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Groundmagnetic survey to investigate on the fault pattern of industrial estate Ogbomoso, Southwestern Nigeria

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ABSTRACT

Groundmagnetic method was used to investigate on the fault pattern of industrial estate Ogbomoso which falls within latitude 08^0 06$'$ 07.4$''$ and 08^0 06$'$ 25.4$''$ and longitude 004^0 15$'$ 03.3$''$ and 004^0 15$'$ 49.0$''$ Southwestern Nigeria, with a view to determining the competency of the basement. This is to know whether the basement will be competent enough to withstand the construction of the factories in the study area or not. A total of four traverses were established for the purpose of the groundmagnetic study, and the results were presented as groundmagnetic profiles of varying magnetic intensities. Result from first vertical derivative revealed that the intensities and characteristics nature of the magnetic anomalies as expressed by all profiles are indicative of the different rock types producing them. Qualitative and quantitative interpretation of individual magnetic anomaly and geological knowledge of the survey area yielded information on the depth of geological features (e.g. rock contact, faults or fractures), structures and magnetic properties of rock units. From the preliminary interpretation, the existence of some structural features such as a likely fault and relatively mineralized zones that might contain magnetic minerals of essential magnetite origin is revealed. It was also revealed that industrial estate Ogbomoso is averagely competent for engineering purpose.

Keywords: First Vertical Derivative, Fault, Magnetic Profiles, Fractures, Magnetic Anomaly, Factories.

INTRODUCTION

Collapses of buildings have become more intense and devastating in Nigeria today. Many buildings have collapsed because of the subsurface pattern, contrary to opinion which favours insufficiency or lack of genuine building materials. These happened as a result of little or no idea of the people about the subsurface pattern. If the factories are located on the fracture zones, the vibration of the heavy machines present in the factories will cause little but a very appreciable increment in the lateral extent of the fractures over a long period of time. As the fracture zone increases, there might be deformation in the foundation of the factory due to the continuous vibration of the heavy machines. That is the reason why factories should not be built on the fractured zone. It is therefore imperative to carry out geophysical survey before the building construction commences to avoid collapses which lead to loss of life and properties that are unquantifiable.

The purpose of magnetic survey is to locate rocks or minerals having unusual magnetic properties which reveal themselves as anomalies in the intensity of the earth's magnetic field [1]. It has been used extensively in basement mapping and subsurface geological structures such as rock contacts, rock boundaries, fractures and faulted zones [2, 3, 4, 5, 6, 7]. In the present study, First Vertical Derivative [8] was employed in the analysis of the groundmagnetic data obtained to delineate subsurface linear geologic structures which may lead to building collapse in the future if the factories are ignorantly built on faults or fractures zones. The first vertical derivative is an enhancement technique that sharpens up anomalies over bodies and tends to reduce anomaly complexity, allowing a clearer imaging of the causative structures [9, 10].

SITE DESCRIPTION AND GEOLOGICAL SETTING

The studied area lies within the crystalline Basement Complex of Nigeria [11]. It lies within latitude $08^0\ 06'\ 07.4''$ and $08^0\ 06'\ 25.4''$ and longitude $004^0\ 15'\ 03.3''$ and $004^0\ 15'\ 49.0''$ (Figure 1). The study area is located at the outskirt of Ogbomoso South Local Government and shares boundary with Surulere Local Government Area along old Oshogbo road. The study area is accessible with network of roads that surrounds it and very close to Aarada market.

The rock groups in the area include quartzites and gneisses [12]. Schistose quartzites with micaceous minerals alternating with quartzo-feldsparthic ones are also experienced in the area. The gneisses are the most dominant rock type. They occur as granite gneisses and banded gneisses with coarse to medium grained texture. Noticeable minerals include quartz, feldspar and biotite. Pegmatites are common as intrusive rocks occurring as joints and vein fillings [13, 14]. They are coarse grained and weathered easily in to clay and sand-sized particles, which serve as water-bearing horizon of the regolith. Structural features exhibited by these rocks are foliation, faults, joints and microfolds which have implications on basement pattern [14].

