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DEPTH ESTIMATES FROM A GROUND MAGNETIC SURVEY ACROSS A NORTH-SOUTH TRENDING GEOLOGIC STRUCTURE IN A PART OF THE BASEMENT COMPLEX TERRAIN OF ILORIN, WEST OF CENTRAL NIGERIA

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ABSTRACT

A quantitative interpretation of the ground magnetic data across a north-south trending geologic structure has been made within the basement complex terrain of the University of Ilorin, West of Central Nigeria. The depths to the magnetic basement estimated using the gradient analysis method vary from 2.14 to 19.73 meters. The basement topography based on the geomagnetic cross section of the area, has been found to be undulating due to different degrees of weathering. The residual magnetic anomaly profile gives an impression of a gneissic country rock intruded in places along the east-west profile by basic igneous rocks. A comparison of the geomagnetic cross section with the geo-electrical section shows a good correlation.

KEYWORDS: geomagnetic, gradient, residual magnetic anomaly, interpretation

INTRODUCTION

Several minerals containing iron and nickel display the property of ferromagnetism. Rocks or soil containing these minerals can have strong magnetization and as a result, can produce significant local magnetic fields. The magnetization can be either remanent, that is, a permanent magnetization created by the earth's magnetic field during some process in the history of formation of the mineral; or induced magnetization created by the presence of the earth's magnetic field. In most rocks, both are present (Berkeley, 2001; Lowrie 1997). The goal of a magnetic survey method is to map changes in the magnetization which are in turn related to the distribution of magnetic minerals, (Berkeley, 2001; Lowrie 1997).

The area of study lies entirely within the basement rocks in the western part of central Nigeria bounded by longitudes 4° 39' – 4° 42'E and latitudes 8° 28' – 8° 30'N (Figures 1, 2 and 3). This area falls within the eastern part of Ilorin, a semi-arid region of Nigeria with vegetation mainly of the guinea savannah type with shrubs and undergrowth. Rugged troughs and crests due to erosions characterize the topography of the area. The area is drained by rivers and streams such as Oyun river and river Ile-apa as a tributary of River Niger (Olasehinde, 1999).

The work presented here is a ground magnetic survey across a north-south trending structure over the basement complex of Nigeria. The result will no doubt contribute tremendously to a better understanding of the geological structures of the basement complexes.

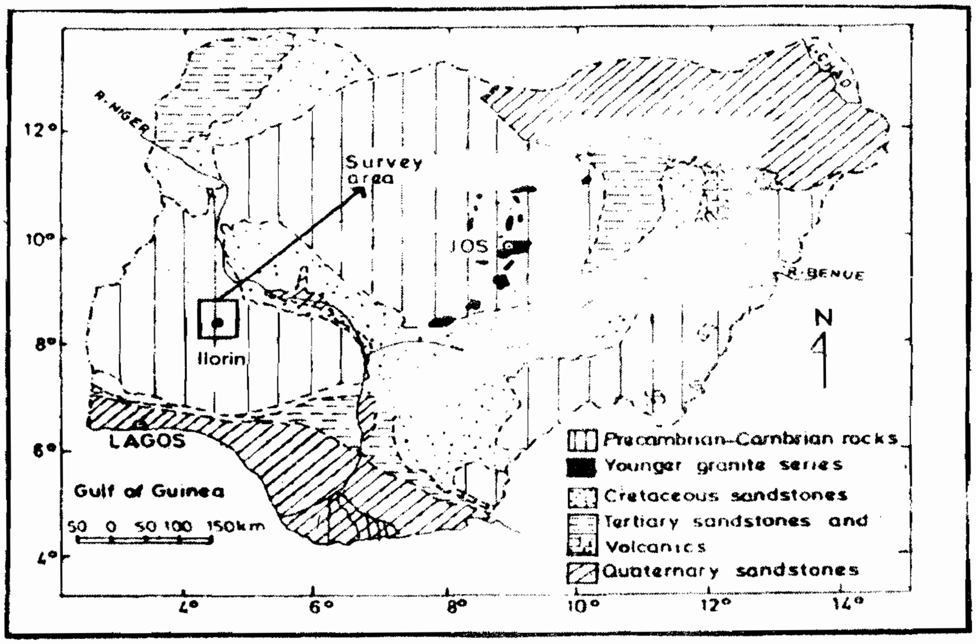

Figure 1. Geologic map of Nigeria showing the survey area

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THEORETICAL CONSIDERATIONS

The Pal's method for magnetic depth calculations is a simplified magnetic inversion gradient analysis strategy, which employs the profile and its horizontal gradient (Pal, 1985). The magnetic anomaly at any point on the profile across a buried source can be written as:

