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Full Length Research Paper

Horizontal derivatives of the ground magnetic interpretation in part of Ilesa area, Southwestern Nigeria

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A horizontal component of ground magnetic intensity was recorded for part of Ilesa town in Osun State, Southwestern Nigeria using a high resolution proton precision geometric magnetometer. Fifteen traverses were established in E-W direction within the study area. The study focused on delineation of geological structures such as rock contacts; rock boundaries, fractures and faulted zones. The field data was qualitatively and quantitatively interpreted; the results generated were used for estimation of lateral and depth extent of the different rock types in the area. Further enhancement analysis on the Horizontal Magnetic Intensity (HMI) data such as Reduced to Pole (RTP), Vertical Derivative (VD) and Band Pass (BP) yielded information on the altitude of the basement rocks which allows its further classification. The anomaly observed are significant enough in the study area in mapping geological subsurface structures that serve as deposit centre for mineral resources.

Key words: Magnetic intensity, residual ground magnetic, geomagnetic sections, horizontal derivatives, Ilesa.

INTRODUCTION

The study area is located east of Ilesha town in Osun State, Southwestern Nigeria. Fifteen traverses were established in the study area with total length of about 107 km. The line orientation was approximately perpendicular to the regional geological strike of the area. However, traverses 11, 12, 14 and 15 cut across the study area. Traverse eleven (T11) starts from Ilesa junction along the Ilesa-Akure Express road to roundabout in Ilesa town. Traverse twelve (T12) starts from Ijebu-Jesa town to Ilesa roundabout. Traverse fourteen (T14) starts Ilesa-Iloko road to a farm settlement. While traverse fifteen (T15) starts along Ilesa-Ijebujesa road Figure 1 (Kayode, 2006, 2010). Humid tropical climate is prevalent in the area, marked by the alternating wet and dry seasons. The temperature is moderately high during the day and also varies from season to season (Kayode, 2006). Two periods of high temperatures are recorded annually due to the passage of the sun on its way to and from the tropic of cancer. The in November to December. The average daily temperature varies between about 20°C (for a very cold day) and about 35°C (for a very hot day). The coolest period is in the middle of the raining season that is July to August (Kayode, 2006; Kayode et al., 2010).

Previous study has shown that this area is underlain by Precambrian rocks typical of the basement Complex of Nigeria (Figure 2) (Rahaman, 1976) The main rock types found in this area are amphibolites complex and schist occupies most part of the area with quartzite and quartz schist also form part of the rock units, Figure 3 (Ajayi, 1981; Ajayi and Ogedengbe, 2003; Folami, 1992, Elueze, 1986a and b, Olusegun, et al., 1995). The topography is gentle with few local outcrops in the northeastern and northwestern part of the surveyed area (Rahaman, 1976).

Magnetic methods

Most rocks of the earth's crust contain crystals with magnetic minerals; thus most rocks have a certain amount of magnetism which usually has two components; induced by the magnetic field present while taking measurement, and remanent which formed during geologic history (Ross, 2002; Telford et al., 1976).

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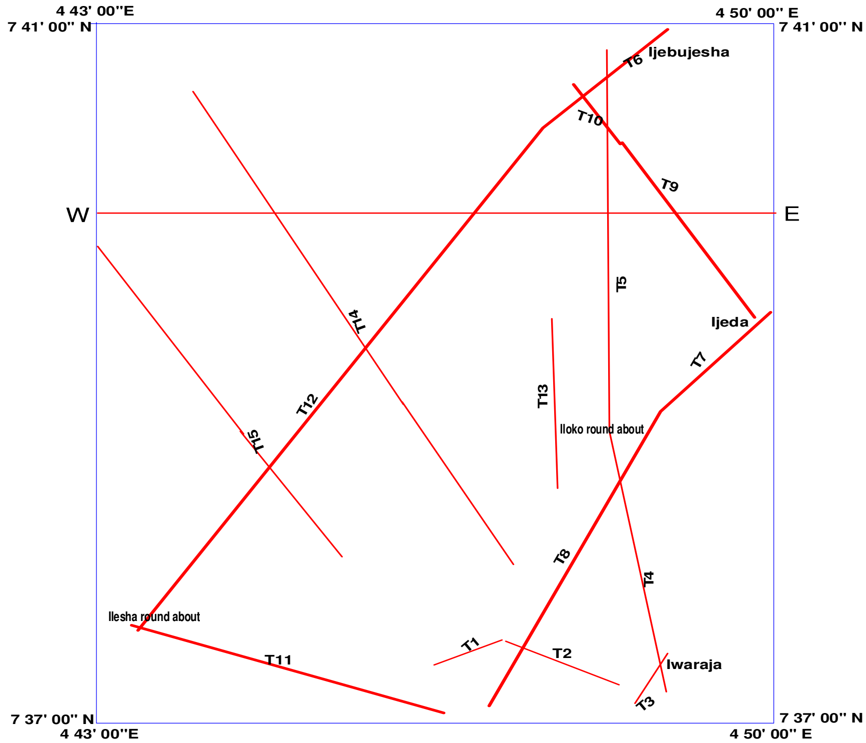

Figure 1. Geophysical layout of the study area.

