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HORIZONTAL COMPONENTS OF GROUND MAGNETIC STUDIES OF IJEBU-JESA AREA SOUTH-WESTERN NIGERIA

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Abstract : The ground magnetic studies of Ijebu-jesa town in Oriade Local Government Area of Osun State Southwestern Nigeria was carried out which involves the use of Horizontal Components (i.e. horizontal magnetic intensities and horizontal magnetic gradients). The field data was qualitatively and quantitatively interpreted and the results give values for horizontal magnetic intensity that varied between a negative peak magnetic anomaly of about -800 gammas to a positive peak magnetic anomaly of about 1800 gammas. While the horizontal gradient give values that varied between a negative peak magnetic anomaly of about -500 gammas to a positive peak magnetic anomaly of about 500 gammas over the different rock types in this area. The magnetic values obtained from the linear trends analysis varied between a negative peak magnetic anomaly of about -100 gammas to a positive peak magnetic anomaly of about 120gammas. Depth to the basement rock was estimated using half slope method. The results generated were used to construct geomagnetic sections from where rock boundaries, bedrock topography major and minor faults were delineated.

1.0 Introduction

The survey area covers a total of fifteen traverses using high resolution proton magnetometer in conjunction with a Garmin Global Positioning System (GPS). The study area is located within southwestern basement complex of Nigeria bounded by Latitudes 7^{o} 37’ 000’’N and 7^{o} 41’ 100’’N and Longitudes 4^{o} 43´ 500’’E and 4^{o} 50´ 700’’E and form the northeastern part of Ilesa schist belt (Kayode, 2006). This report was based on the three traverses that covered the area of interest Figure-1. Traverse five (T5) starts from Iloko round about it runs approximately south-north direction and ends along Esaoke road, opposite first bank Plc, Ijebu-jesa. Traverse six (T6) starts from the new garage along Esaoke road it runs approximately east-west direction to Ilesa road and ends opposite a shopping complex. Traverse ten (T10) starts from Ijeda junction near the Local Government Secretariat it runs approximately southeast-northwest direction.

Keywords : Magnetic intensity, Residual Ground magnetic, geomagnetic sections, Rock boundaries, Ijebu-jesa.

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 (Kayode, 2006; Ajayi, et al. 2003; Folami, 1992; Ajayi, 1981, Elueze, 1986). The topography is gentle with few local outcrops in the northeastern and northwestern part of the surveyed area (Rahaman, 1976).

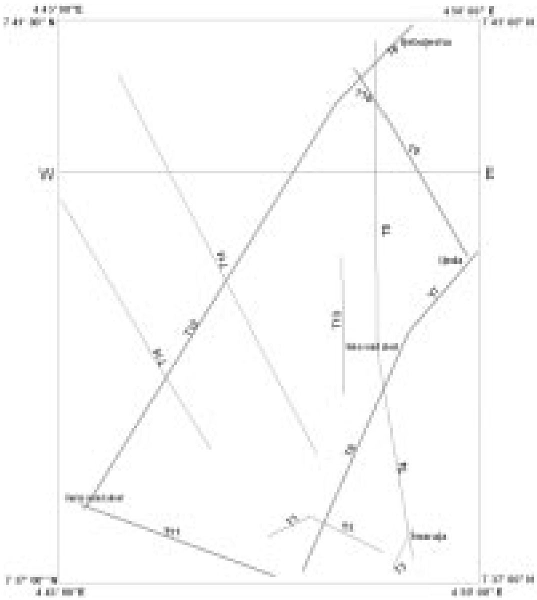

Figure-1 : Geophysical Layout of the study area the dotted line showing the present report.