$$\Delta F = C_f [(\o_A - \o_B)\cos\theta_F + \sin\theta_F \ln (r_A/r_B)] \; .....1$$

Where ΔF is ΔZ, ΔH or ΔT (the vertical, horizontal or total field magnetic anomaly depending on what is measured). Here the vertical field magnetic values were measured. The coefficient C_f and θ_F are (2kF' sin θ) and (I'- θ) for ΔF = ΔZ, (2kF' sin θ sin α) and (I'- θ - 90) for ΔF = ΔH, (2kF' sin θ sin I cosec I') and (2I'- θ - 90) for ΔF = ΔT respectively. Where α = angle that the dike's strike makes with the magnetic meridian, F and I are the strength and inclination, F' and I' are the effective strength and inclination of the local geomagnetic vector in the direction of the profile and θ is the dip angle of the dike.

The depth estimates using the Pal's method for the magnetic profile were carried out at ten stations. Magnetic measurements were carried out at 161 stations. Electrical resistivity survey involving dipole-dipole pseudo section and depth estimates at 25 stations were carried out earlier on (Nwankwo et al, 2004).

GEOLOGICAL SETTING

The rocks are mainly banded gneiss, sheared gneiss and augen gneiss intruded by granodiorites and granites at the southeast. The structural fabric is mainly a north-south trending fracture system dominated by a southerly plunging (6^0 - 10^0) anticlinorium with a gentle westerly dipping limb is depicted (Olasehinde, 1984) (Figure 2).

Five major groups of rocks had been recognized in the basement complex of southwestern Nigeria (Rahaman, 1973). These include,

1. Migmatite – Gneiss complex which comprises gneisses, quartzite, calc silicates rocks, biotite hornblende schist and amphibolites
2. Slightly migmatised to unmigmatised para-schists and meta-igneous rocks
3. Charnockitic rocks
4. Older granites
5. Unmetamorphosed dolerite dykes, which comprises pegmatite, quartz veins and doleritic dykes.

FIELD SURVEY

A ground magnetic survey was carried out using a digital Fluxgate Magnetometer. The vertical field magnetic intensity measurements were taken at 15 meters interval in 161 stations along an east-west profile using the Tanke-University of Ilorin road for access. A single magnetometer was used, and as such; a base station was chosen at the beginning of the day's work and a schedule arranged which permitted the return to the base station for the purpose of a repeat reading for diurnal variation correction (Dobrin, 1976).

