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CONTENTS

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BRIEF INTRODUCTION

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Geophysical Evaluation of Gold Occurrence in Part of Bishini Sheet 165 SWKafin – Koro Northwestern Nigeria

Abdullahi Suleiman[1, *], Alabi Adekola Amos[2]

[1]Department of Geology, Federal University of Technology, Minna Niger State, Nigeria

[2]Department of Geology, School of Mining and Geology, University Rwanda, Kigali, Rwanda

Email address

absuleiman@futminna.edu.ng (A. Suleiman), alabiadekola@futminna.edu.ng (A. A. Amos)

[*]Corresponding author

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Abstract

The distribution of gold mineralization in the Nigeria Basement Complex is favored by different geologic orogenic episodes that deposit gold in a structurally control quartz veins. The principal physical properties that have been the focus of geophysical exploration methods are: density, magnetization (induced and remnant), conductivity, chargeability, radioactivity and seismic velocity. Sometimes the desire mineralized target has physical properties that permits direct discovery, while others by virtue of the physical properties of association with other minerals that permit indirect method. The geology of the study area is a typical geology of Kusheriki – Minna region, comprising of crystalline rocks that have been divided into three groups like that of the Nigeria basement complex, namely; gneisses and migmatite, schist belts composed of medium-to low grade supracrustal cover, and intrusive granitic rocks. Magnetic methods was used in the survey as an indirect approach to map the linear structural features like veins, fractures and contacts which act as conduits and host gold mineralization, also electrical imagining geophysical survey involving Induced polarization (IP) and resistivity methods was carried in a potential gold mineralized zone within the area to complement the other methods. Magnetic survey measurements were taken with GSM-19v7.0 Over Hauser Instrument manufactured by GEM SYSTEMS. Also, IP and resistivity imaging survey was carried out simultaneously with Geomative GD-10 Supreme 2D Geoelectrical system. The residual magnetic field intensity map generally shows major NE/SW and N/S trending. IP survey revealed that most of the magnetic anomalies investigated are chargeable and that their chargeability increases with depth.

Keywords

Gold Mineralization, Basement Complex, Magnetic Survey, Induced Polarization

1. Introduction

The application of geophysical exploration for mineral resources is dependent primarily on a single factor, namely the resource and/or its hosting geological environment associated with physical or chemical properties that differ significantly from those of the adjacent crust. Historically, the principal physical properties that have been the focus of geophysical exploration methods are: density, magnetization (induced and remnant), conductivity, chargeability, radioactivity and seismic velocity. Sometimes the desired commodity or mineralized target has a physical property (or properties) that permits direct discovery, for example lead-zinc deposits (galena-sphalerite) have large densities that may be detected directly by a gravity survey. On the other hand, many base metal deposits are discovered by virtue of the physical properties of association with other minerals that permit indirect method.

The great potential of geophysical method in exploration for ore mineral deposits is presently unrealized [5][4]. Some of the reason is that many geophysical techniques have been developed for petroleum exploration and have not been focused on solid minerals or somewhat gold deposits. Also, technically; gold deposits are commonly small, thus requiring resolution that is not commonly available with many geophysical tools. This study is carried out with the purpose of identifying and delineating anomalous area (s) for gold mineralization potential in Kaffin- Koro area (Figure 1) through the identification of structural, lithological, geophysical and topographic features.