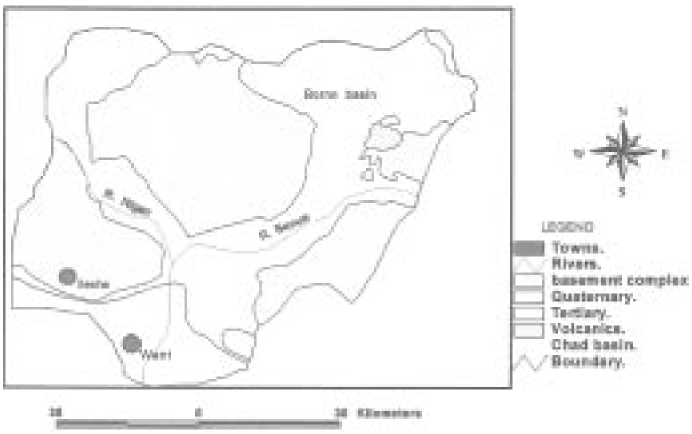

Figure-2 : Map of Nigeria Showing Geological Boundaries after Rahaman 1976.

2.0 Geological Setting

The major rock associations of this area form part of the Proterozoic Ilesa schist belt in Southwestern part of Nigeria, which is predominantly, developed in the western half of the country. In terms of structural features, lithology and mineralization, the schist belts of Nigeria show considerable similarities to the Achaean green stone belts (Olusegun, et al., 1995). However, the latter usually contain much larger proportions of mafic and ultramafic bodies and assemblages of lower metamorphic grade Olusegun, et al., 1995, Ajayi and Ogedengbe, 2003). Rocks in the Ilesa schist belt are structurally divided into two main segments as shown in Figure 3, by two major fracture zones often called the Iwaraja faults in the eastern part and the Ifewara faults in the western part (Kayode, 2006; Folami, 1992, Elueze, 1986).

However, this study focuses on part of the former faults zone. The area north of the fault comprises mostly amphibolites, amphibole schist, meta-ultramafites, and meta-pelites. Extensive psammitic units with minor meta-pelite constitute the eastern segment (Rahaman, 1976). These are found as quartzites and quartz schist. All these assemblages are associated with migmatitic gneisses and are cut by a variety of granitic bodies (Olusegun, et al., 1995; Ajayi and Ogedengbe, 2003; Rahaman, 1976, Elueze, 1988).

The rocks of the Ilesa district may be broadly grouped into gneiss-migmatite complex, mafic-ultramafic suite (or amphibolites complex), meta-sedimentary assemblages and intrusive suite of granitic rocks. A variety of minor rock types are also related to these units. The gneiss-migmatite complex comprises migmatitic and granitic, calcereous and granulitic rocks. The mafic-ultramafic suite is composed mainly of amphibolites and amphibole schist and minor meta-ultramafites, made up of anthophillite-tremolite- chlorite and talc schist (Rahaman, 1976). The meta-sedimentary assemblages, chiefly meta-pelites and psammitic units are found as quartzites and quartz schist. The intrusive suite consists essentially of Pan African (c.600 Ma.) Granitic units. The minor rocks include garnet-quartz-chlorite bodies, biotite-garnet rock, syenitic bodies, and dolerites (Olusegun, et al., 1995; Folami, 1992, Rahaman, 1976).

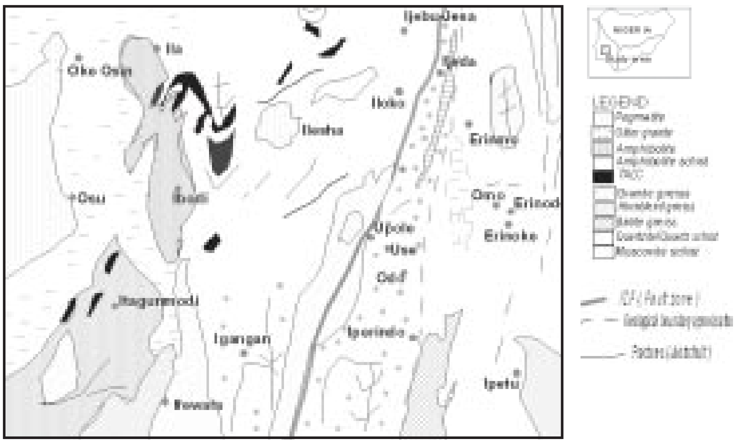

Figure-3 : Geological Map of Ilesa schist Belt showing the study area after Elueze, 1986.