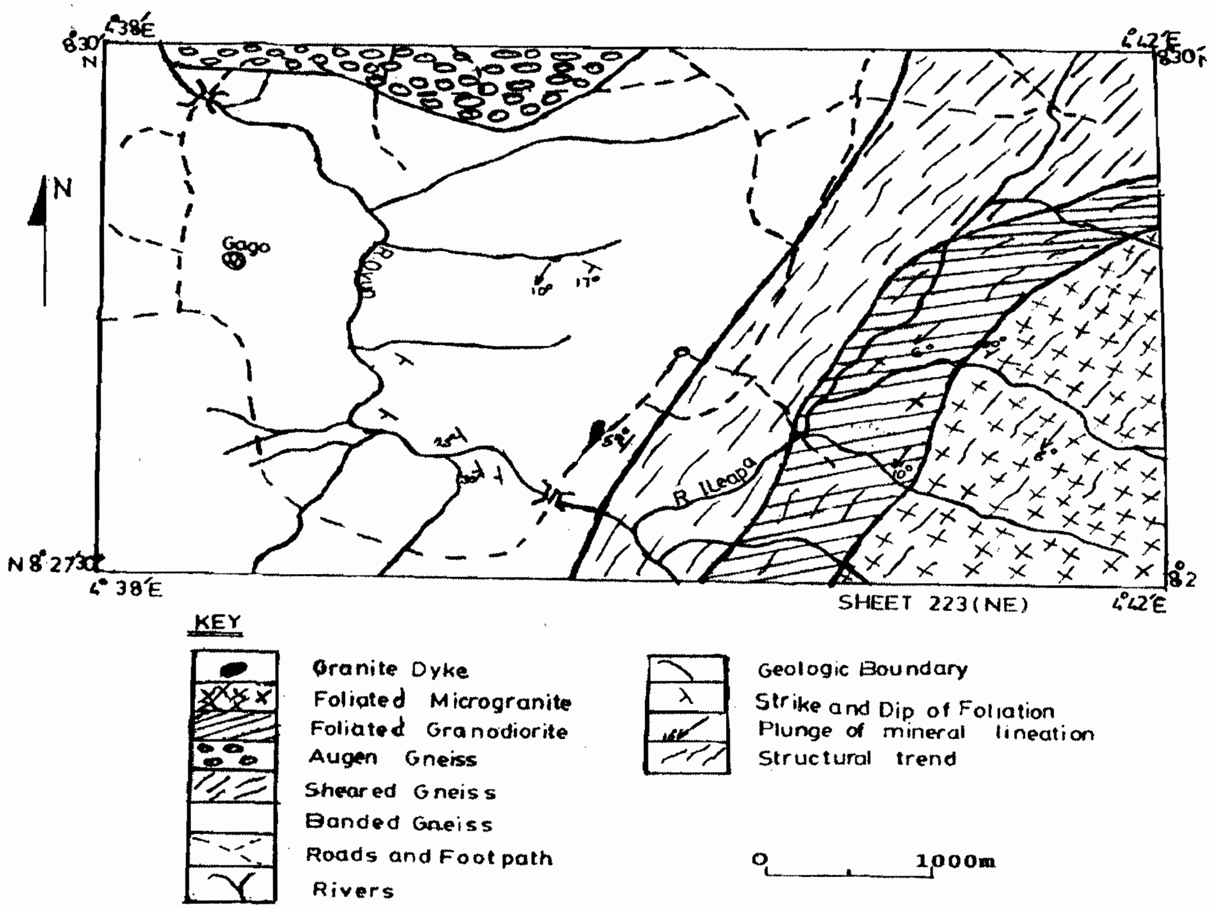

Figure 2. Geologic map of the survey area (After Olasehinde, 1984).