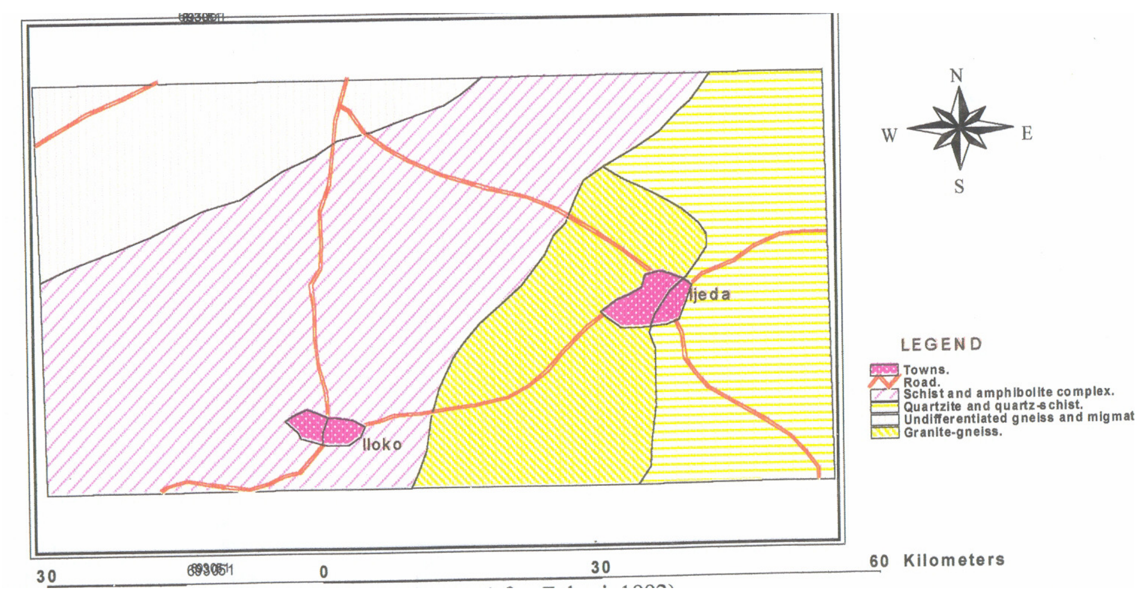

Figure 2. Geological map of the study area (Folami, 1992).

The origin of the earth's magnetism is commonly believed to be the liquid outer core, which cools at the outside as a result of which the material becomes denser and sinks towards the inside of the outer core, and new warm liquid matter rises to the outside; thus, convection currents are generated of liquid metallic matter which move through a weak cosmic magnetic field which subsequently generates induction currents (Obot and Wolfe, 1981). It is this induction current that generate the earth's magnetic field (Kayode et al., 2010).

However, the ground magnetic study is used for detail mapping in order to understand the subsurface geology of an area (Nettleton, 1976). The technique requires measurements of the amplitude of magnetic components at discrete points along traverses distributed regularly throughout the survey area of interest. In ground magnetic study, three components are measured which are Horizontal, Vertical and Total components. The vertical components and the total components are mostly used in the past studies to delineate faults, fractures, depth to magnetic basement and other geological structures (Folami, 1992; Nettleton, 1976).

Susceptibility values are important for the quantitative interpretation of magnetic data and can be used for differentiating rock types. The magnetic susceptibility of rocks is controlled by the amount of magnetic minerals in them, grain size and mode of distribution. Ferrimagnetic substances give rise to higher magnetization and hence higher susceptibility (Parasnis, 1978; Telford et al., 1976)

METHODOLOGY

This study focused on the subsurface geological structures such as rock contacts; rock boundaries, fractures and faults zones which serves as deposit centre for mineral resources based on the qualitative and quantitative interpretations from Horizontal component magnetic derivatives data collected during the fieldwork that was carried out in the months of April and May 2004, (Kayode et al., 2010). The magnetic survey was designed in such away that deep insight into the depth to magnetic sources in the area was delineated. The data acquisition technique requires measurements of the magnetic intensities at discrete points along traverses regularly distributed within the area of interest so as to cover enough segment used to determine the structure and the structural history of the study area. The following methods were adopted in the interpretation of the Horizontal Derivatives:-

Data acquisition

Horizontal field magnetic readings were recorded using a proton precession magnetometer. The survey direction and station locations were determined using Garmin GPS model GPS map 60CSx units. Coordinates were recorded using the WGS84 datum in the UTM zone 31 N, (Kayode, 2006). In order to get the optimum information for preparation of magnetic anomaly maps, a line separation of approximately 1000 m, station spacing of 60m was selected. The total length of the surveyed lines approximated 107 km. The line orientation was approximately perpendicular to the regional geological strike, (Nettleton, 1976; Telford et al., 1976).