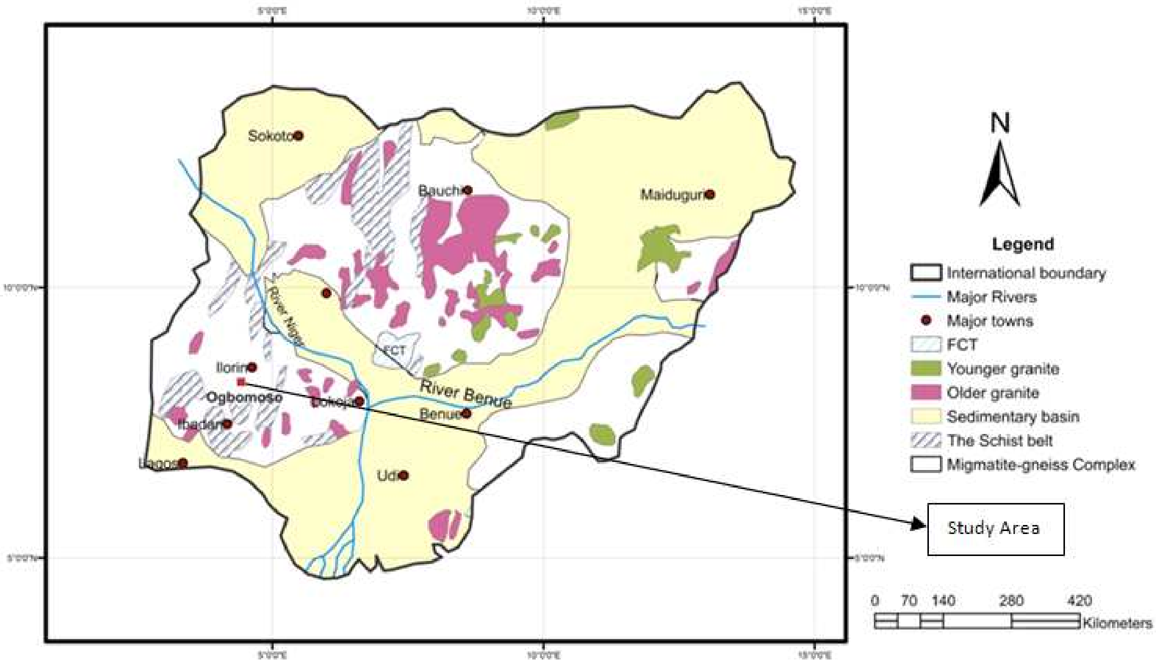

Figure 1: Geological map of Nigeria showing the study area. (Modified after Ajibade et al, 1988).

MATERIALS AND METHODS

The magnetic method was carried out in the month of May 2011 using the Proton Precision Magnetometer model GSM-19T along four traverses (figure 2) in East-West and North-South directions. The traverse lengths range from 220m to 520m with inter station spacing of 20m. A base station was carefully selected, where the magnetic intensities are being measured at a stationary point in order to check for the diurnal variations. The raw data was input into a personal computer (PC) to remove regional field from the Total Magnetic Intensities (TMI) recorded for each traverses using Signproc software [15]. In order to prepare the data for interpretation, the residual anomaly that has been separated from the regional field was further enhanced using first vertical derivative filtering technique [8].

The eventual magnetic data were presented as magnetic profiles by plotting the magnetic values against station separations for each traverse. Magnetic contour map (2D plot) and surface map (3D plot) of First Vertical Derivative were also constructed for more qualitative interpretation using Surfer 8 software [16]. The quantitative interpretation involved the use of half-width of the amplitude method for the estimation of overburden thickness to the causative bodies [2, 3].