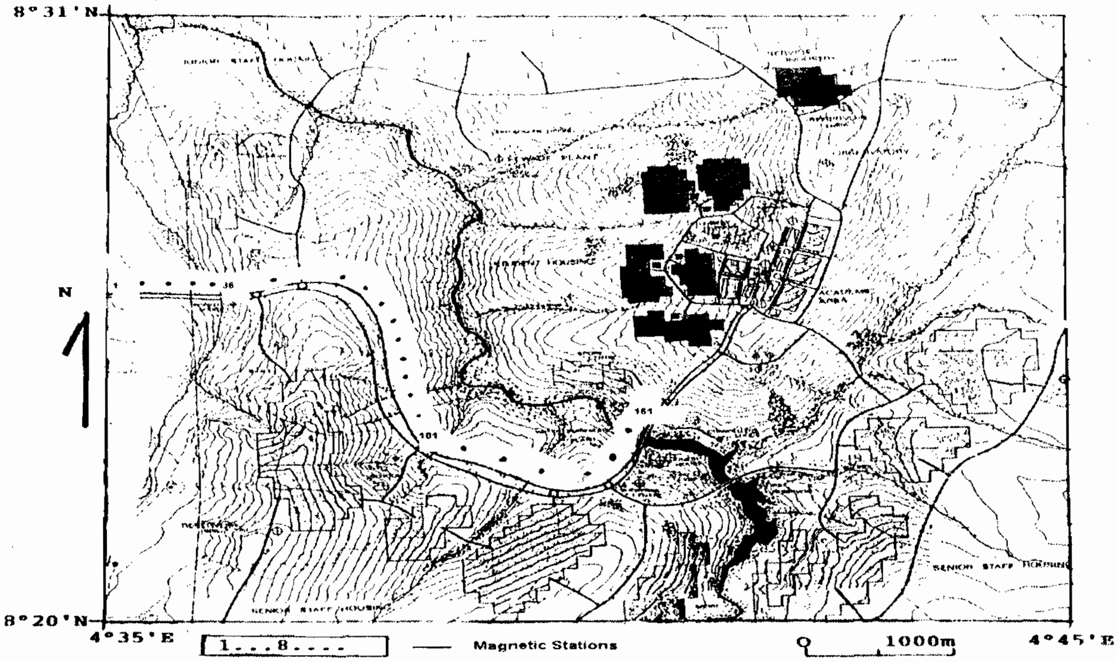

Figure 3. Topographical map of the survey area showing magnetic profile

RESULTS OF THE FIELD SURVEY

In ground magnetic survey, the diurnal correction can be applied to the data (Dobrin, 1976). The residual magnetic profile was therefore constructed from the difference between the observed data and the diurnal variation. After the application of diurnal correction in this study, a butterworth digital filter was applied to the observed data. The purpose was to remove noise from the observed data in order to obtain a smoothed data. The raw and smoothed data are shown in Figure 4. The residual magnetic profile (Figure 5) was then divided into 10 equal segments in order to enhance the computation of the basement depths. The determination of the depth to the basement requires the calculation of a large number of depth estimates for magnetic markers. The quantitative interpretation was done based on the magnetic gradient analysis method. This method has been described and used by Baranov (1953), Agarwal and Lal (1972) and Pal (1985) among others. Pal's (1985) simplified inversion strategy for the gradient analysis of the magnetic profile was primarily used to calculate the depths to the magnetic basement in this study.

The result is shown in Table 1 while a geomagnetic cross section based on the estimated depths is shown in Figure 6.