Data processing

The earth's geomagnetic field is not constant at any one point and time on the surface but undergoes diurnal variations mostly due to magnetic storms and diurnal variations, (Peters, 1949). In order to remove the effect of spontaneous ionospheric magnetic readings, the magnetometer was been continuously returned to the base station to check and correct this effect on a regular basis.

Data enhancement

The effect of the International Geo-reference Magnetic Field (IGRF) was assumed to be negligible on the survey grid which had dimensions that were roughly 3 by 5 km. The diurnally corrected data was gridded with a cell size of 25m which is a quarter of the line separation using the Geosoft software (Obot and Wolfe, 1981; Rajagopalan, 2003).

The gridded Horizontal Magnetic Intensity (HMI) data was presented on scaled maps to aid interpretation and geo-referencing of anomalies and infrastructure data. In order to improve the information content, short wave length noise that was introduced into the data by observed and recorded features such as fences, gates, power lines, telephone lines and cell phone towers was despiked and voids were interpolated using the Geosoft Software, (Obot and Wolfe, 1981; Rajagopalan, 2003).

Data interpretation

The Horizontal Magnetic Intensity (HMI) was interpreted qualitatively and quantitatively to give information on the depth extent. The Horizontal Magnetic Intensity (HMI) was further enhanced using filtering techniques such as Reduced to Pole (RTP), Horizontal Derivative (HD) and Band Pass (BP). The qualitative approach to interpretation involves deducing useful information on structure and trends from the changes in intensity of contours on diurnally corrected magnetic maps (Dobrin, 1960; Rajagopalan, 2003; Telford et al., 1976).

The Reduction to Pole (RDP) is a theoretical solution which normalizes the effect of induced magnetization and the strike on the shape of the magnetic anomaly while preserving dip and textural information. The RTP anomaly over a vertically dipping dyke, having no remanence magnetization is always symmetrical is always a symmetrical magnetic high located directly over the dyke (Nettleton, 1976; Rajagopalan, 2003; Reijers, 1996; Telford et al., 1976).

Quantitative interpretation methods are used to estimate source depths and widths (Dobrin 1960). The Analytical Signal (ANSIG) is symmetrical as the dip varies. The source position of a magnetic body can be mapped from ANSIG data (Nettleton, 1976, Reijers, 1996). The analytical signal shape can be used to derive the depth to the magnetic sources from the anomaly width at half the amplitude data. In order to estimate the depth to the source of magnetic anomalies ANSIG profiles were taken across two anomaly zones. The basic assumptions being field observations that include geology and magnetic susceptibility values (Nettleton, 1976; Rajagopalan, 2003; Telford et al., 1976).

The Horizontal Derivative (HD) enhances shortwave length anomalies. It suppresses the effect of deep seated geological bodies, which are normally not prospective mineral exploration targets. The Band Pass filter (BP) enhances the effect of features confined to specified wavelengths; this enables the identification of possible anomalies (Nettleton, 1976; Telford et al., 1976).

RESULTS AND DISCUSSION

Ground magnetic interpretations

Traverse 11 (SE – NW)

Traverse eleven runs approximate southeast–northwest direction from Ilesa–Akure express road and ends at Ilesa roundabout very close to the central mosque. It covered a total distance of about 6.6 km. Amphibolites complex and muscovite schist are the two major rock types delineated by the geomagnetic section along this profile.

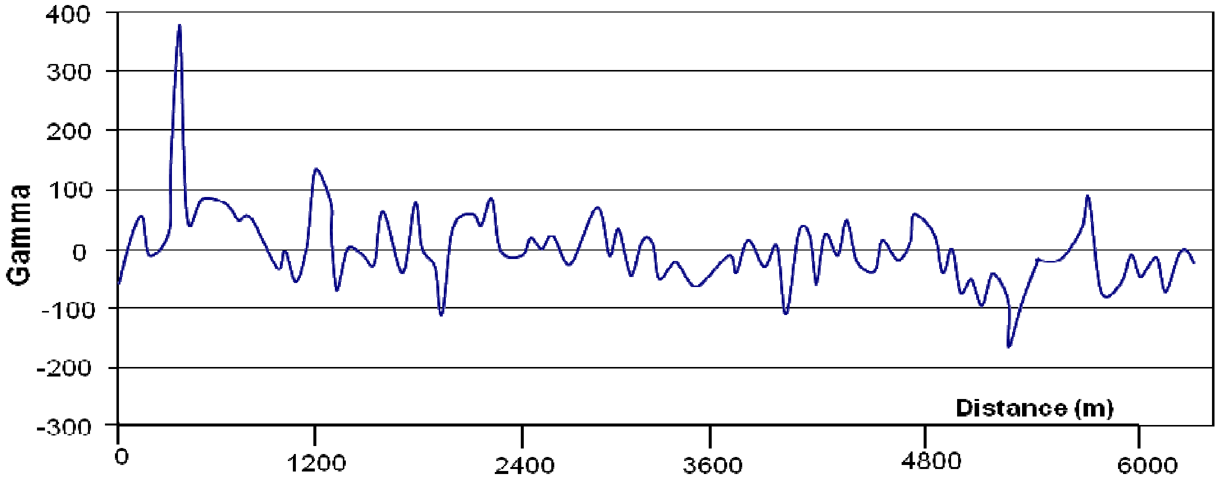

Figure 3a. Horizontal relative magnetic intensity along traverse 11 (SE - NW) of the study area.