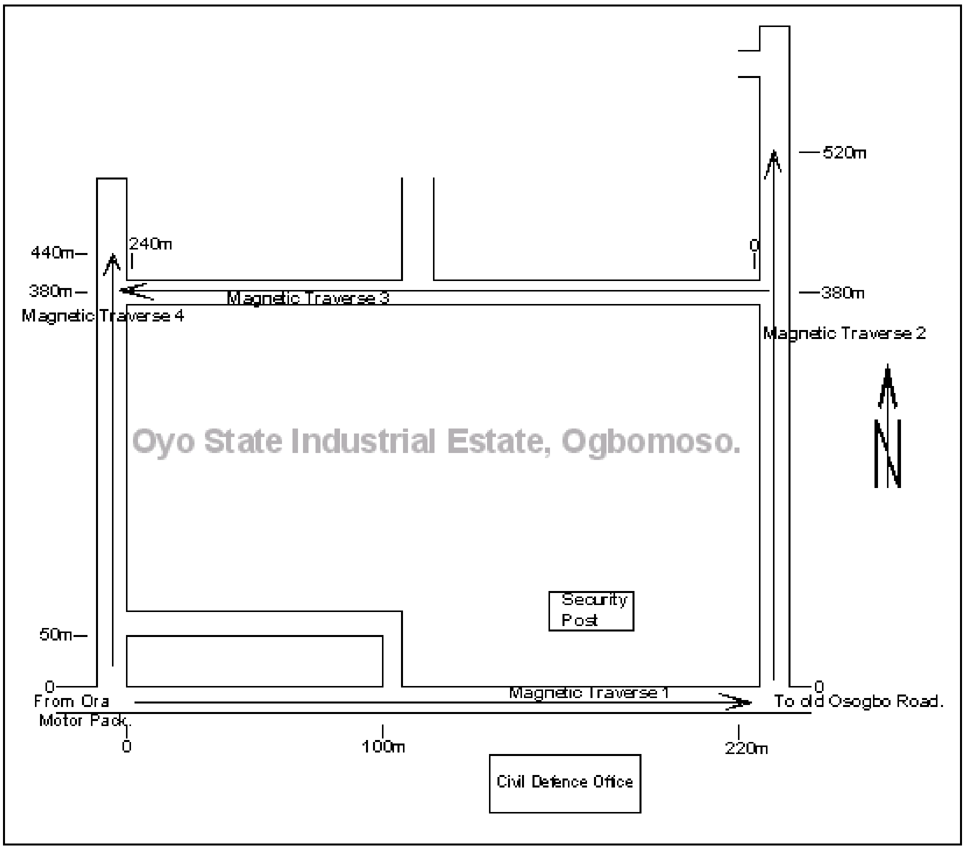

Figure 2: Layout map of groundmagnetic survey.

RESULTS AND DISCUSSION

The results of the analysis of the groundmagnetic data from the study area were discussed in terms of qualitative and quantitative interpretations. The quantitative interpretation involves the estimation of depths to the causative bodies and is as shown in Table 1. It indicates varied basement topography with depth ranging from 5.0m to 20.0m. Thickness of this kind can averagely be advantageous for engineering purposes because competent rocks are close to the surface. Areas with fairly thick overburden can be excavated before the construction of factories begins. The qualitative interpretation involves interpretation of the magnetic profiles, magnetic contour map and magnetic surface map.

QUALITATIVE INTERPRETATION

Magnetic Profiles

Traverse 1

The traverse covers a total length of 220m (figure 3a) and trends in West to East direction. The station positions 40 to 60, 100 to 110, and 170 to 180 metres shows a significantly low values which are indicative of faults or fractures. Heavy machines must not be installed in the factories that will be built on these zones because of vibration which might lead to building collapse in the future. However, artificial basement must be created before laying of foundations at these regions [17].