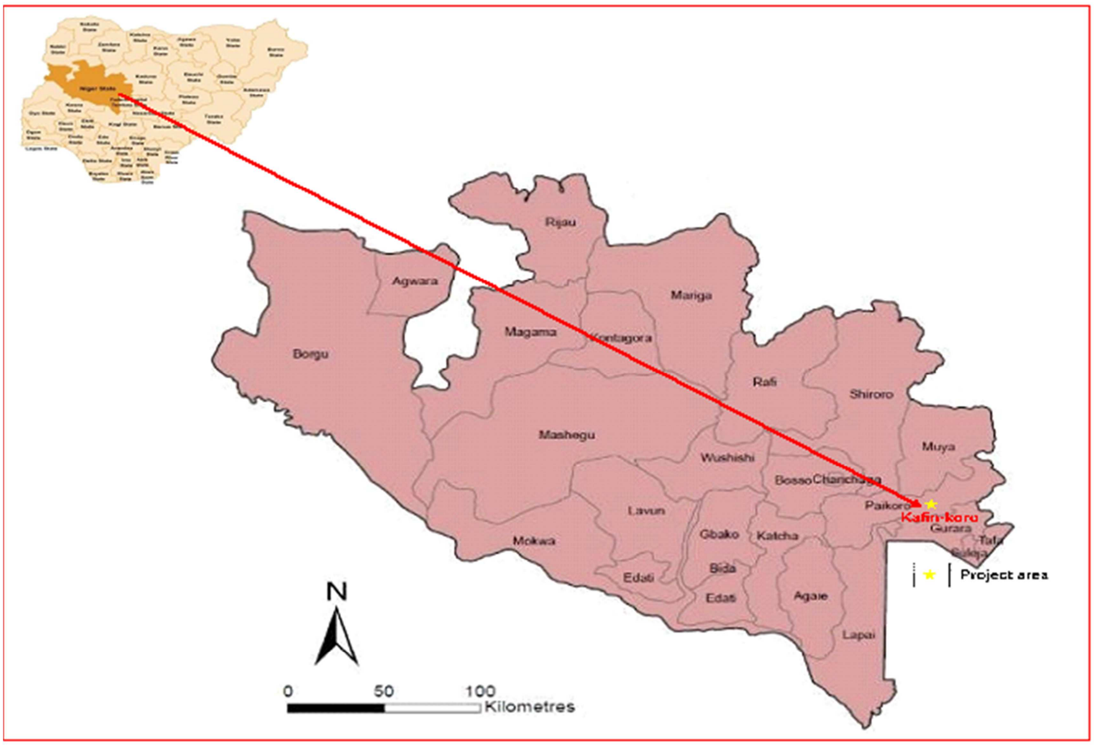


Figure 1. *Location of the study arae within Map of Nigeria and Niger state.*

2. Geology of the Study Area

The geology of the area of investigation (Kafin-Koro) is a typical geology of Kusheriki – Minna region, comprising of crystalline rocks that have been divided into three groups like that of the Nigeria basement complex, namely;

(1) Basement unit comprising gneisses and migmatite with relicts of supracrustal rocks.

(2) North-south trending schist belts composed of medium-to low grade supracrustal cover.

(3) Intrusive granitic rocks (Older Granite Suite) which intrude both the gneiss, migmatite and the low grade schist belt.

Three schist belts have been mapped in Kusheriki – Minna region [1]. These belts include Kushaka, Birnin Gwari and Ushama schist belts, and are of typical of the geology of northwest schist belt of Nigeria.

The Kushaka schist belt is well exposed in the south-eastern region of Minna (which extended to Kaffin-koro area) and intruded by the large volume of granitic rocks. These intrusions fragmented the belt in to small bodies of rock masses mainly made up of granite and granodiorites. The migmatization of Kushaka schist belt is as a result of emplacement of the granitic rocks by Pan-Africa orogeny. The schist belt is deeply weathered in some locations and displayed intense shearing in other places.

Part of theKushaka schist belt that constitute the adjoining basement rocks to the project area was reported to consist of micaceous schist, phyllite, quartzite, muscovite quartzite and ferruginous quartzite of which the ferruginous quartzite is composed of thin bands of iron oxide, mostly magnetite with a little haematite alternating with less iron-rich quartzite by [9] and [3]. Rocks in part Paiko Sheet 185 NW that constitute western part of the project area was classified into porphyritic biotite granite, tonalite and granodiorite [2]. Two generation of NE and NNE structural trend hosting gold mineralization within the quartz vein of the Kusheriki schist formation was mapped and delineated [10].

3. Materials and Method

Magnetic method was used in the survey as an indirect approach to map the linear structural features like veins, fractures and contacts which act as conduits and host for ores. In addition to the magnetic method, Electrical imagining geophysical survey involving Induced polarization (IP) and resistivity methods was carried in a potential mineralized zone within the area to complement other methods. Combination of these methods has proved overtimes to be very useful in delineating priority targets for the exploitation of ore mineralization within the host rocks.

3.1. Magnetic Survey Measurements

Magnetic survey measurements were taken with GSM-19v7.0 Over Hauser Instrument (Figure 2) manufactured by GEM SYSTEMS, Canada. Electronically, the detection assembly includes dual pick-up coils connected in series opposition to suppress far-source electrical interference, such as atmospheric noise. Base station method for correction of diurnal variations was used while the area selected for base station was magnetically quiet, i.e. free from moving automobiles and is not close or on top of any major outcrop. Fourteen (14) profiles of 2.4km long each trending east-west were covered in the area with GSM-19 v7.0 Over Hauser instrument. The stored data from the instrument is dumped on a computer system. The dumped data is later saved in an Excel Spread-sheet for easy management. All Magnetics Stations were tied to their respective coordinates. A field notebook used for recording observations on geology, cultural features and all possible source of n oise aided the execution of QC and QA on the data.

Figure 2. *Magnetic and Geomative IP Data acquisition.*

3.2. Induced Polarization and Resistivity Imaging Field Operations

Based on the result from the magnetic survey, anomalous areas delineated were further explored using Induced polarization and resistivity imaging. Such areas were based on unique magnetic response which is diagnostic of potential mineralization zone. The IP and resistivity imaging survey was carried out simultaneously with Geomative GD-10 Supreme 2D Geoelectrical system manufactured by ST Geomative Co., Ltd, China. Twenty-six (9) lines of about 360m to 600m each were covered with the Geomative GD-10 Supreme 2D Geo-electrical system in the study area. The value for each IP and resistivity combination is plotted on a pseudo-section which resembles a cross section of the region under the profile.