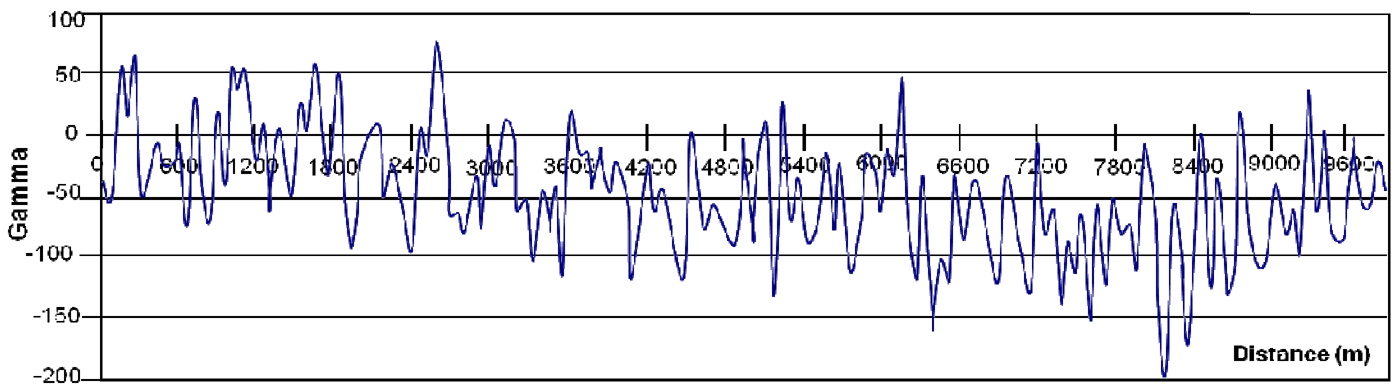

Figure 3b. Horizontal relative magnetic intensity along traverse 12 (E – W) of the study area.

The magnetic signatures obtained for traverse 11 shows considerable varying amplitudes between minimum peak values of about -160 gammas recorded at a distance of about 5000m from the first station position. A maximum peak value of about 380 gammas at a distance of about 600m was recorded along this traverse (Figure 3a). The corresponding geomagnetic section shown in Figure 4a confirms the two major rock units along this profile:

1. Muscovite schist: - Muscovite schist forms the first segment of the profile. The rock unit starts from first station and extended to about 3500 m from the initial station position along the profile with depth to the magnetic basement, which varies between 20 to 60 m.
2. Amphibolites schist**: -** The second rock unit
3. Delineated along the profile covers most part of the traverse starting from about 300 m and spread to the end of the traverse with depth to the magnetic basement ranging from 40 to 100 m.

Traverse 12 (E - W)

This is the longest traverse which covers about 11 km. It runs approximate east - west direction from Ijebu-Jesa town starting from the shopping complex along Ilesa road to Ilesa roundabout and ends very close to the central mosque. Three major rock units were delineated from the geomagnetic section. The magnetic signatures obtained along traverse 12 shows considerable varying amplitude between minimum negative peak values of about -200 gammas at a distance of about 8000 m from the initial station position and a maximum positive peak value of about 80 gammas at a distance of about 2600 m was recorded along this traverse respectively (Figure 3b). The corresponding geomagnetic section shown in Figure 4b confirms the three major rock units along this profile:

1. Quartz schist and Quartzite: - The first and third segments were delineated as quartz schist starting from the initial point at Ijebu-Jesa town covering about 2.8 km

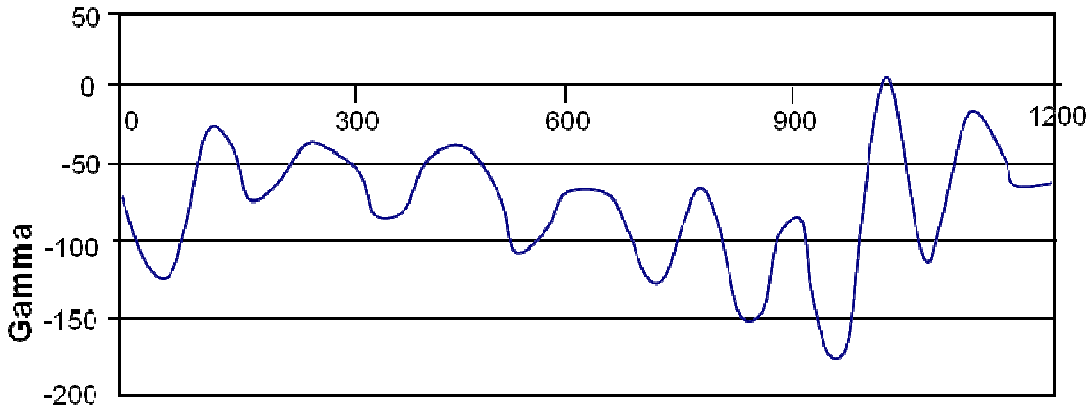

Figure 3c. Horizontal relative magnetic intensity along traverse 14 (SE - NW) of the study area.

for the first part and from about 5 km to about 8.4 km for the second segment. The depth to the magnetic basement varies between about 55 m and about 100 m at the first and second segments respectively.