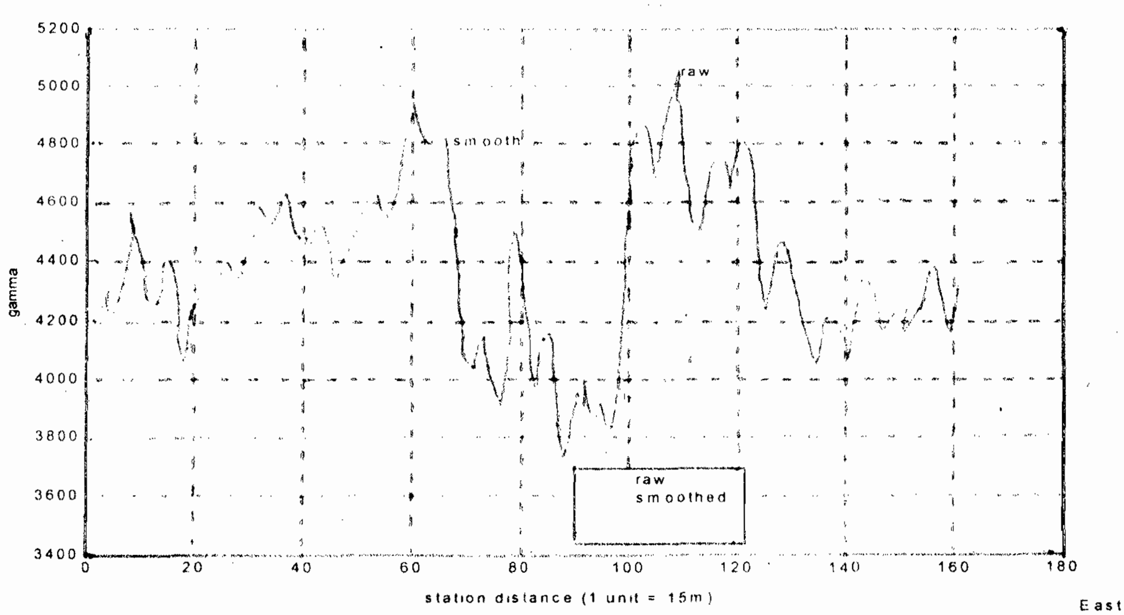

Figure 4. Raw and Smoothed Anomaly Profile

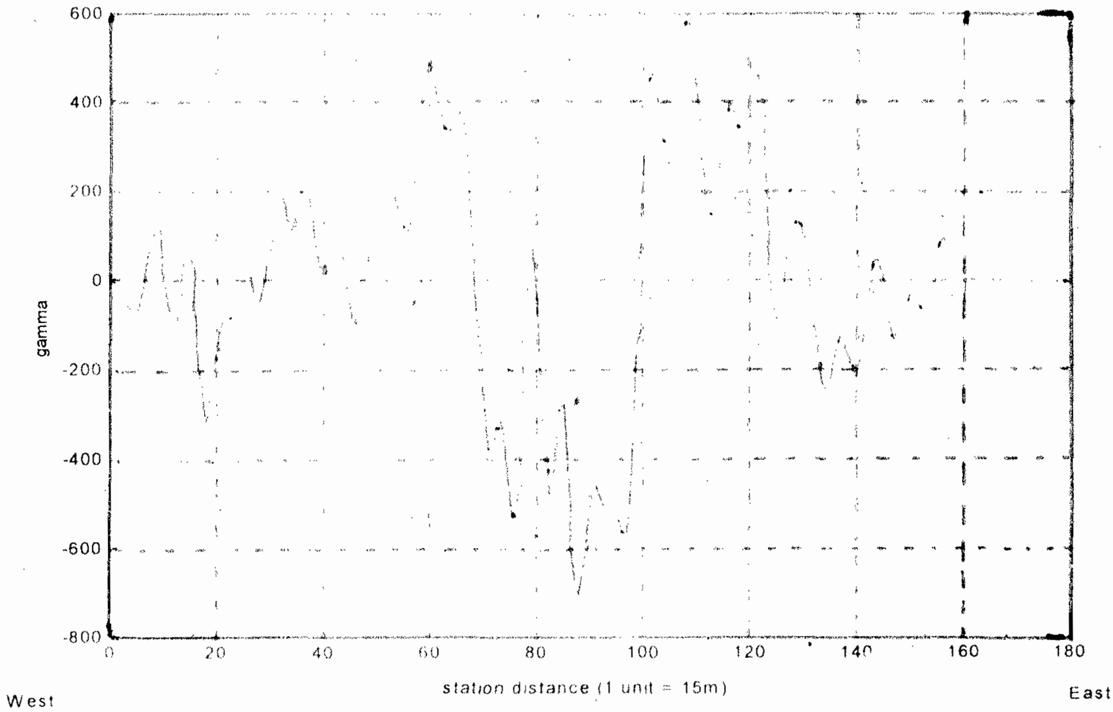

Figure 5. Residual Anomaly Profile

TABLE 1. Estimated Basement Depths

SEGMENTS	STATIONS	AVERAGE DEPTH (m)
1	1-16	8.68
2	16-32	9.87
3	32-48	12.78
4	48-64	13.21
5	64-80	13.73
6	80-96	11.81
7	96-112	13.94
8	112-128	19.73
9	128-144	2.14
10	144-161	5.79

