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Ground Magnetic Survey for the Investigation of Mineral Deposit at Itesi Village in Orile Ilugun, Odeda , South West Nigeria

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ABSTRACT

Advances in technique development and data interpretation have greatly improved our ability to visualize the subsurface. A Magnetic survey was carried out at a site in Itesi village, Ilugun, Odeda Local Government Area of Ogun State, Nigeria using a portable proton precession magnetometer (G-856 AX). A total of ten profiles were established in an E-W direction in the study area. The acquired magnetic field data were corrected for drift. Qualitative and quantitative interpretations were adopted to obtain negative peak value and the maximum positive peak value. The depth to top of basement rock was estimated using Peter's Half slope. Likewise the depth to centre of basement rock was estimated using the Half width rule. The contour maps, 3-D surface map and the 1-grid vector map present the subsurface image.

The whole survey area has a total length of 100 m at a line spacing of 10 m and a breadth of 45 m at 5 m spacing. The whole area was characterized by complete varying negative amplitudes from a very low peak value of about -9.9 nT and a maximum positive peak value of about 17.4 nT respectively. The closely spaced, linear sub-parallel orientations of contours from the South western part of the map suggest the possibility of faults or local fractured zones.

Key Words: Magnetic Anomaly, Magnetic survey, Proton magnetometer, Fractured zone

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INTRODUCTION

The magnetic method is a geophysical technique that measures variations in the earth's magnetic field to determine the location of subsurface features. This non destructive technique has numerous applications in engineering and environmental studies, including the location of voids, near-surface faults, igneous dikes, and buried ferromagnetic objects like storage drums, pipes etc.(Weymouth, 1985). Magnetic field variations can be interpreted to determine an anomaly's depth, geometry and magnetic susceptibility. Magnetic data, measured in gammas and either collected as total field or gradient measurements are collected in a grid or along a profile with stations spacing between 1 and 10 meters. The immediate purpose of magnetic surveys is to detect rocks or minerals possessing unusual magnetic properties which reveal themselves by causing disturbances or anomalies in the intensity of the Earth's magnetic field.

In recent years, geophysical methods have been employed in various applications. These include engineering applications such as assessment of road failure, pipe leakages, ground-water contamination and assessment of construction sites for dams and bridges (Musset and Khan, 2000). Because of the nature of the random test-pitting method generally employed by archaeologists which is both tedious and inaccurate, the need has arisen for the introduction of better techniques which could help in the location of these materials (Audah and Okpoko 1994; Gibson, 1986).

Other similar research works carried out in Nigeria include the Structural trends of Ijeda-Iloko area, Horizontal Component of ground magnetic study of Ijebu-jesa area, Geophysical investigation of some flood prone areas in Ota, Vertical components of the ground magnetic study of Ijebu-jesa, Ground Magnetic Data Interpretation of Ijebu-Jesa Area, all in the Southwestern Nigeria were carried out with the use of the proton Precession magnetometer (Kayode, 2006; Kayode, 2009). Previous studies have also shown that this region is underlain by precambrian rocks typical of the basement complex of Nigeria (Rahaman, 1976, Kogbe, 1976). The main rock types found in the region are amphibolites complex, schist, quartzite and quartz schist (Kayode, 2006; Ajayi, 2003,; Folami, 1992; Folami, 1991; Ajayi, 1981a; Elueze, 1986; Kayode, 2009; Kayode, 2010).

In further search for magnetic minerals in Southwest Nigeria, a ground magnetic survey carried out in Orile Ilugun, shows that the depth to center and top of magnetic bodies are shallow and exhibit positive and negative magnetic susceptibilities indicating that paramagnetic and diamagnetic minerals are present.

In this study, magnetic survey method has been used in the search for iron ore materials. It aims at locating the position and approximate depth of burial of these iron ore minerals using the magnetic survey method.

GEOLOGY OF THE STUDY AREA

The study area (Itesi Village, Ilugun, Ogun State) is located within Latitude N 7° 40377' to N 7° 40457' and Longitude E 3° 65514' to E 3° 65603'with elevation varying between 250 m and 310 m and lies within the basement complex of South western Nigeria, which is characterized by migmatite gneiss (Elueze, 1986 and Kayode, 2009). The local geological mapping of the study area revealed that the area is underlain mainly by a rock unit, granite gneiss. The rocks are concealed in most areas and some outcrops are exposed around the study area. It is therefore suspected that the overburden is relatively thin within the study area. The rocks are generally trending in Northwest-Southeast direction and dipping to the west. All the exposed outcrops observed have low fractures, indicating minor evidence of deformation. The megascopic minerals observed in this rock type include quartz, feldspar and biotite. (Rahaman, 1976).