2. Amphibolites Schist: - Amphibolites schist that spread across a total distance of about 5 km underlay the second and the last segments of this traverse. The depth to the magnetic basement within this rock unit varies between 60 and 100 m.

3. Undifferentiated Schist: - This rock type was delineated at about 8.2 km from the starting point and ends at about 9.6 km towards the end of the profile. The depth to the magnetic basement for this rock unit varies from 80 to 160 m.

Traverse 14 (SE – NW)

Traverse 14 covers a total distance of about 1.2 km. It runs approximate southeast–northwest direction from Ilesa–Iloko road closed to Gold FM Radio station and ends very close to the ridge inside a cocoa farm. Three major rock units were delineated from the geomagnetic section. The magnetic signatures obtained for the horizontal relative magnetic intensity along traverse 14 shows considerable varying negative amplitude between minimum negative peak value of about –170 gammas at a distance of about 960 m from the starting point and a maximum positive peak value of about 5 gammas at a distance of about 1020 m from the initial station position (Figure 3c). The corresponding geomagnetic section shown in Figure 4c confirms the three major rock units along this profile:

Quartz schist and Quartzite: - This rock unit was delineated at about 420 m to about 1020 m from the initial station position. The depth to the magnetic basement varies between about 40 m and about 60 m.

Amphibolites Schist: - Amphibolites schist was delineated at a distance of about 1020 m towards the end of this profile. The depth to the magnetic basement within this rock unit is fairly constant at about 40 m.

Undifferentiated Schist: **-** This rock type was delineated at the starting point covering a distance of about 420 m from the starting point. The depth to the magnetic basement within this rock unit varies from about 30 to 60 m.

Traverse 15 (NW - SE)

Traverse 15 covers a total distance of about 2 km. It runs approximate northwest - southeast direction from Ilesa – Ijebu-Jesa Road and ends very close to a building fence. Two major rock units were delineated from the geomagnetic section. The magnetic signatures obtained for the horizontal relative magnetic intensity along traverse 15 shows considerable varying negative amplitude between a minimum negative peak value of about –170 gammas at a distance of about 1800m from the starting point and a maximum positive peak value of about 40 gammas at a distance of about 240m from the initial station position (Figure 3d). The corresponding geomagnetic section shown in Figure 4d confirms the two major rock units along this profile:

Quartz schist and Quartzite: - This rock unit was delineated at the first and last segments about 540 m and about 1540 m from the initial station position. The depth to the magnetic basement varies between about 20m at the last segment and about 70 m at the first segment.

Amphibolites Schist: - The amphibolites complex was delineated at the central part of the traverse starting from about 540 m and extended to about 1540 m from the starting point. The depth to the magnetic basement within this segment varies between about 30 and 70 m.

Linear trend

The residual ground magnetic map of the study area

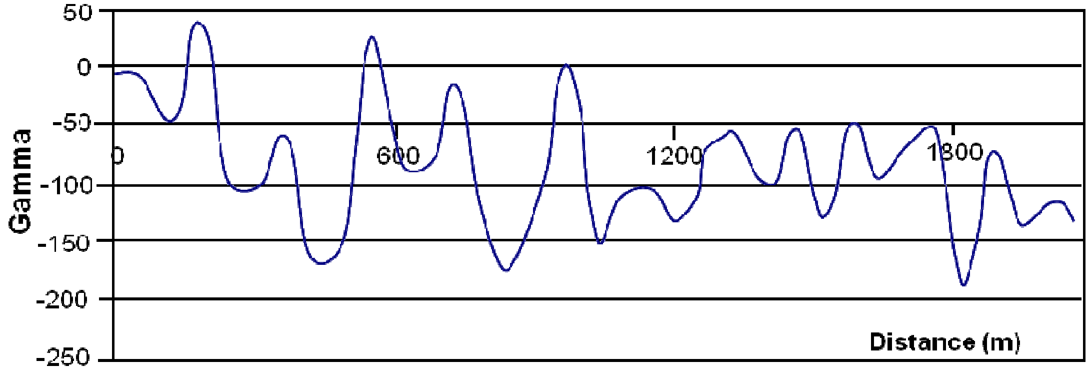

Figure 3d. Horizontal Relative Magnetic Intensity along Traverse 15 (NW - SE) of the study area.