3.0 Geophysical investigation

The geophysical study of the research area covers fifteen traverses and runs in all directions assumed to have crossed the axis of the inferred fault. Measurements were taken at each station positions that were established at 60m intervals. Though fifteen traverses was established during the field work but only that of interest (i.e. traverses 5, 6 and 10) was presented in this report.

3.1 Horizontal component of ground magnetic interpretations

Qualitative interpretation relies on the spatial patterns, which can be recognized by the geophysicists or geologists. The total magnetic anomalies are highly variable in shape and amplitude. However, faults, lineaments, dykes, and folds are usually easily identified than features given by some number of sources, which can produce an anomaly that may result in complexities in the interpretations (Folami, 1992; Rose, 2002; Regnier et al., 2002; Cui et al., 2003, Green, 2004).

A plot of the field data corrected for diurnal variations relative to the base station against distance along each profile is as shown in Figures 4a to 4f. The plots show a magnetic anomaly signature, which varies over the different rock types. The differences in the magnetic properties present in each rock unit results in the contrast between the magnetic anomalies signatures. However, rock contacts, intrusions and the effect of fissures also contribute to the magnetic anomaly (Folami and Ojo, 1991).

3.2 Depth to basement calculations

The depth estimation of the basement in the area and identification of the rock boundaries was carried out using half slope method for depth estimate (Folami, 1992). Table-1 shows the depth estimate from the horizontal relative magnetic intensity data, while Table-2 is the depth estimate from the horizontal magnetic gradients data. The location of inflection points which is an indicative of rock contacts couple with the pre-knowledge of the geology of the study area during the fieldwork, enables the geomagnetic sections of the area to be drawn Figures-5a to 5f.

Table-1 : Depth Estimates of the study area using half slope method for Horizontal Relative Magnetic Intensity

Profile No	**Anomaly**	
	1	**2**
5	60m	120m
6	40m	148m
10	70m	30m

Table-2 : Depth Estimates of the study area using half slope method for Horizontal Magnetic Gradients

Profile No	**Anomaly**	
	1	**2**
5	40m	190m
6	40m	157m
10	63m	55m

3.3 Traverse 5 (S – N)

Traverse 5 starts from Iloko Garage at the roundabout and runs through Ijebu-jesa road in approximately south – north direction to cover a total distance of about 5.4km at inter station spacing of 60m it was terminated at the opposite First Bank Plc along Esaoke Road, in Ijebu-jesa town. The magnetic plot of this component shows two major rock units along the traverse.

3.3.1 Relative Magnetic Intensity

The magnetic signature obtained for the horizontal relative magnetic intensity along this traverse shows a minimum negative peak magnetic anomaly value of about -148 gammas at a distance of about 3000m from the initial station position and a maximum positive peak magnetic anomaly value of about 145 gammas at a distance of about 2200m (Figure-4a). Two rock units were delineated from the corresponding geomagnetic section as shown in Figure-5a.

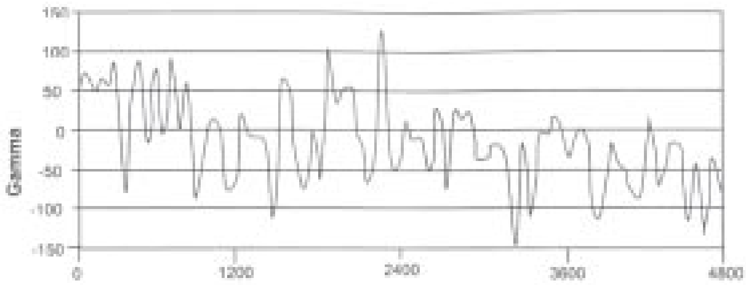

Figure-4a : Horizontal Relative Magnetic Intensity along Traverse 5 (S - N) of Ijeda - IIoko Area