MATERIALS AND METHODS

In this work, Magnetic measurements were carried out using the portable proton precession magnetometer (G-865 AX). The Global Positioning System was used to measure the Longitude, Latitude and elevation along the profiles. A total of ten magnetic profiles were taken across the study area in an E-W direction. After which the magnetic data were corrected for the effect of drift and regional magnetic variations of the study area. The corrected magnetic data were then plotted against distance to obtain magnetic profile as well as against the Longitude and Latitude to obtain the contour map of 3D, image maps, 1- grid vector maps of the whole survey area. The magnetic profiles plots were interpreted using the Half-Slope method and the Half-Width rules to determine the approximate depth to the top of the buried body and depth to the center of the buried magnetic body of the survey area respectively. The points on table 1 and 2 represent peaks on the magnetic anomaly profile graphs.

THE PETER'S HALF-SLOPE AND HALF WIDTH METHODS

The depth estimation of buried magnetic body to the top of the basement rocks can be calculated by the use of Peter's Rule called Half-Slope method. This illustration can be found in the figure 3.3 and the following steps were applied to determine the depth to top, after data correction using trend analysis are illustrated below:

Find the maximum slope of the anomaly for each profile and using a right-angled triangle construction. Construct two lines with the slope which is equal to half the maximum slope and tangential to the curve and ;Measure the horizontal separation between the two points of tangent d is a measure of the depth to the magnetic body.

Therefore the estimation of the depth of magnetic anomaly is based on the slope of the curve created by the anomaly in a profile data (Davis, 1973). The depth of an anomaly is related to the horizontal extent of tangent to the maximum slope such that: $d = K S$where: d is the depth, S is the horizontal extent of the tangent and $1.67 \leq K \leq 2.0$

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Note: S = 1.2 d if body is very thin

S = 2.0 d if body is very thick

S = 1.6 d halfway thickness (which was taken)

Where d = depth to the top of buried body

Another basic concept of the slope method is to approximate the anomaly curve using a straight line whose slope is the maximum slope of the anomaly (see figure 3.3). According to Sheriff, R.E., Peter's Rule is less subjective than the maximum slope method. The approach is to determine two points; points at which lines with half the maximum slope are tangent to the magnetic profile. Then, if we divide the horizontal distance by an "index value" of 1.2 to 2.0, we obtain an estimate for the depth to the body. Note that this index value increases with the width to depth ratios for the causative body.

In general, it can be said that the depth of investigation is a function of the target size and shape; for near surface investigations, depth of investigation varies from 0 to 55 m depending on the quantity (i.e. size) of the buried source. A gradiometer will read much closer to surface, say, up to 5 to 10 m for a large source (ex. ton of iron). Generally, near surface gradiometer anomalies will have depths from 0 to 3m (i.e. assuming relatively small magnetic bodies). Moreover, it is important to note that there is also typically information from deeper sources in the data as evidenced by longer wavelength anomalies. The corresponding sources can be from several hundred meters to 1000 m or more, depending, as indicated before, on the "size" of the buried object or geologic horizon (Gibson, 1986).