4. Data Processing and Interpretation

4.1. Magnetic Data Processing

The first stage in magnetic data processing involve the Removal of diurnal variations of the earth's magnetic field, which may be resolved into secular changes, solar-diurnal changes, lunar changes and changes resulting from magnetic storms [7]. In this study, base station method was used to correct for diurnal variation. Tuning field of 33,000nT was used for magnetometer throughout the survey. After recording, the magnetic data for a particular day were reduced to an arbitrary datum (i.e., base field for the day). The reduced magnetic data for all profiles was then put into a database for further two dimensional processing and interpretation. A micro leveling or decorrugation method was used to remove line-to-line leveling errors of magnetic data which are visible as linear anomalies parallel to the lines. This was achieved using Butterworth and cosine directional filters.

To estimate the geometry of geologic structures and depths to causative bodies, mathematical functions were applied to the total intensity magnetic field data. These were regional-residual calculations, derivatives calculations and source parameter imaging (SPI). Colour-shaded map of the total magnetic intensity map of the study area is shown in figure 3.

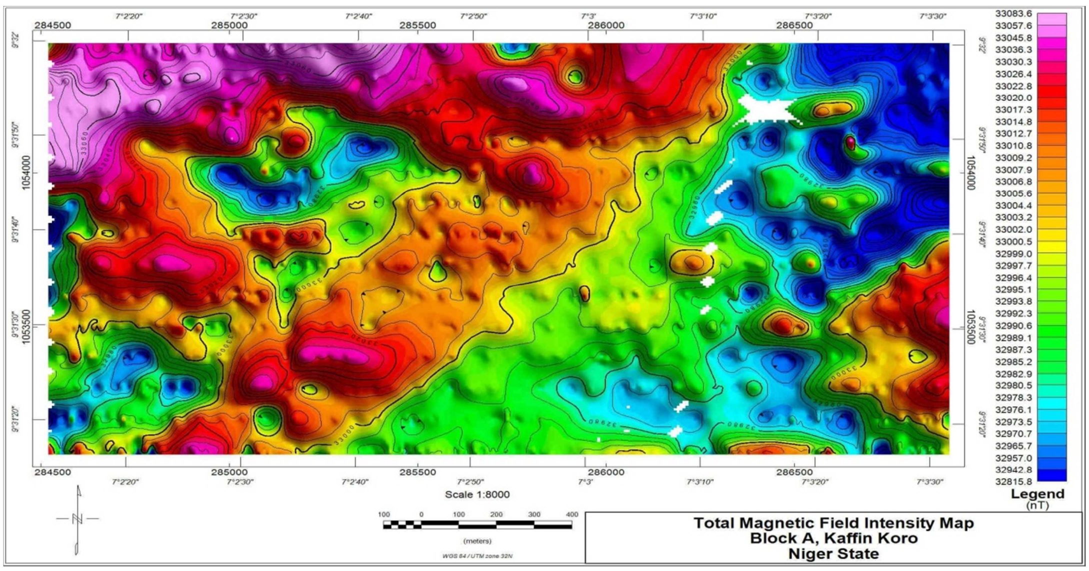


Figure 3. *Total Magnetic Field Intensity map of the study area.*

4.2. Regional-Residual Separation and Other Magnetic Products

The observed magnetic field at every point is a vector sum of various components, such as the regional field and the local field components. In addition to induced magnetism, rocks may also have remnant magnetic component [6]. Remnant magnetism is the effect of the primary magnetic field at the time of rock formation. The total magnetic response is proportional to both the induced magnetism as well as remnant magnetism [8]. The regional field was assumed to be a first order polynomial plane and it was derived by least-square fitting of a plane:

$$T(x, y) = (a_o + a_1x + a_2y) \quad (1)$$

Where x and y are unit spacing along the two axes of the blocks and a_o, a_1 and $a_2$are the coefficients of the plane. From this relation the regional gradients along any line were calculated. This was achieved with the aid of Geosoft MAGMAP software which is based on least square (best-fit polynomial). The computed regional magnetic field intensity map (Figures 4) were subtracted from the corresponding total magnetic field intensity map to obtain the field due to local geological events i.e. residual magnetic maps (Figures 5). The computed residual field components of the magnetic data were calculated along profiles and were plotted against station locations for profile analysis. These plots of residual fields were stacked to allow for qualitative interpretation (Figures 6).