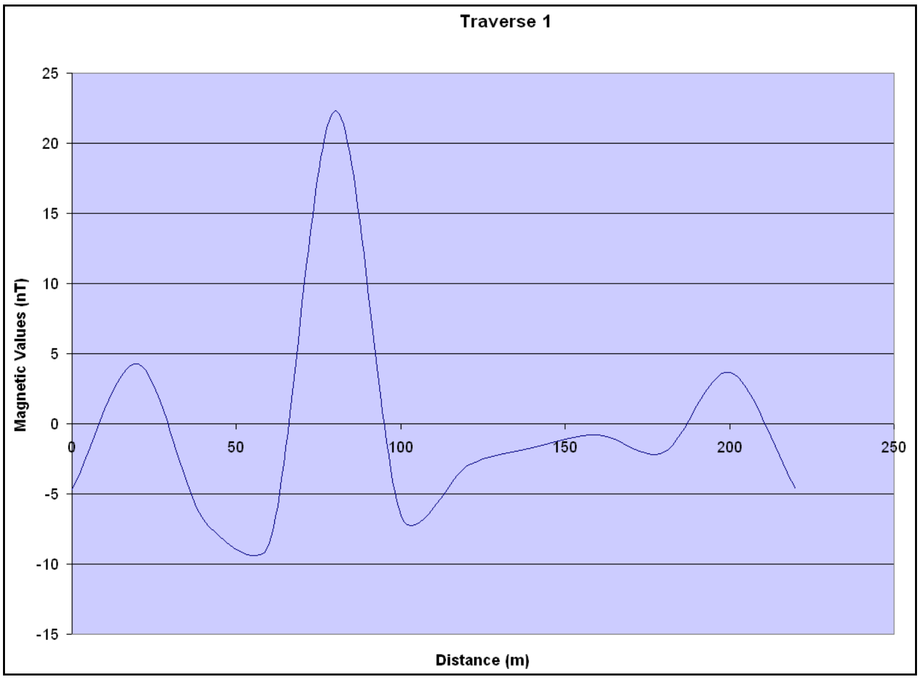

Figure 3a: Magnetic profile along traverse 1.

Traverse 2

The traverse covers a total length of 520m (figure 3b) and trends in South to North direction. The traverse shows relatively low magnetic values at stations position 20, 100, 120 to 180, 220, 250 to 300, 340 to 380, 415 and 465 metres and these are interpreted as faults or fractures. Heavy machines should not be installed in the factories that will be built on these zones to avoid vibration which might lead to building collapse in the future. However, artificial basement must be created before laying of foundations at these region [17].

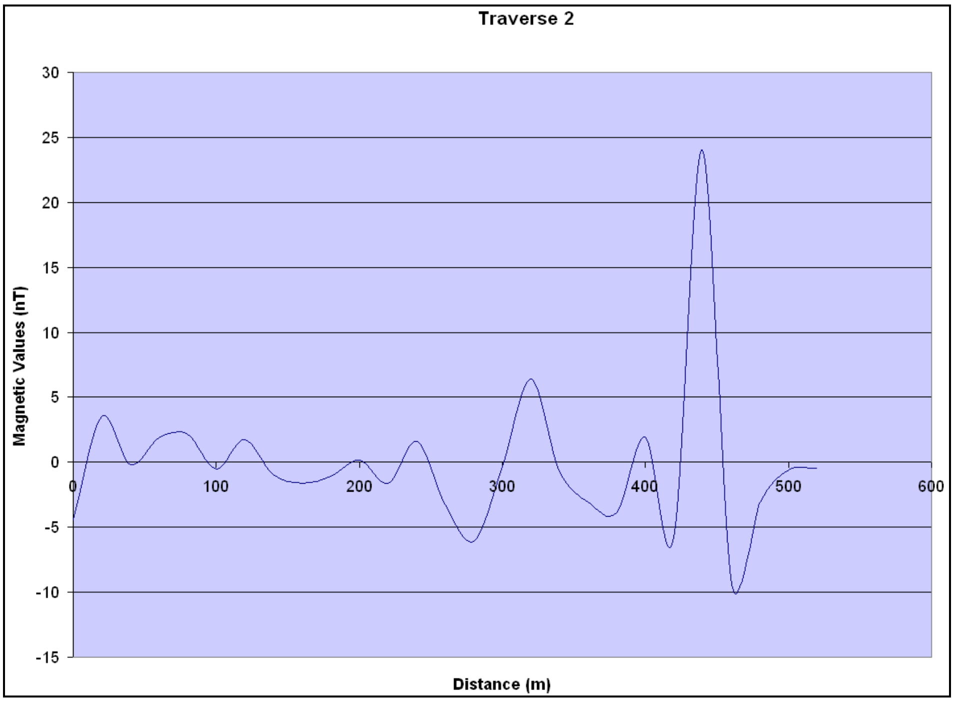

Figure 3b: Magnetic profile along traverse 2.