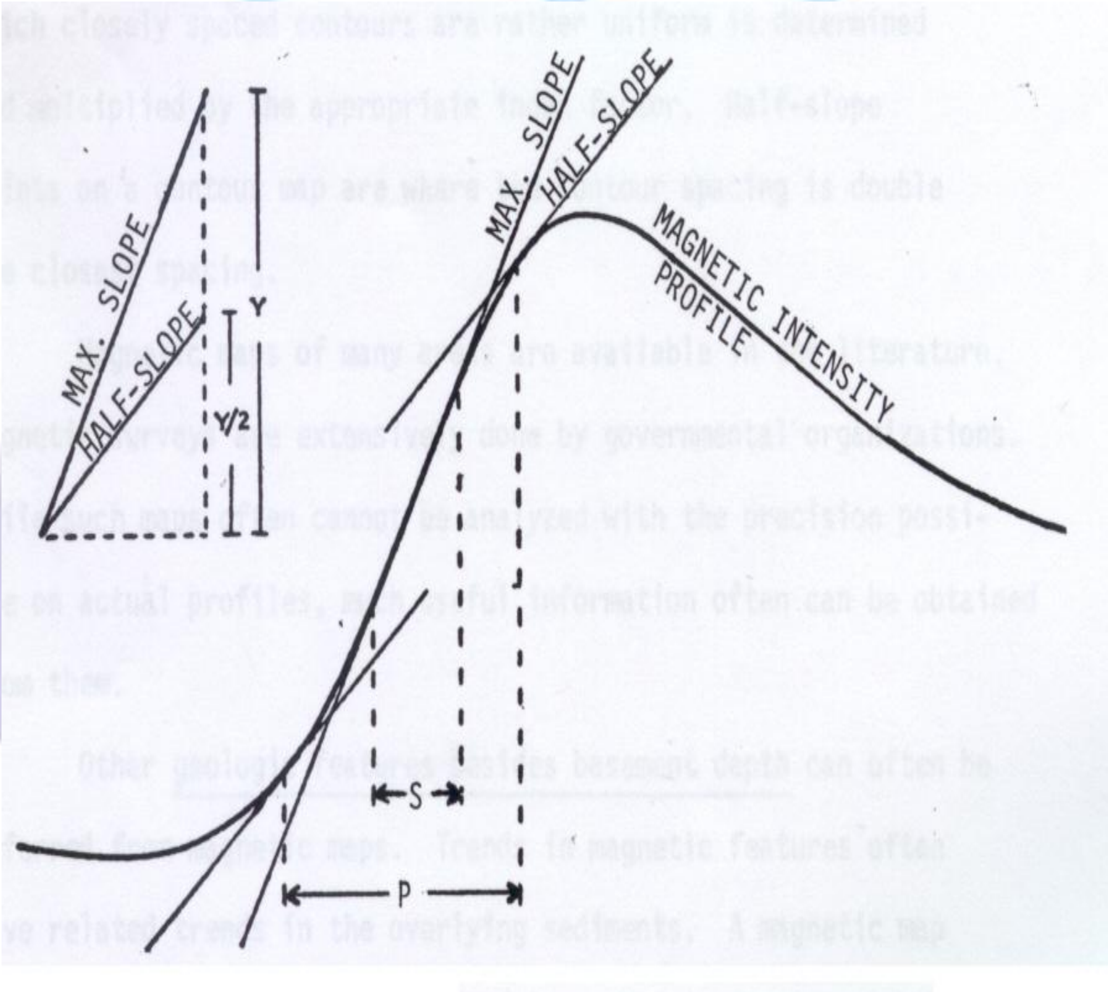

Figure 3.3: Derivation of values for Half-Slope and Peter's Methods (Sheriff, 1978)

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THE HALF WIDTH PROOCEDURES:

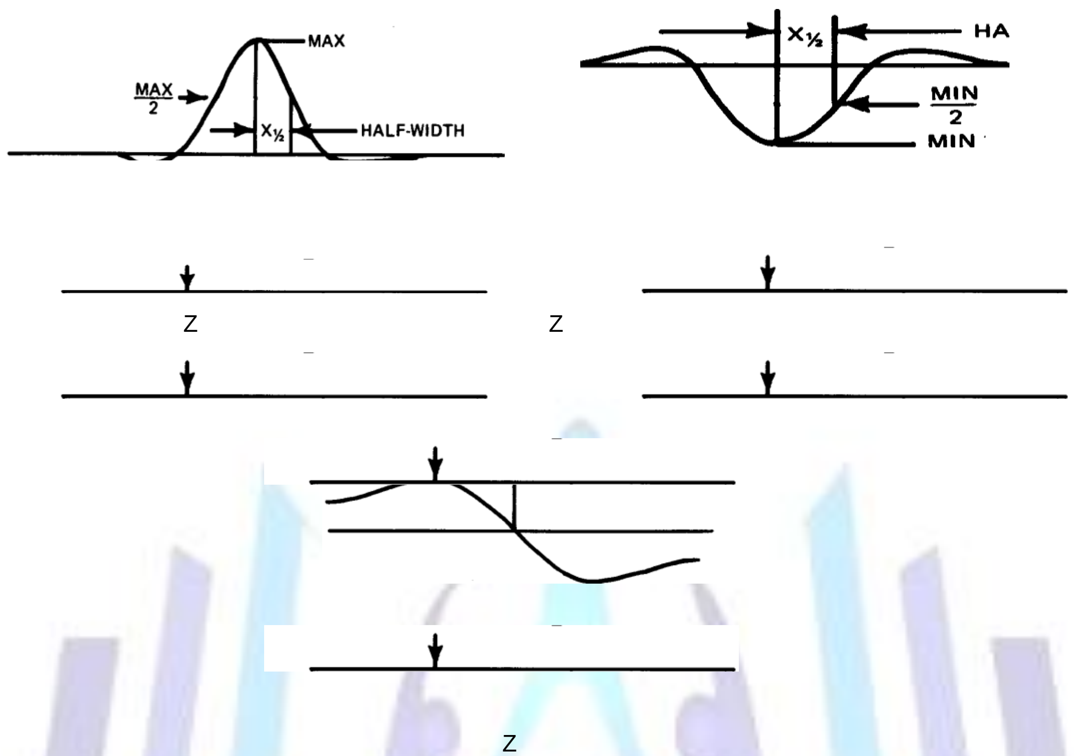

Figure 3.4: Half-Width Rules and slope Method for Depth Estimation

Where:

Sphere (Dipole)	Z = 2 X1/2
Vertical Cylinder (Monopole)	Z = 1.3 X1/2
Edge of Narrow Dike	Z = X1/2
(Line of Monopoles)	
Horizontal cylinder	Z = 2 X1/2
(Line of Dipoles)	

Z = the depth to the centre of the anomaly source.

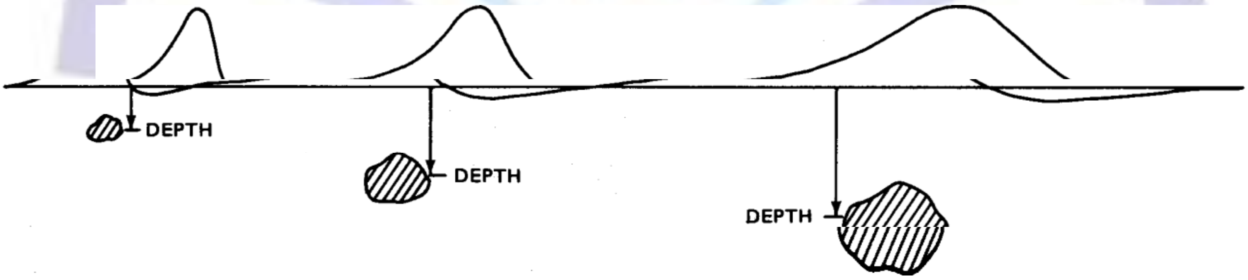

Figure 3.5: Effect of Depth on Anomaly Width and Depth/Amplitude Behaviour of Anomalies

Source: Grant, F. S and West, G.F., Interpretation Theory in Applied Geophysics, 1965

RESULTS AND DISCUSSION

The individual profile interpretation shows variable anomalies which is an indication of susceptibility contrast of the rock types. The individual profiles were also interpreted for depth to the top of geological structure such as fractures, faults, and dykes that may be hosts to the minerals (see tables 1 and 2).A visual inspection of the whole area map (figure 1 - 3) shows that the contour lines of the North eastern and South eastern part of the map are widely spaced indicating that the depth and to the magnetic basement in these areas are relatively high and also has high magnetic intensities. Whereas at the south western portion of the map, the contour lines are closely spaced indicating that the depth to magnetic basement in those areas are shallow. The closely spaced, linear sub-parallel orientations of contours from the south western part of the map suggest the possibility of faults or local fractured zones.On the basis of the variation in magnetic intensity across the survey area, there appear a general increase in magnetic intensity from lower western part towards the north eastern part, this indicates the presence of iron bodies with high susceptibility. This is also supported from the 1-grid vector map in figure 3, the direction exhibits almost the four kinds of magnetic interaction i.e paramagnetic, ferromagnetic, ferrimagnetic and diamagnetic. If the susceptibility, is small and positive, the material is said to be paramagnetic and when negative, diamagnetic. Both ferromagnetic and ferrimagnetic susceptibility are also a function of the magnetic field intensity in which they are measured. Five profiles exhibit negative susceptibilities while the other five is positive (diamagnetic and paramagnetic in nature).

Kearey and Brooks (2002) observed that zones of low magnetic intensity correspond to sedimentary rocks, those of intermediate intensity are associated with igneous rock. Zones of high magnetic intensity are characterized by rocks such as volcanic, peridotite and serpentnite. The whole area is characterized by complete varying negative amplitudes from a very low peak value of about -9.9 nT and a maximum positive peaks value of about 17.4 nT respectively.