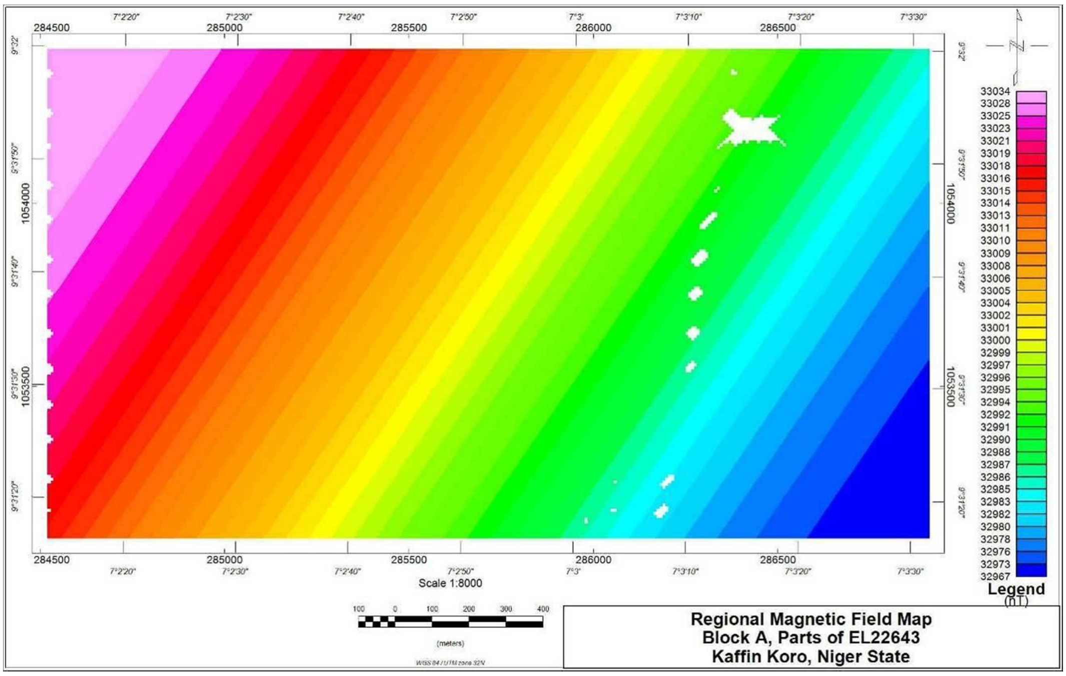


Figure 4. *Regional Magnetic Field Intensity map of the study area.*