Traverse 3

The traverse covers a total length of 240m (figure 3c) and trends in East to West direction. Low magnetic values with a bowl-shape are experienced at station 50 to 90 metres. Also, relatively low magnetic values occur at station

140 and 200 metres. These are again interpreted as faults or fractures. Another interesting feature on this traverse is the inflection point at the beginning of the traverse which could be interpreted as contact between two rocks in the area. Again, heavy machines should be avoided in the factories that will be built on these zones.

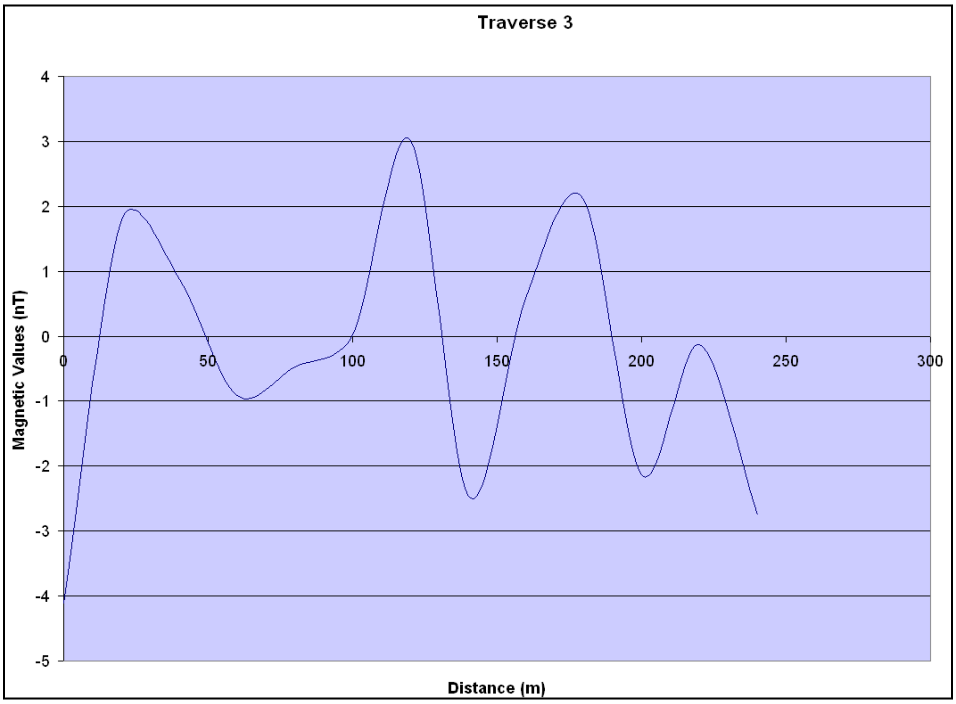

Figure 3c: Magnetic profile along traverse 3.

Traverse 4

The traverse covers a total length of 440m (figure 3d) and trends in South to North direction. this traverse shows series of magnetic low values at station 20, 100, 150, 200 265, 310 360 and 420 meters and these are interpreted as faults or fractures. Artificial basement must be created before laying of foundations at these regions [17] to avoid subsidence that might lead to loss of life and properties that are unquantifiable in the future.