CONCLUSION

The ground magnetic study of this area (Itesi village, Ilugun,Ogun State) has helped to reveal that the area is underlain by magnetic minerals at low depths, delineate lineament and target zones depicted by the point of the peak of the anomalies in each of the profile collected. The study also revealed the lithological units in basement structure such as bedrocks, topography, bedrock depression, rock boundaries, contact zones and fractures/faults which serves as deposit centers for mineral resources. The depth to the magnetic basement in each profile was obtained using slope method which gives values between 6 m and 22 m. These values are not real depths but approximate ones. The linear nature of the anomalies in this area support the report that rocks are bounded and offset by fractures/faults which serves as deposit centre for mineral resources.

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Table 1: Depth to center of anomaly body or source in each profile using the half-width rules

	Point 1	Point 2	Point 3	Point 4	Point 5
Profile 1	8 m	16 m	15 m	-	-
Profile 2	12 m	7.5 m	12 m	10 m	10 m
Profile 3	12 m	12 m	15 m	-	-
Profile 4	18 m	20 m	-	-	-
Profile 5	12 m	16 m	-	-	-
Profile 6	10 m	22 m	-	-	-
Profile 7	10 m	-	-	-	-
Profile 8	10 m	16 m	-	-	-
Profile 9	8 m	10 m	16 m	-	-
Profile 10	6 m	12.5 m	-	-	-

Table 2: Depth to top of anomaly body or source in each profile using the Peter's Half-Slope Methods

	Point 1	Point 2	Point 3	Point 4
Profile 1	5 m	3.125 m	3.125 m	-
Profile 2	1.875 m	2.5 m	2.5 m	2.5 m
Profile 3	5 m	2.5 m	3.125 m	-
Profile 4	4.375 m	3.75 m	-	-
Profile 5	1.25 m	2.5 m	-	-
Profile 6	3.75 m	2.5 m	-	-
Profile 7	2.5 m	-	-	-
Profile 8	5.625 m	-	-	-
Profile 9	1.875 m	3.125 m	-	-
Profile 10	1.25 m	1.25 m	-	-