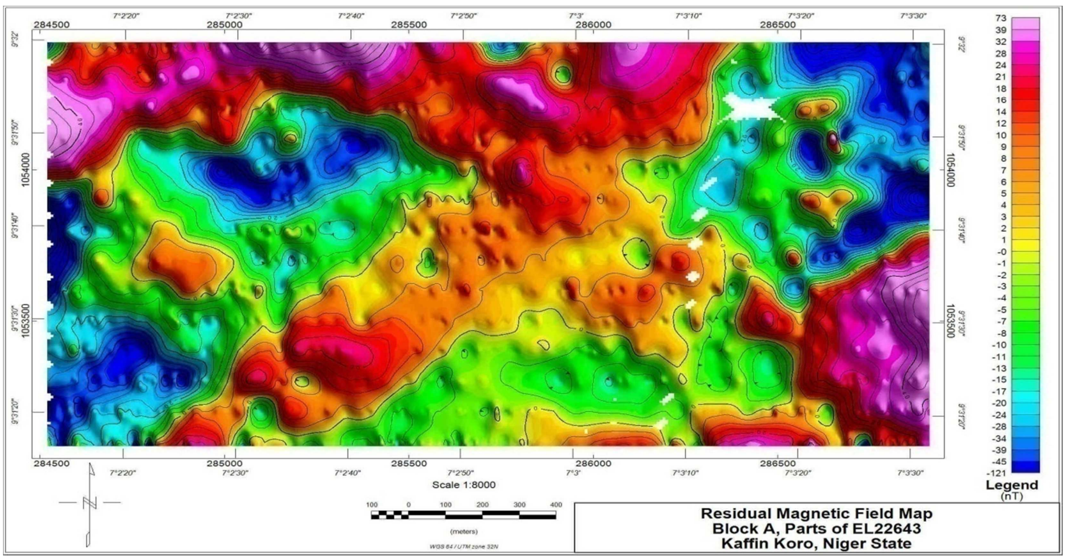
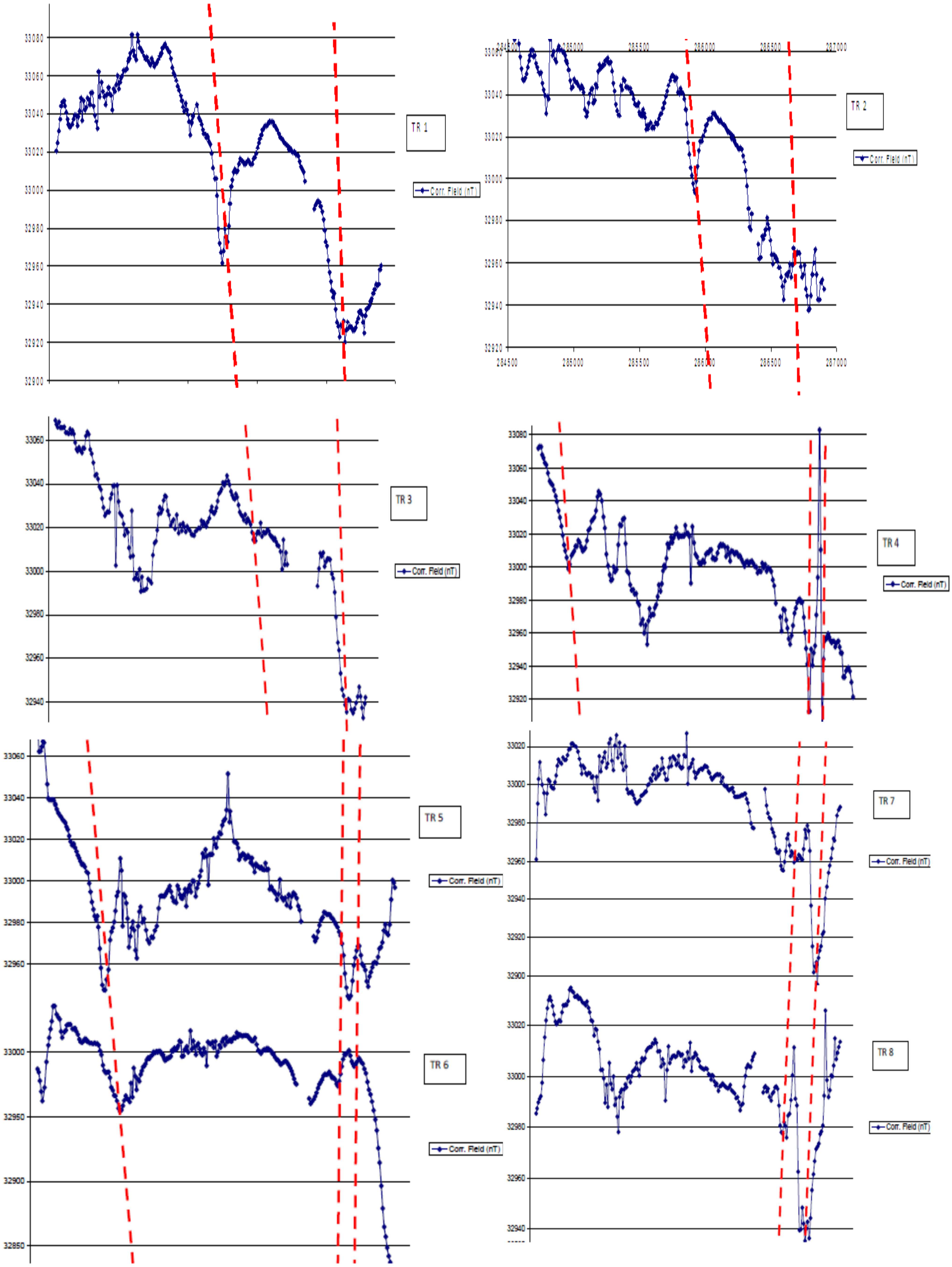