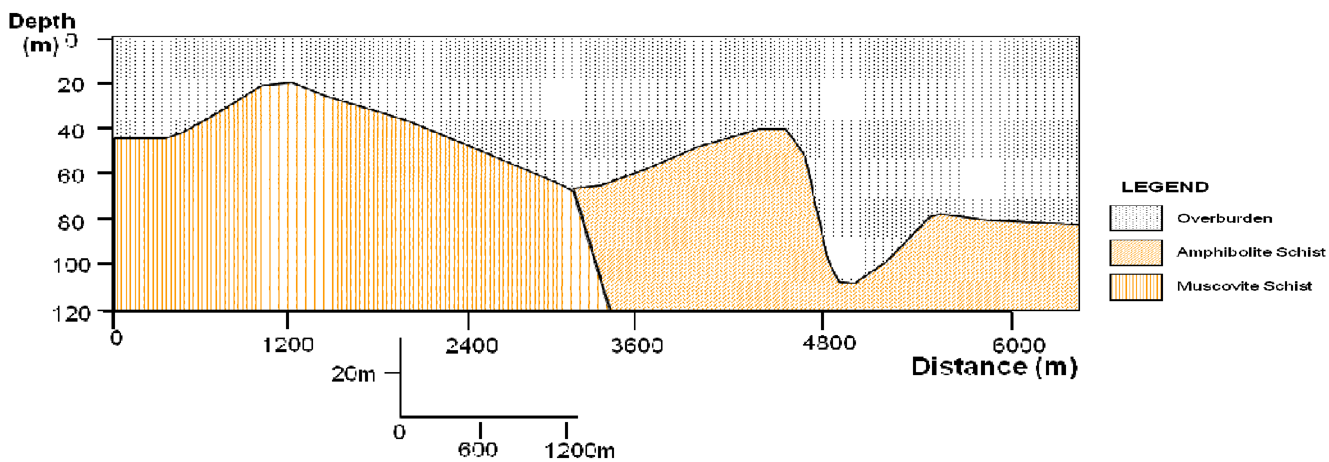

Figure 4a. Geomagnetic section along traverse 11 (SE – NW) of the study area.

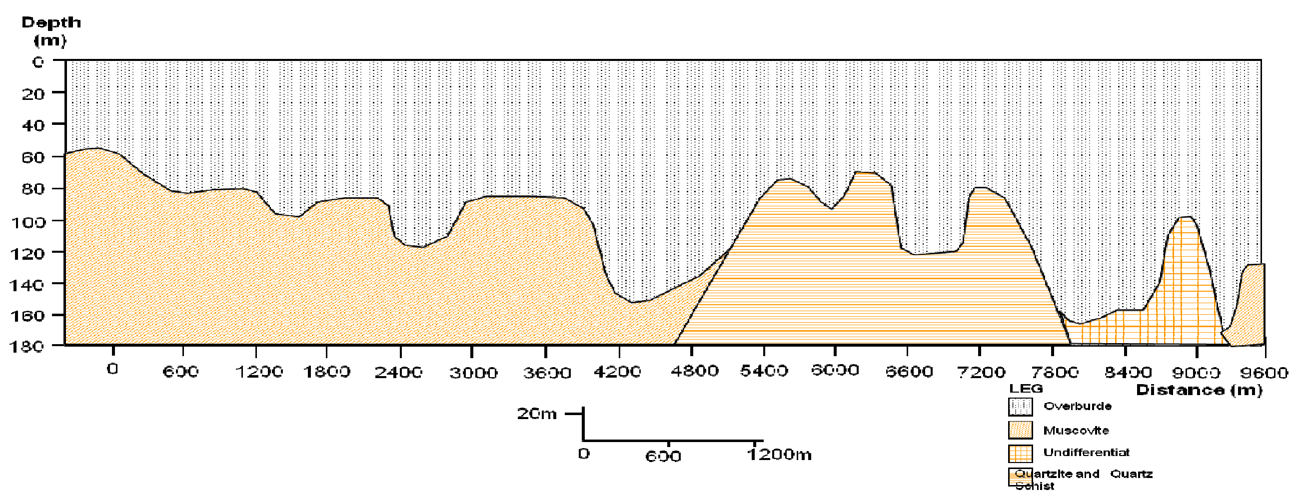

Figure 4b. Geomagnetic Section along Traverse 12 (E – W) of the study area.

using Horizontal relative magnetic components allowed this area to be better mapped. The magnetic values recorded are moderately low and varied from about -250nT to about 60nT, Figure 5. Two regions of (Positive