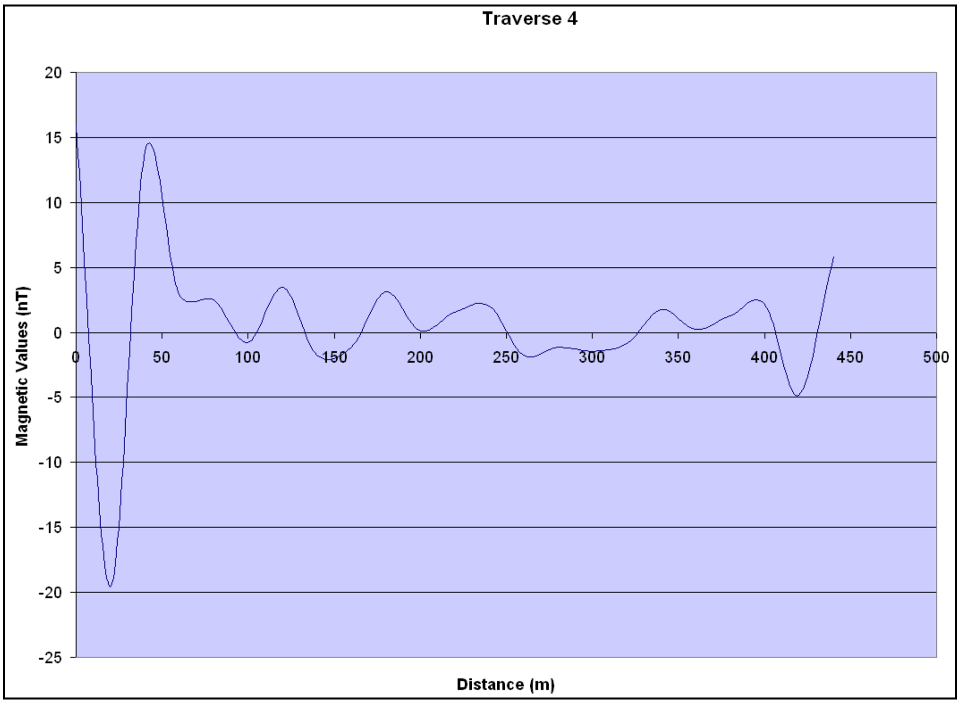

Figure 3d: Magnetic profile along traverse 4.

Magnetic Contour (2D) Map

The magnetic contour map constructed using first vertical derivative data generated from the magnetic values for the study area is as shown in figure 4. The constructed coloured map showed a decrease in magnetic value between -18nT to -8nT (Neon Red Colour) and between -6nT to -2nT (Deep Rose Colour). The lowest magnetic values are perhaps the deepest fracture or fault. From the contour map, deepest fracture or fault are not widely distributed in this study area. It only appears like a hole at the tip of Southwestern and towards the peak of Northeastern region of the study area. However, areas with magnetic values ranging from -6nT to -2nT could be interpreted as a broad sited basement that are far from the surface. Artificial basement are needed to be created before the laying of foundation of factories commence in these zones [17]. Heavy machines must not be installed in the factories that will be built on these zones to avoid subsidence that might occur in the future which might lead to loss of life and properties. The other positive magnetic values observed are due to the presence of near-surface magnetic minerals especially of magnetite origin.

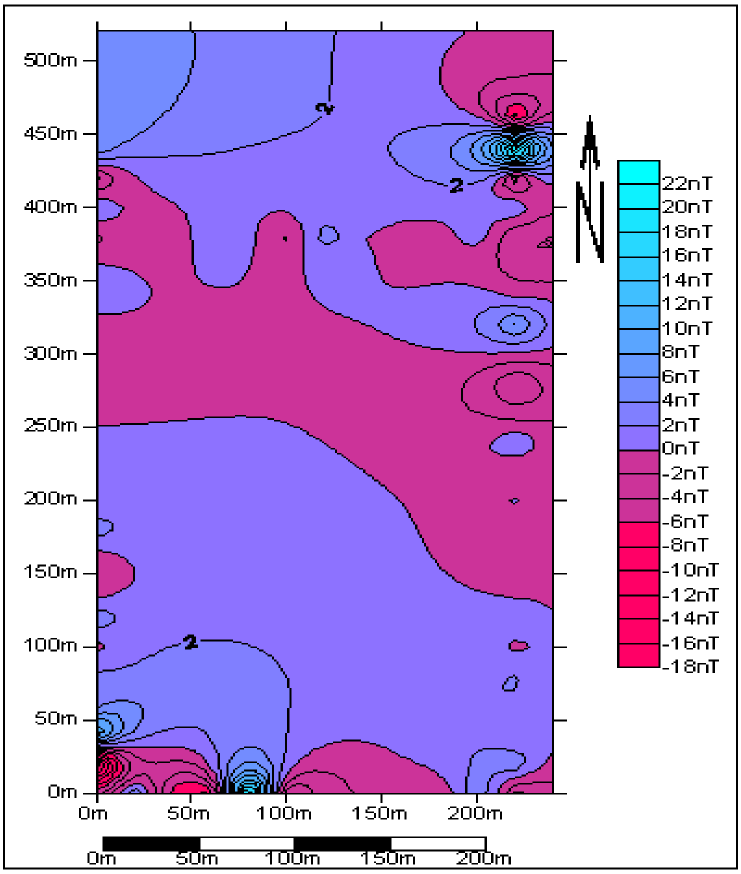

Figure 4: The contoured map (2D plot).