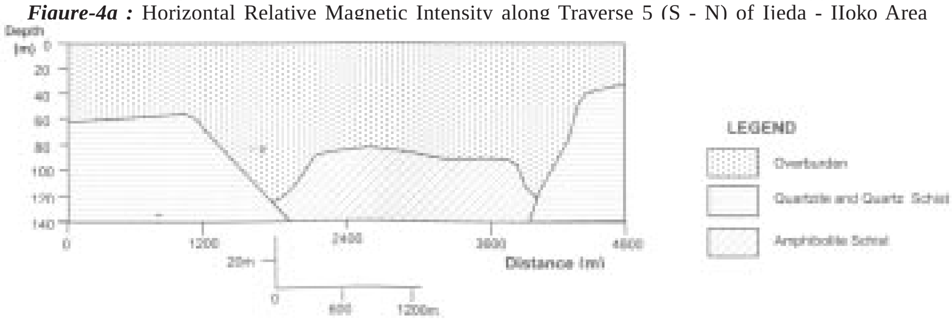

Figure-5a : Geomagnetic Section along Traverse 5 (S - N) of Ijeda - IIoko Area

Quartzite and Quartz schist : The first rock type delineated at the earlier and later part of the traverse based on the geological information is called quartzite and quartz schist. The rock unit covers a distance of about 2000m from the initial station position and from a distance of about 4000m to the end of the traverse. The depth to the magnetic basement for this rock unit varies between about 40m at the end of the profile and about 65m at the initial station position (Figure-5a).

Amphibolites complex : This rock type covers most part of the central portion of the profile. Amphibolites schist was delineated between a distance of about 2000m from the starting point and extended beyond a distance of about 4000m along the profile. The depth to the magnetic basement varies between about 80m to about 135m.

3.3.2 Magnetic Gradient

The magnetic signature obtained for the horizontal magnetic gradient plot along traverse 5 shows a very low negative peak magnetic anomaly value of about -123 gammas at a distance of about 2820m from the initial station position and a positive peak magnetic anomaly value of about 170 gammas at a distance of about 1980m (Figure-4b). Two rock units were delineated from the corresponding geomagnetic section as shown in Figure-5b.

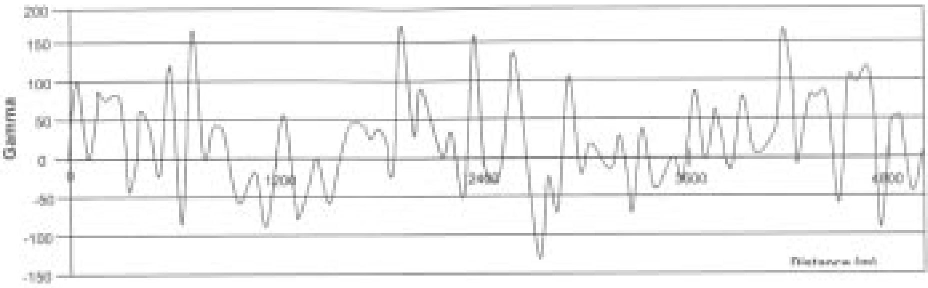

Figure-4b : Horizontal Magnetic Gradilent along Traverse 5 (S - N) of Ijeda - IIoko Area

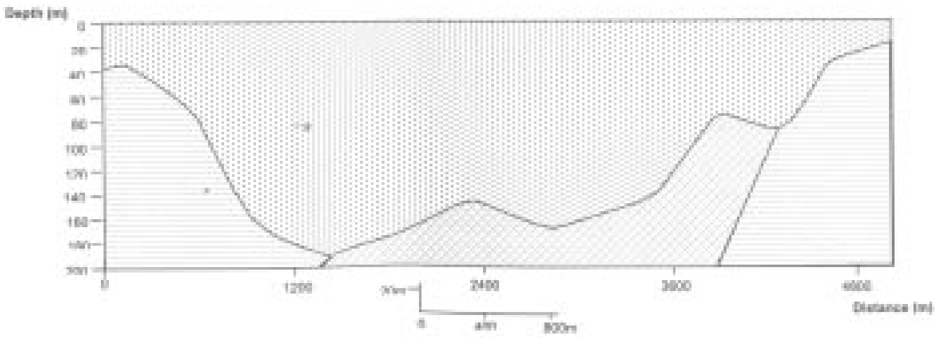

Figure-5b : Corresponding Geomagnetic Section along Traverse 5 (S - N) of Ijeda - IIoko Area

