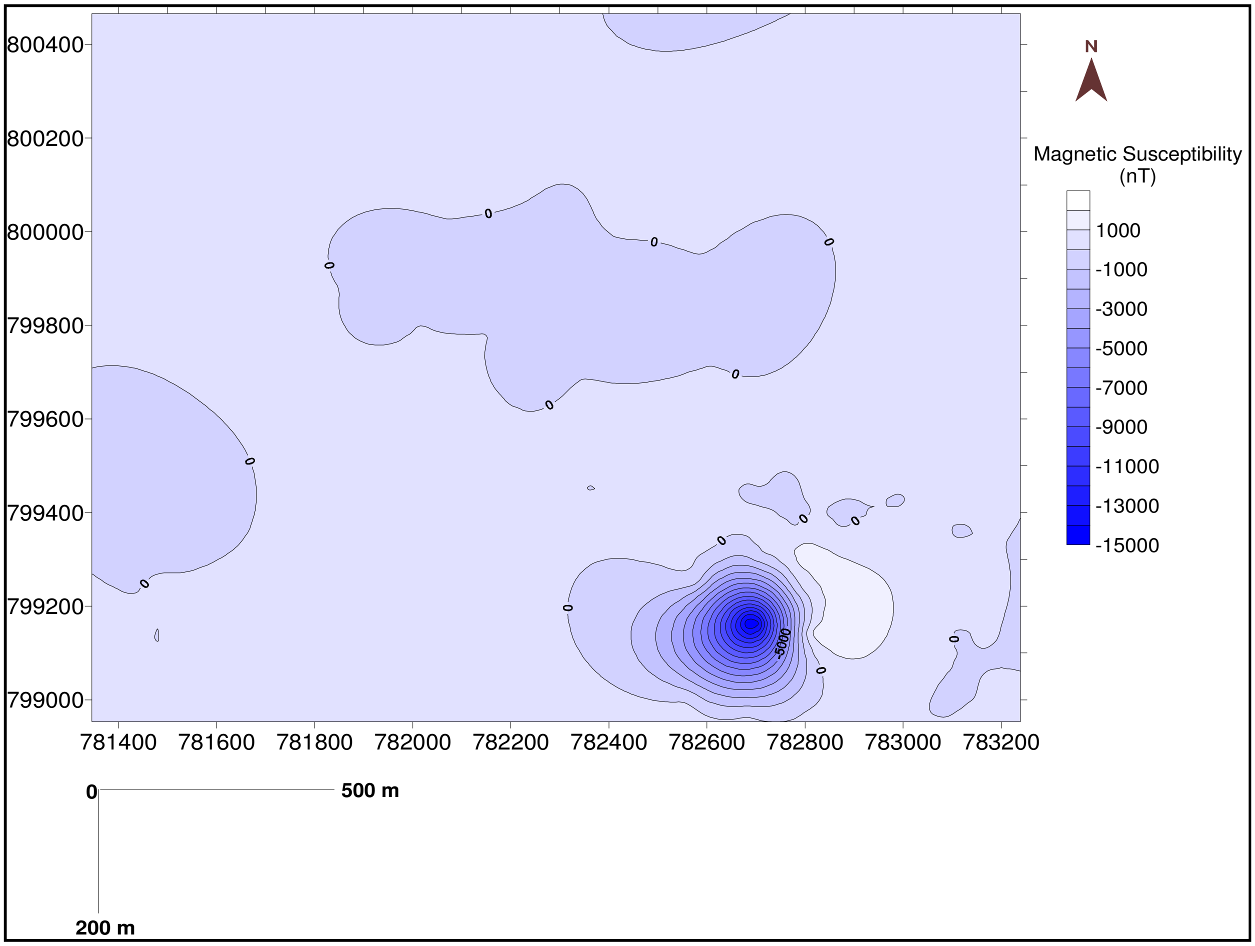

Figure 31: Magnetic Anomaly obtained from the study area

4. Conclusion

Therefore, the magnetic field intensity over the study area is generally noisy (multiples anomalous zones) of thin magnetic anomalies. The relative magnetic intensity across the study area varies between -16090 and +1741 nT. Although this variation of values is not unusual in the crystalline basement terrain (Telford *et al.,* 1990). Although, the magnetic profiles show a low magnetic anomaly which could be associated with joint, fault or weathered materials. There are multiple anomalies observed along some profiles which suggest an inhomogeneity within the subsurface materials.

5. References

i. Iloeje, N.P. (1981). A new geography of Nigeria (New Revised Edition). Published by Longman Nig. Ltd., Lagos, 201pp.
ii. Parasnis, D.S. (1962). Principles of Applied Geophysics. Methuen and Co. Ltd. London.
iii. Sharma, P.V. (1997). Environmental and Engineering geophysics. Cambridge University Press, United Kingdom, 475p.
iv. Sheriff, R.E. (1991). Encyclopedic Dictionary of Exploration Geophysics, 3rd edition. Geophysical References series I, Soc. Expl. Geophysicists.
v. Telford, W.M., Geldart, L.P. and Sheriff, R.E. (1990). Applied Geophysics (Second Edition) Cambridge University Press, Cambridge. Pp 546.