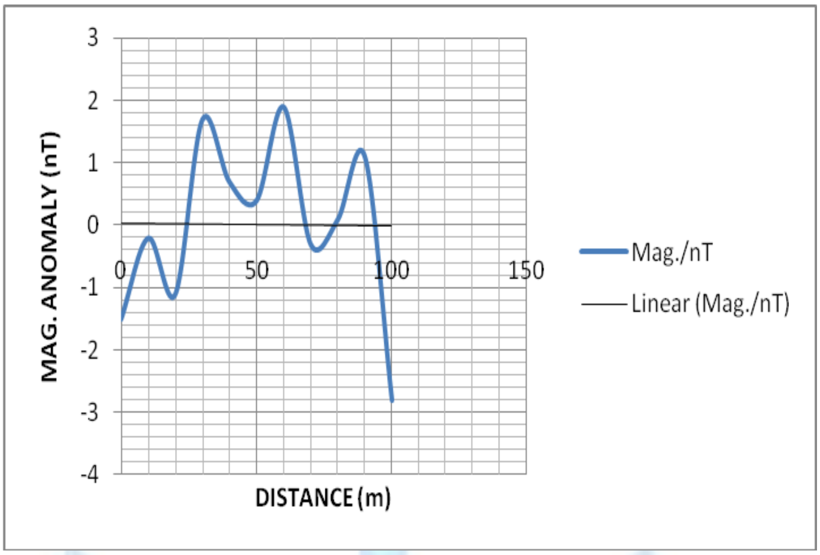


Figure 4.1c: Corrected magnetic Field Plot for Profile 2

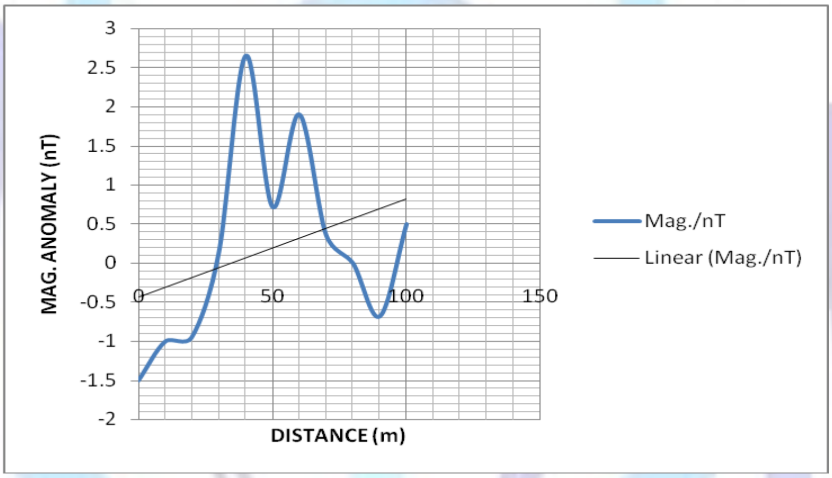
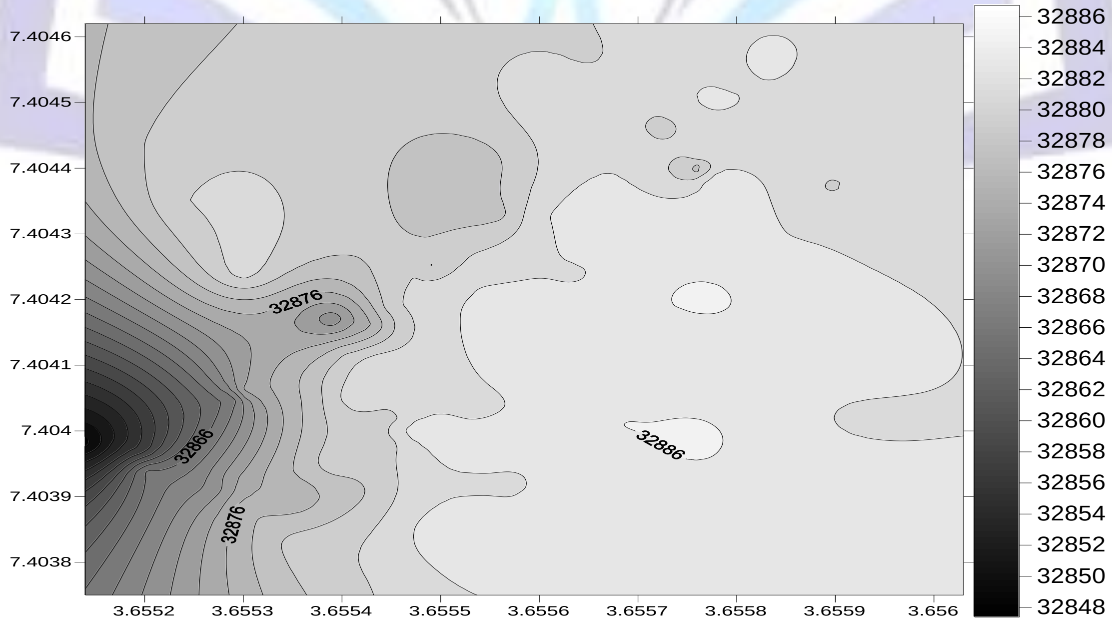