Quartzite and Quartz schist : The first rock type delineated at the earlier and later part of the traverse based on the geological information is called quartzite and quartz schist. The rock unit covers a distance of about 1300m from the initial station position and from a distance of about 4000m to the end of the traverse. The depth to the magnetic basement for this rock unit varies between about 20m and 65m at the end of the profile and about 35m and 190m at the initial station position.

Amphibolites complex : This rock type covers most part of the central zone of the profile. Amphibolites schist was delineated between a distance of about 1300m from the starting point and extended beyond a distance of about 4000m along the profile. The depth to the magnetic basement within this rock unit varies between about 80m to about 190m.

3.4 Traverse 6 (E – W)

Traverse 6 runs approximately east – west direction from Esaoke road close to a mechanic workshop towards the end of Ijebu-jesa town through the town centre and ends at the shopping complex along Ilesa road. The magnetic plot of each component shows two rock types.

3.4.1 Relative Magnetic Intensity

The magnetic signature obtained for the horizontal relative magnetic intensity along this traverse shows a minimum negative peak magnetic anomaly value of about -180 gammas at a distance of about 1900m from the initial station position and a maximum positive peak magnetic anomaly value of about 85 gammas at a distance of about 1000m (Figure-4c). Two rock units were delineated from the corresponding geomagnetic section shown in Figure-5c.

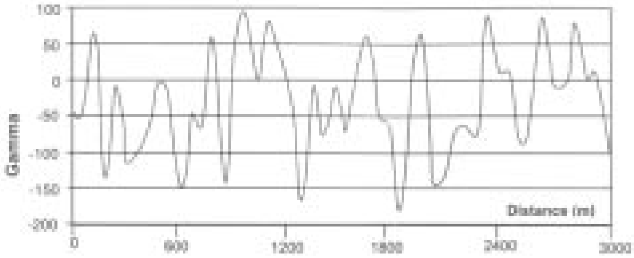

Figure-4c : Horizontal Relative Magnetic Intensity along Traverse 6 (E - W) of Ijeda - IIoko Area

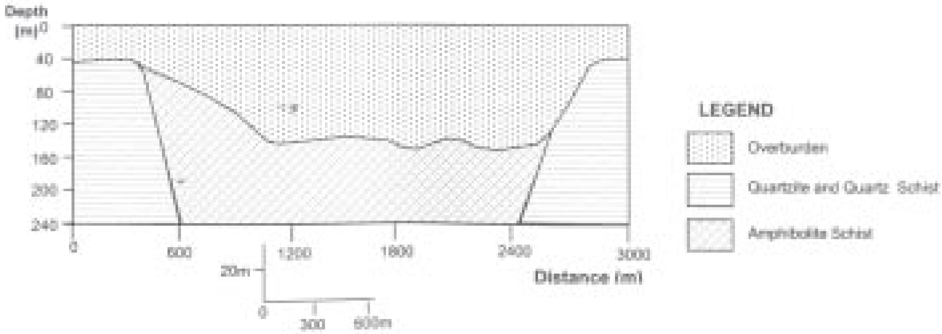

Figure-5c : Geomagnetic Section along Traverse 6 (E - W) of Ijeda - IIoko Area

Quartzite and Quartz schist : This rock type covers the earlier and later part of the profile. The first segment extended from the initial station position to a distance of about 600m and the second segment starts from a distance of about 2500m to the end of the profile. The depth to the magnetic basement is fairly constant at about 45m.

The Amphibolites Complex : Amphibolites schist covers the central segment of the profile, which extended from a distance of about 600m to a distance of about 2500m with depth to the magnetic basement which varies between about 50m and about 150m.