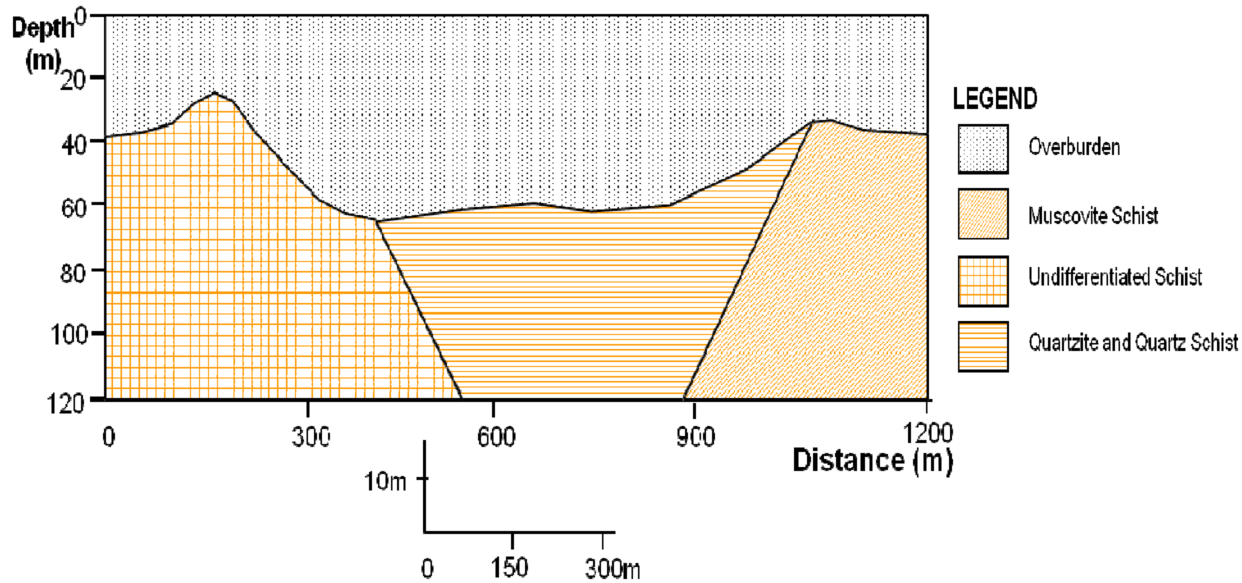

Figure 4c. Geomagnetic section along traverse 14 (SE – NW) of the study area.

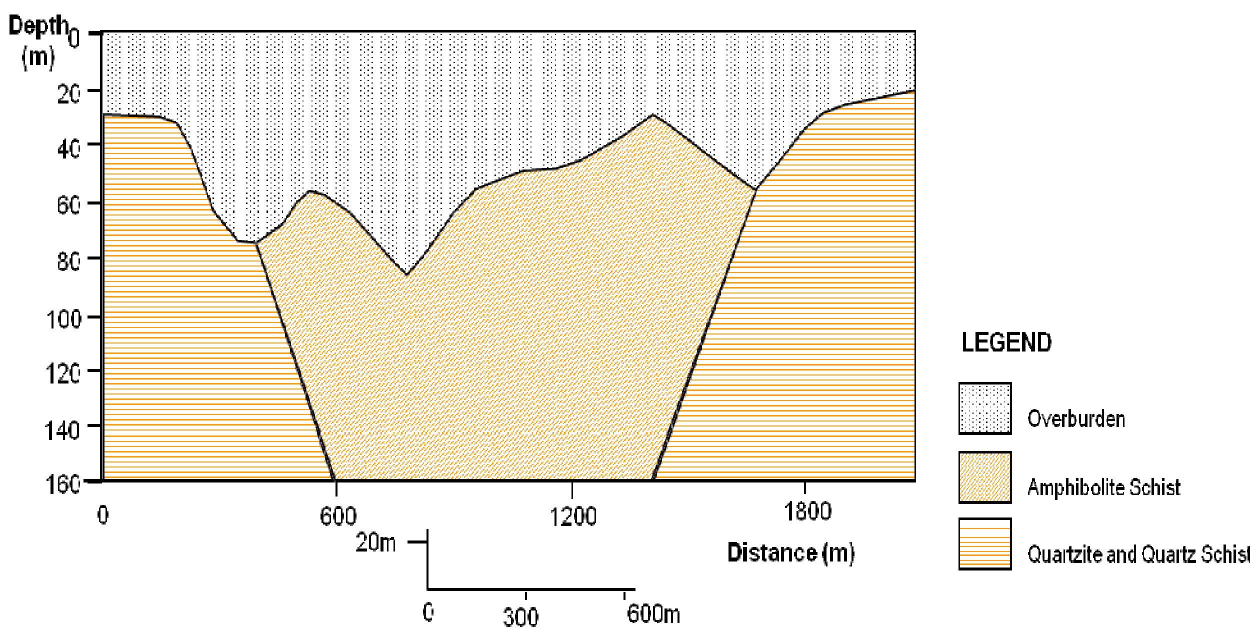

Figure 4d. Geomagnetic section along traverse 15 (NW - SE) of the study area.

and Negative) magnetic anomaly with highest value of about 60nT recorded in the southeastern part of the area and negative anomaly region with the lowest value of about -250nT recorded at around the western and eastern parts of the area. The map further helped to delineate the major and minor rock contacts as indicated with different colours on the map. The highest magnetic value of about 60nT recorded in the southeastern part further supports the earlier submissions by Kayode, 2006. This is an indicative of shallow subsurface geologic structures. The northeastern part through the eastern area towards the southern part of the area supports the previous reports on the existence of these geological structures in this part of the Ilesa schist belt.