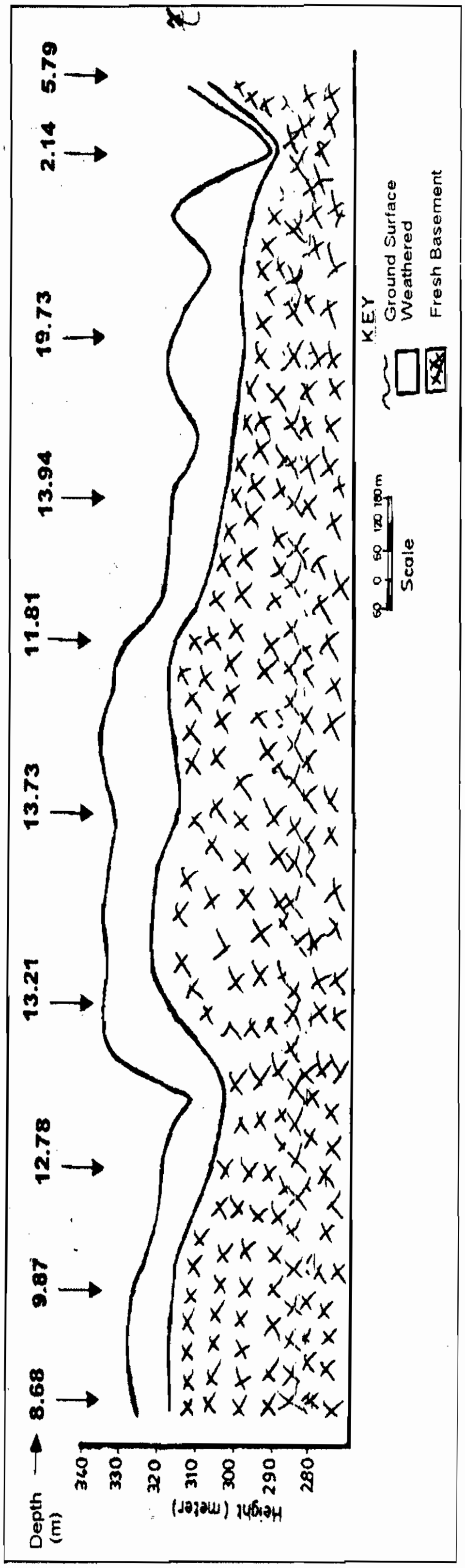

Figure 6. Geomagnetic section along E-W profile, East of Ilorin, Nigeria

DISCUSSION OF THE RESULTS

Basement depths have been determined from a ground magnetic profile within the basement complex terrain of the University of Ilorin main campus. The terrain is predominantly gneissic (Figure 2). This country rock is expected to be of lower magnetic intensity and intensely weathered (Olasehinde, 1984). From the residual magnetic anomaly profile, it can be inferred that the terrain is a gneissic country rock intruded in places by basic igneous rocks as evident from high magnetic values along the profile length.

Using the gradient analysis of the residual magnetic data, it was found that the basement thickness varies between 2.14 and 19.73 meters along the profile. The shallow depths coincide with places of high magnetic anomalies as well as high electrical resistivity values, as evident from figures 7 and 8 (Nwankwo et al, 2004). Stations 60 to 100 on the residual anomaly profile has low (negative) magnetic anomaly, which also coincides with places of thick weathering (13.21 to 13.94 meters). To the west and to the east of the portion, the weathering profile is relatively shallow (2.14 to 9.87 meters). Coincidentally, these shallow weathering portions lie on the topographically low land where rock exposures are more pronounced (Figure 3). The whole area had been mapped by as banded gneiss but the picture emanating from this study gives an impression of a gneissic rock in the central portion of the area flanked to the west and east by a rock body intruded in places by more basic igneous rocks. This shows greater lithological details more than what can be inferred from the geo-electric section (Figure 7)

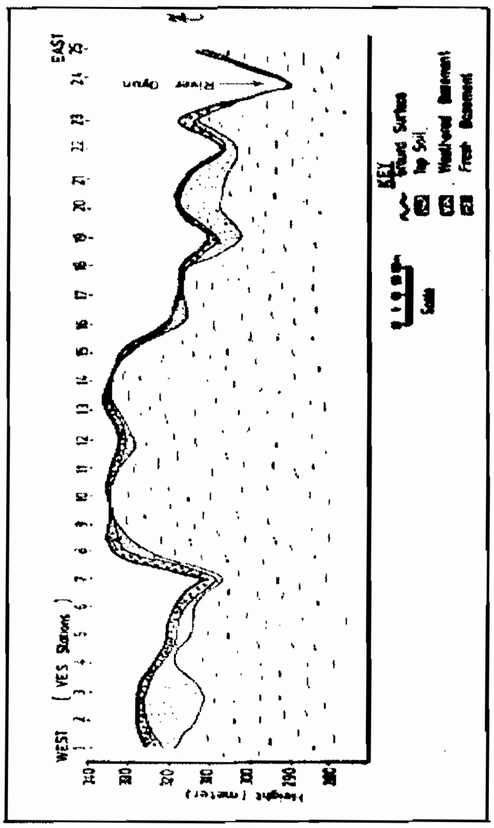

Figure 7. Geoelectrical section along E-W profile, East of Ilorin, Nigeria (After Nwankwo et. al., 2004)

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