3.4.2 Magnetic Gradient

The magnetic signature obtained for the horizontal magnetic gradient plot along traverse 6 shows a minimum negative peak magnetic anomaly value of about -160 gammas at a distance of about 1900m from the initial station position and a maximum positive peak magnetic anomaly value of about 470 gammas at a distance of about 2700m (Figure-4d). Two rock units were delineated from the corresponding geomagnetic section shown in Figure-5d.

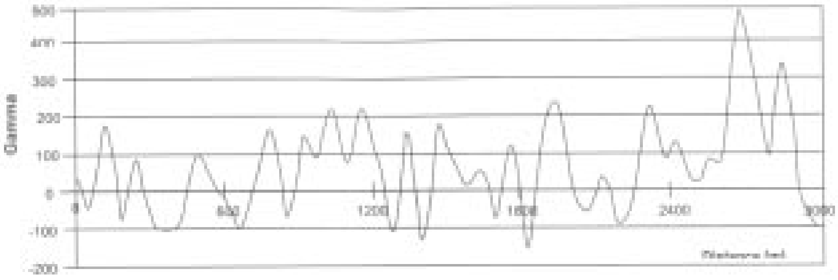

Figure-4d : Horizontal Magnetic Gradilent along Traverse 6 (S - N) of Ijeda - IIoko Area

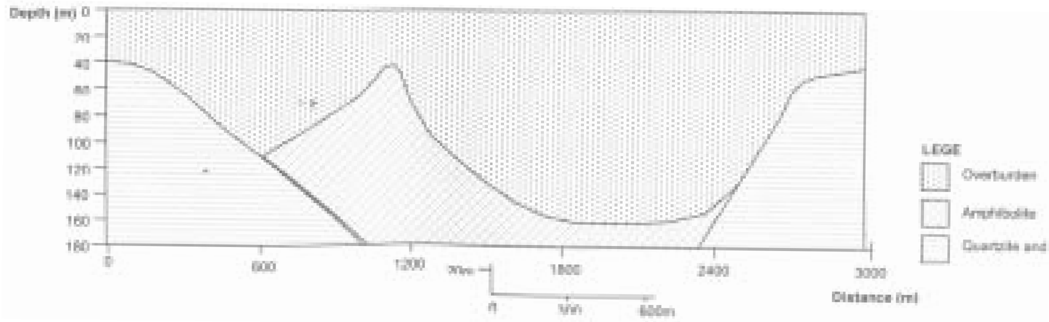

Figure-5d : Corresponding Geomagnetic Section along Traverse 6 (S - N) of Ijeda - IIoko Area

Quartzite and Quartz schist : This rock type covers the earlier and later part of the profile. The first segment extended from the initial station position to a distance of about 1000m and the second segment starts from a distance of about 2300m to the end of the profile. The depth to the magnetic basement varies between about 40m and 110m.

The Amphibolites Complex : Amphibolites schist covers the central segment of the profile, which extended from a distance of about 600m to a distance of about 2500m with depth to the magnetic basement which varies between about 40m and about 150m.

3.5 Traverse 10 (SE – NW)

Traverse 10 starts from Iloko–Ijeda junction through Ijebu-jesa town and ends at the back of a mechanic workshop across Ilesa road. The traverse runs approximately southeast - northwest direction and covered a total distance of about 1.2km. Quartz schist and Amphibolites schist were the two major rock units delineated along this profile as shown by the geomagnetic sections.

3.5.1 Relative Magnetic Intensity

The magnetic signatures obtained for the horizontal relative magnetic intensity along traverse 10 shows complete negative amplitude between minimum peak magnetic anomaly values of about -680 gammas at a distance of about 120m from the initial station position, and a maximum peak magnetic anomaly value of about –100 gammas at a distance of about 1000m was recorded (Figure-4e).

Two rock units were delineated from the corresponding geomagnetic section shown in Figure-5e.