Figure 5. *Residual Magnetic Intensity map.*


TR 1
Corr. Field (nT)
TR 2
Corr. Field (nT)
TR 3
Corr. Field (nT)
TR 4
Corr. Field (nT)
TR 5
Corr. Field (nT)
TR 6
Corr. Field (nT)
TR 7
Corr. Field (nT)
TR 8
Corr. Field (nT)

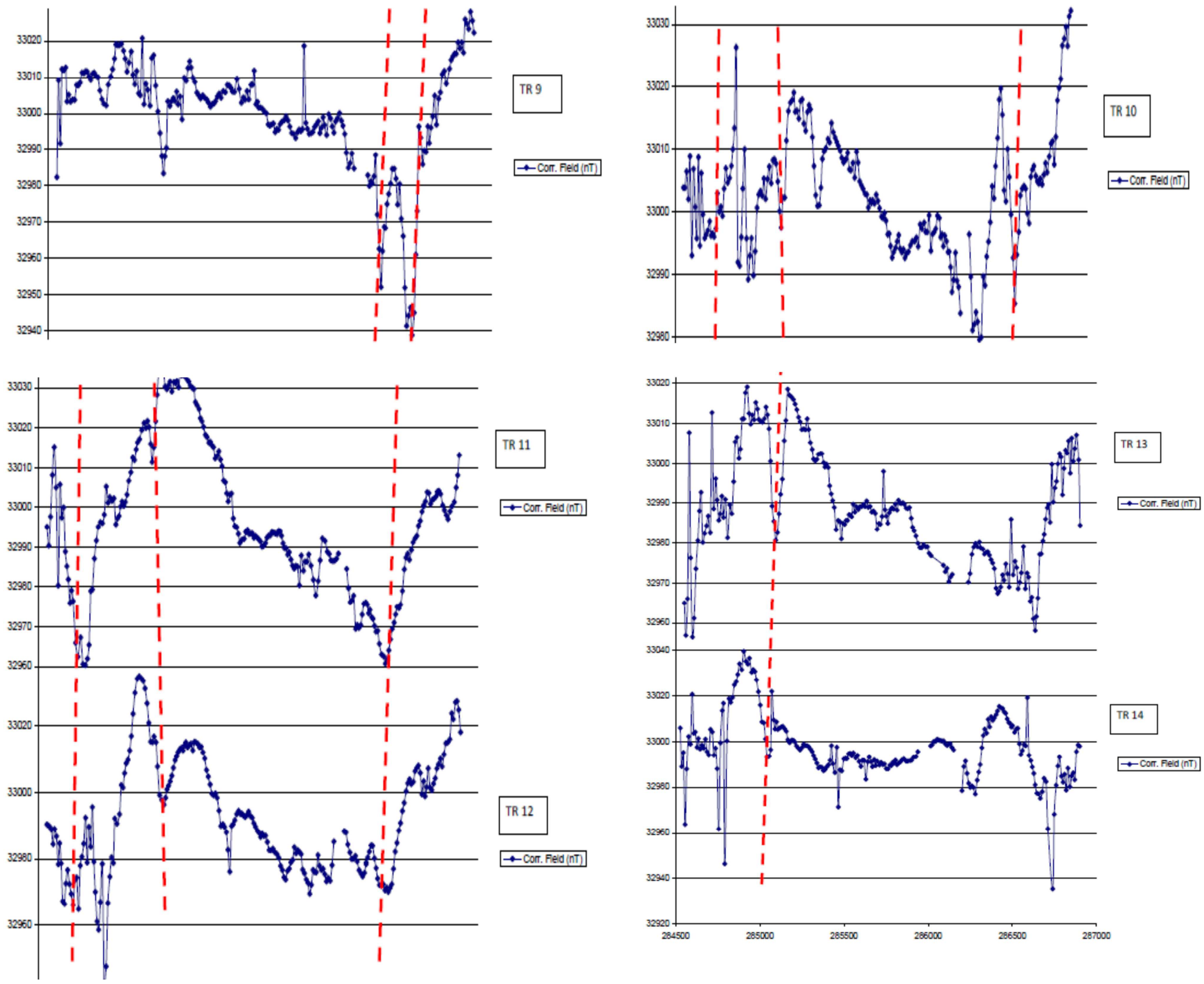


Figure 6. *Stacked plot of the magnetic data of the study area.*

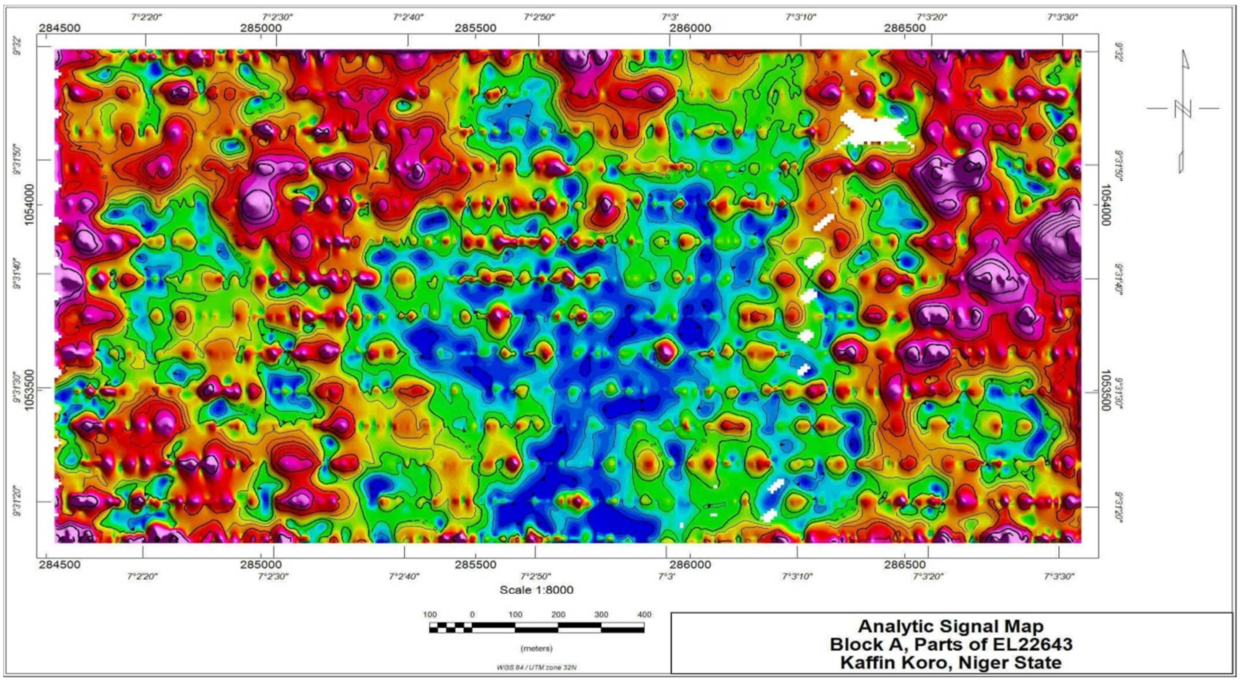


Figure 7. *Analytical Signal grid of the TMI grid for Block A.*

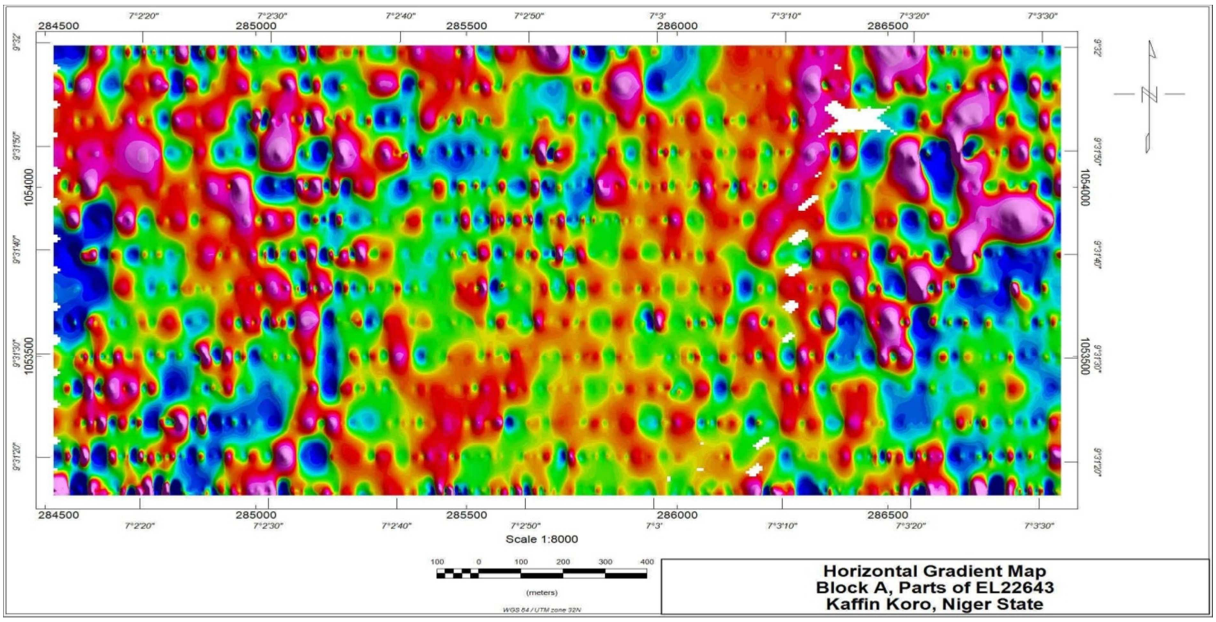


Figure 8. *Horizontal Gradient Map of the TMI grid of the study area.*

Several derivatives of the residual total magnetic field provide value-added products that may contribute to the geological interpretation of magnetic data. Since analytical signal is useful in locating the edges of magnetic source bodies, particularly where remanence and/or low magnetic latitude complicates interpretation. The analytical signal map of the residual magnetic field was produced (Figure 7). In order to observe the near-surface magnetic anomaly and likely vein structures in the study area, first vertical derivative and horizontal gradient maps (Figures 8) were produced.

4.3. Interpretation of Magnetic Survey Data

The magnetic profiles in the study area showed anomalies of varying amplitudes. The variation in amplitudes of the residual intensity may be due to the presence of geological structures such as fractures and intrusions in the area. The Total magnetic Intensity Maps of the area exhibits zoning and alteration. This is an indication of hydrothermal alteration which is usually associated with mineralization as a result of intrusion.

The anomaly showed minima and maxima amplitude. Generally, the signature showed positive magnetic amplitude (maxima) of about 73nT above the background whiles the negative amplitude (minima) of about -121nT. The residual magnetic field intensity map generally show major NE/SW and N/S trending anomalies which conform with some of the structural trend in the area as identified from the regional aeromagnetic interpretation especially at Northeastern and western portion.