Figure 4.1d: Corrected magnetic Field Plot for Profile 3

Latitude



Longitude Figure 1 : CONTOUR MAP OF THE STUDIED AREA

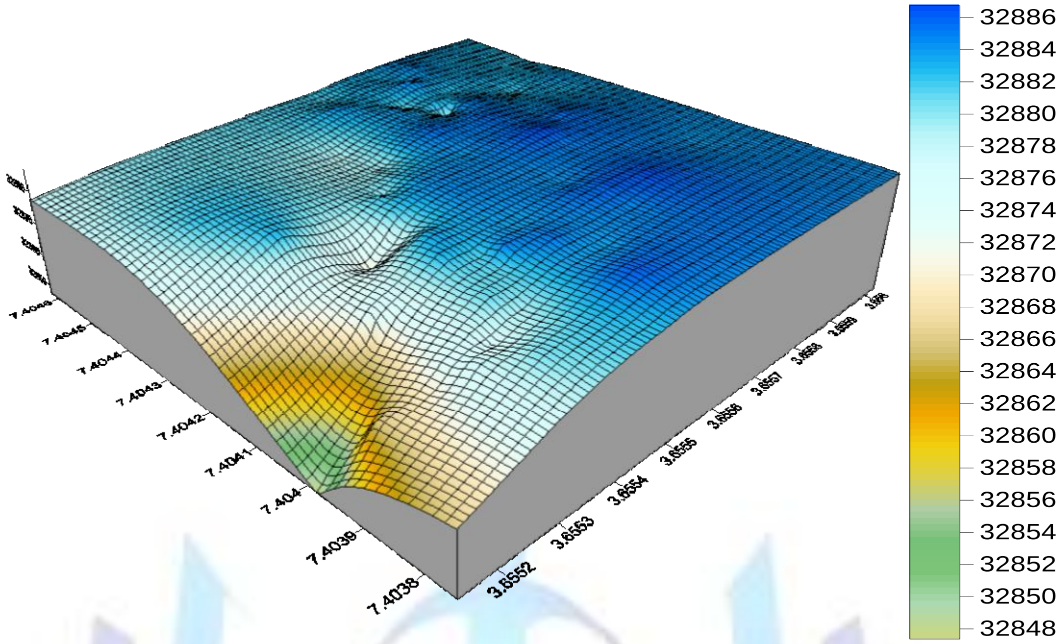


Figure 2: 3-D SURFACE MAP OF THE STUDIED AREA

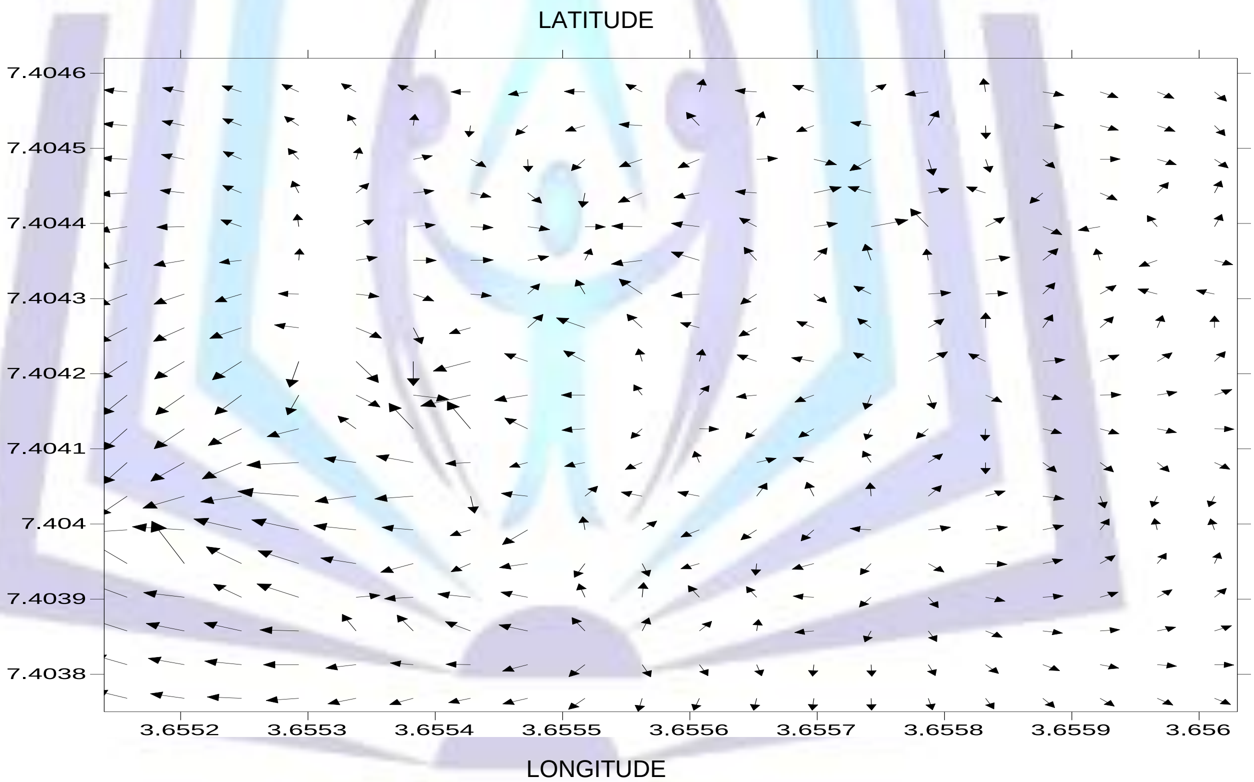


Figure 3: 1-GRID VECTOR MAP OF WHOLE AREA