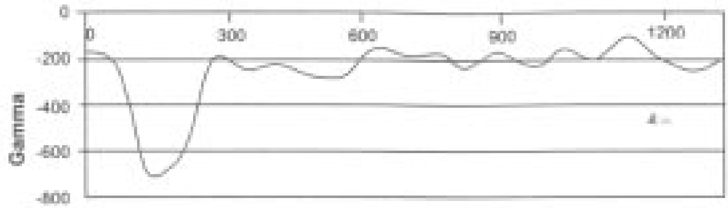

Figure-4e : Horizontal Relative Magnetic Intensity along Traverse 10 (SE - NW) of Ijeda - IIoko Area

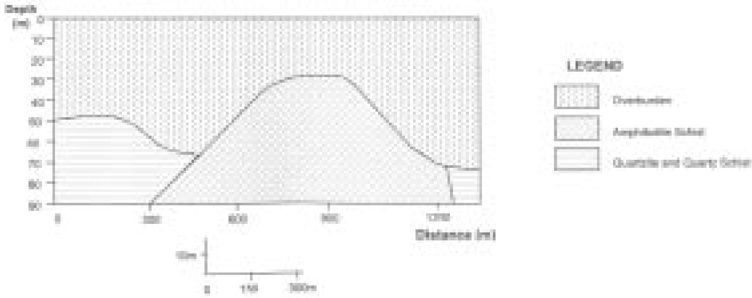

Figure-5e : Geomagnetic Section along Traverse 10 (SE - NW) of Ijeda - IIoko Area

Quartzite and Quartz schist : occupies the first segment of the profile covering about 300m from the starting point with depth to the magnetic basement, which varies between about 50m and 65m within the rock unit.

The Amphibolites schist : This rock type occupies about 90% of the profile and covers a distance of about 280m to about 1200m at the central part of the profile with depth to the magnetic basement of about 30m.

3.5.2 Magnetic Gradient

The magnetic signature obtained for the horizontal magnetic gradient plot along traverse 10 shows a varying amplitude from a negative peak magnetic anomaly value of about -500 gammas at a distance of about 120m from the initial station position to a maximum positive peak magnetic anomaly value of about 100 gammas recorded at a distance of about 600m Figure-4f. The corresponding geomagnetic section is shown in Figure-5f which shows two rock units delineated.

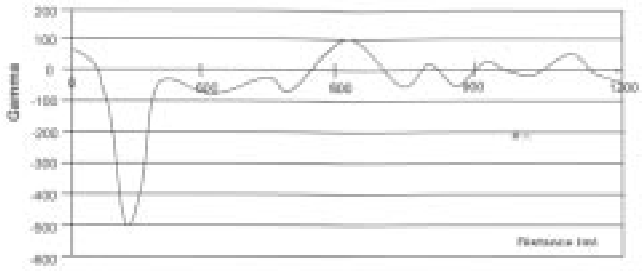

Figure-4f : Horizontal Magnetic Gradilent along Traverse 10 (NW - SE) of Ijeda - IIoko Area

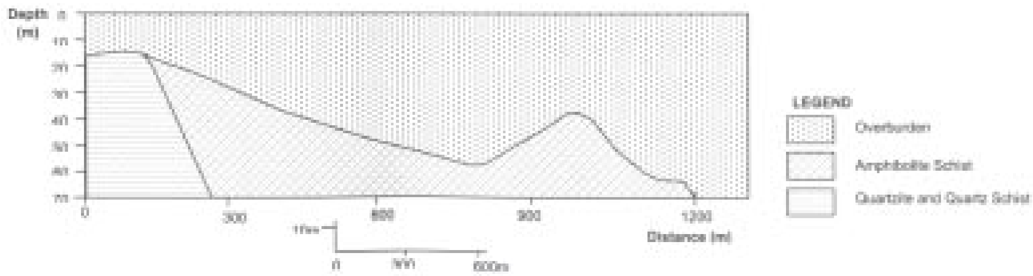

Figure-5f : Corresponding Geomagnetic Section along Traverse 10 (NW - SE) of Ijeda - IIoko Area

Quartzite and Quartz schist : occupies the first and last segment of the profile covering a distance of about 300m from the starting point with depth to the magnetic basement at a distance of about 15m.