Conclusion

From the results of qualitative and quantitative interpretation of the Horizontal ground magnetic data,

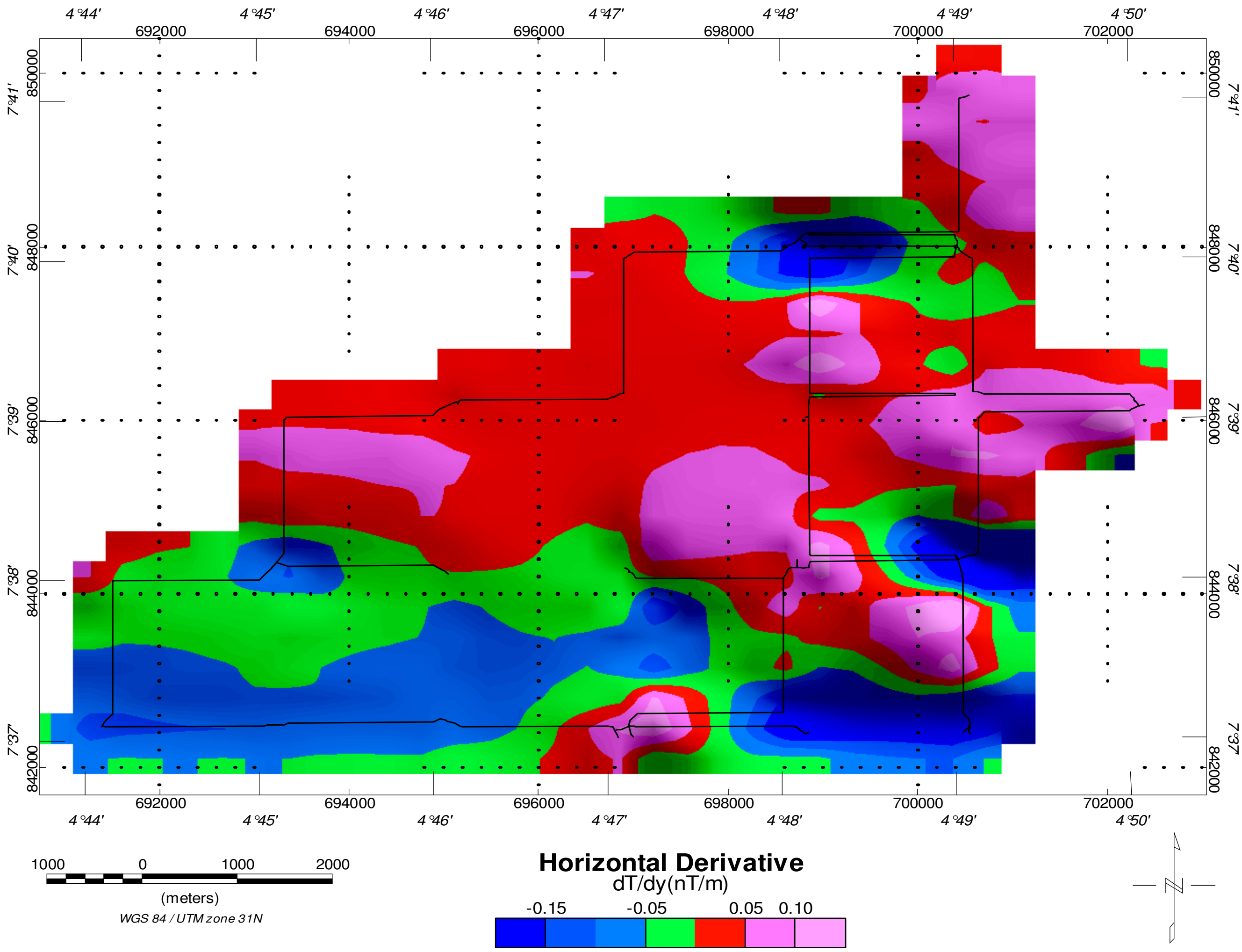

Figure 5. Horizontal Derivative map of the study area using linear trend.

lineaments and target zones were delineated. The ground magnetic study of this area has helped in mapping the subsurface geological structures which serves as deposit centre for mineral resources that are of great benefits for the development of solid minerals sector of Nigeria economic. The geomagnetic sections of the study area helped in mapping the different rock contacts and geological boundaries that are very useful in delineation of the basement structures in the area and this has help to unveil the solid mineral potential of this schist belt zone. The major rocks delineated, i.e. the Amphibolites, Quartz and Quartz schist and Undifferentiated schist will aid and accelerate the mineral exploration work in the area. The linear nature of the anomalies in this part of the schist belt suggests that rocks in this part of the Ilesa schist belt are bounded and offset by the Iwaraja faults. Therefore, this study needs to be aided by latest technology to meet the demands for solid minerals deposits in the country.

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