Magnetic Surface (3D) Map

This is the 3D map of the subsurface in order to understand the interpretation of the magnetic contour (2D) map very well. The magnetic 3-D surface map indicates the levels or magnitude of the magnetic contrast as shown through the colour and the colour code bar (figure 5). The colour difference shows the same trend as that of the 2-D contour map and the magnetic values shows a significant magnetic contrast which defines the level of magnetization in the study area.

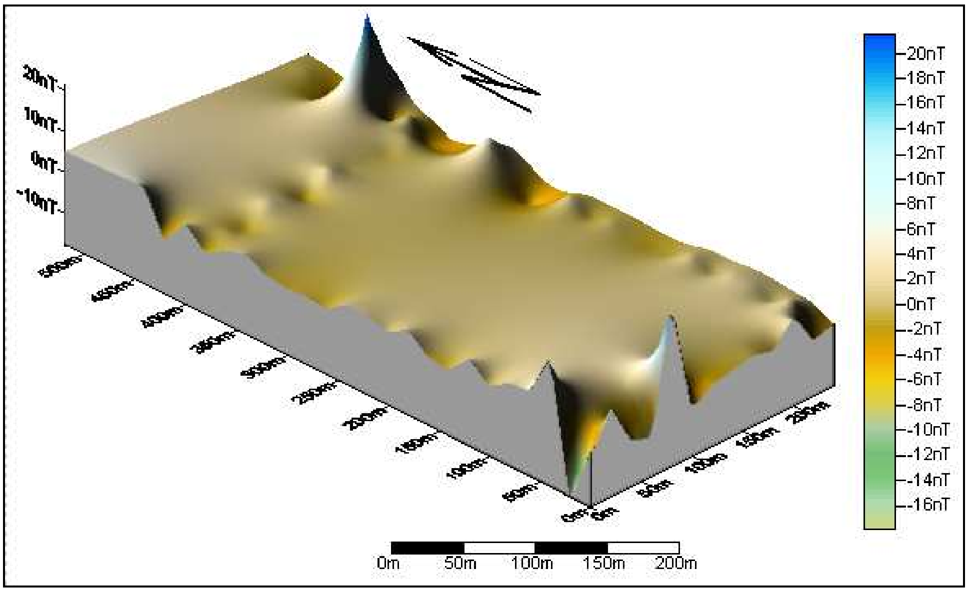

Figure 5: The surface map (3D plot).

QUATITATIVE INTERPRETATION

The positive magnetic values observed across some station points along the four traverses are probably due to some near-surface magnetic minerals (magnetite). The quantitative interpretation involved the use of half-width of the amplitude method for the estimation of overburden thickness [2, 3]. The estimated magnetic depths to the basement along each traverse were determine and presented in table 1.

Table 1: Depth estimates of groundmagnetic traverses relative to the ground surface from Industrial Estate, Ogbomoso using Half-Width of the amplitude method.

Traverses	Depth to the magnetic sources (m)							
	A	B	C	D	E	F	G	H
Traverse 1	11.5	10.5	12.5					
Traverse 2	8.5	20	10	12.5	10	20	11	10
Traverse 3	15	15.5	16.5	10				
Traverse 4	10	5	10	15	9	11.5		

CONCLUSION

The groundmagnetic data from industrial estate Ogbomoso southwestern Nigeria has been analyzed using first vertical derivative. First vertical derivative has proved to be a versatile enhancement technique and a fast tool for delineating buried faults. The study revealed a network of geologic features along the traverses which are associated with faults and fractures. Also, near-surface magnetic minerals were suspected from the traverses. It can be concluded that the industrial estate Ogbomoso is averagely competent for construction of factories. However, quark building contractors should not be consulted when planning to construct factories in the study area. It is recommended that other geophysical methods be used in the study area to confirm the predictions in this work. Also, other enhancement techniques like Analytic Signal, Power Spectrum, Horizontal Derivative and so on should be used in the interpretation of the data in the study area to confirm the competency of the basement.

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