The Amphibolites schist : This rock type occupies most part of the profile and covers from a distance of about 280m to about 1200m at the central segment of the profile with depth to the magnetic basement that varies between 20m to a maximum of about 60m within the rock unit.

3.6 Linear Trend Analysis

The linear trend analysis for the horizontal components of the ground magnetic study of this area was obtained using Equations 1 to 6 from Microsoft Excel package for the interpretations of the three traverses (i.e. traverse 5, 6 and 10) for both the horizontal magnetic intensity and horizontal magnetic gradients.

$$y = -0.0322x + 21.407 \quad (1)$$

$$y = 2.6077x - 2.77 \quad (2)$$

$$y = 6.285x - 106.65 \quad (3)$$

$$y = -1.1444x + 35.012 \quad (4)$$

$$y = 2.2992x - 63.188 \quad (5)$$

$$y = 10.035x - 335.7 \quad (6)$$

●r (residual) = ●T (corrected field data) – ●R (regional) (7)

Equations 1 to 6 were used to obtain the regional magnetic, ΔR values for the horizontal components of the ground magnetic study of this area where x is the station position. The residual magnetic, ●r values were obtained using Equation (7) by subtracting the regional magnetic, ΔR values from the corrected field data values, ΔT. The results obtained were used to construct the residual ground magnetic map of the area.

3.6.1 The Residual Ground Magnetic Map for Horizontal Components

The residual ground magnetic map of the study area using linear trend analysis for horizontal magnetic components is as shown in Figure-6. The area was divided into two regions; Positive magnetic anomaly region with highest value of about (ΔT ● 0 ● 130nT) was recorded in the northwestern part of the study area. The negative anomaly region with the lowest value of about ($\Delta T \bullet 0 \bullet -100$ nT) was recorded around the western, northeastern and central parts of this area. The map further reveals the major and minor rock contacts in the area. The highest magnetic value of about 130nT recorded in the northwestern part further confirms the earlier submissions (Kayode, 2006). This is an indicative of shallow subsurface geologic structure. The northeastern part through the eastern area towards the southern part of the area supports the previous reports on the existence of geological structures such as faults.

3.7 Isopach Map

This is a contour map of the bedrock elevations beneath the study area. The values were obtained by subtracting the thickness of the overburden materials above presumably fresh bedrock from the surface elevation above mean sea level.

The highest elevation of about 280m was recorded in the north central part and about 260m was recorded in the southeastern area (Figure-7). Relatively low values were recorded in the northeastern and southern areas which were in the range of about 160m.

This map reveals the bedrock topography and the structural disposition of the study area. It delineates some depressions in the northeastern area and southwestern part which further suggests presence of subsurface geological structures such as faults.

However, the north central part and the southeastern area shows high elevations above presumably fresh bedrock which in essence confirmed the presence of a ridge and a granitic boulder respectively in these part of the study area.

Furthermore, there are depressions which could be visibly seen along the northeastern-southwestern trending with the deepest part of the depression at the base of the northern and southern flanks respectively.

4.0 Conclusion

The ground magnetic study of this area has helped in many ways to delineate the geologic structures. First, the geomagnetic sections of the study area helped in delineation of the different rock contacts and geological boundaries that are very useful in mapping the basement structures of the area. Secondly, the major subsurface structures that were delineated include Amphibolites, Quartz and Quartz Schist. Lastly, the depth to the magnetic basement in each rock unit was obtained using half slope method which gives the overburden thickness that varies between about 40m to about 200m these values may have been exaggerated because of the depth estimated method used. The linear nature of the anomalies in this part of the schist belt suggests that the rocks may be bounded and offset by faults. The results further confirmed the area as high mineralized zone with the delineation of faults in this part of the schist belt. Therefore, the study further confirms that ground magnetic can equally reveal lithologic units in basement structures.

5.0 Acknowledgement

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