4.4. Induced Polarization (IP) and Resistivity Data Processing and Interpretation

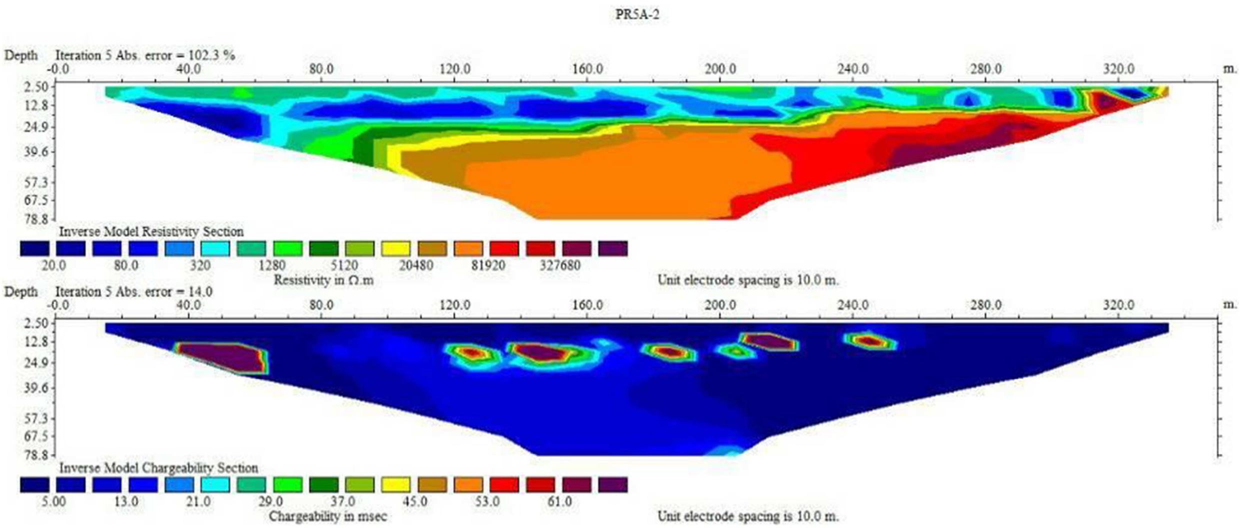


Figure 9. *2-D inverted IP-Resistivity mode plot for Profile 5A_West (285340 to 285989, 1054000).*

In the IP and resistivity models (Figures 9 to 17), Bodies with high resistivity with corresponding high chargeability were identified at a relatively shallow depth (less than 48m. IP survey revealed that most of the magnetic anomalies investigated are chargeable and that their chargeability increases with depth. Also some massive chargeable bodies were delineated at depth (Figure 14). Four (4) major bodies with such anomalous signatures were identified from nine (9) IP profiles within the study area (one in the western part and three in the eastern part).

The identified chargeable bodies' length ranges from less than 100m to maximally 400m while their width ranges from 25m to maximally 80m. Their orientation varies slightly but mostly in N/S direction (the identified body in western part trend NNE/SSW, (Figure 18).

High IP response with corresponding low resistivity signatures were observed in some profile (Figures 9 – 12). This may be sheared/fractured zone filled with water with or without associated mineralization. The geophysical characteristics of each of the delineated anomalous points are shown in table 1.

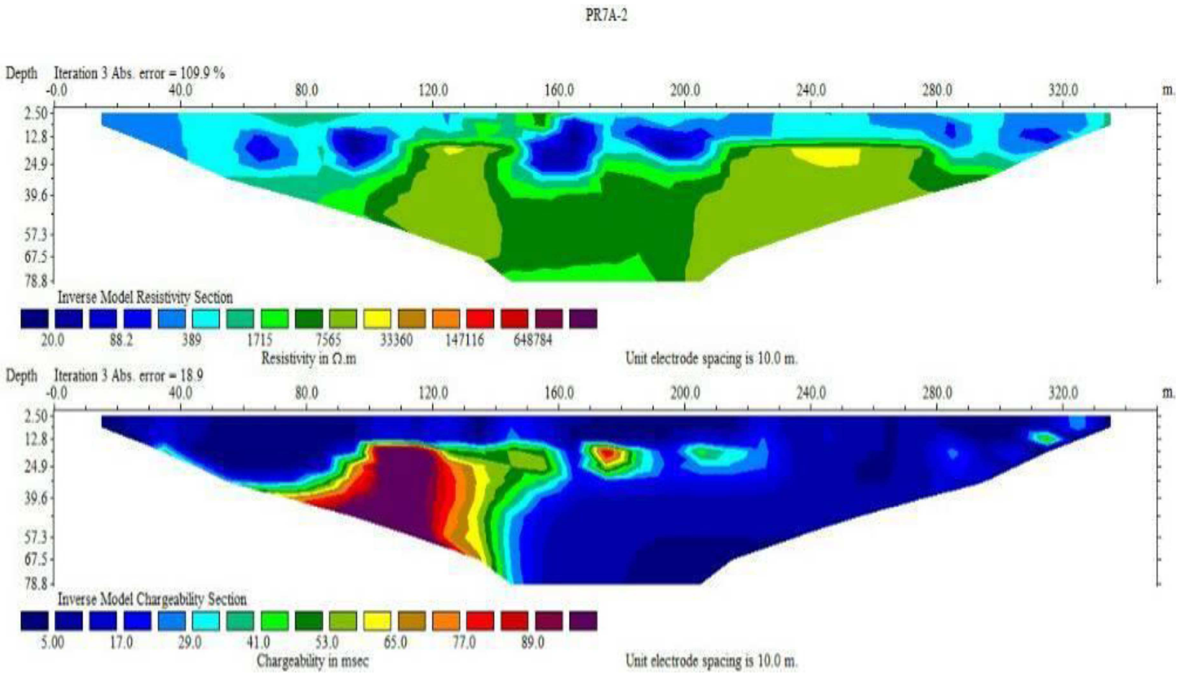


Figure 10. *2-D inverted IP-Resistivity mode plot of Profile 7A_West (285340 to 285986, 1053800).*

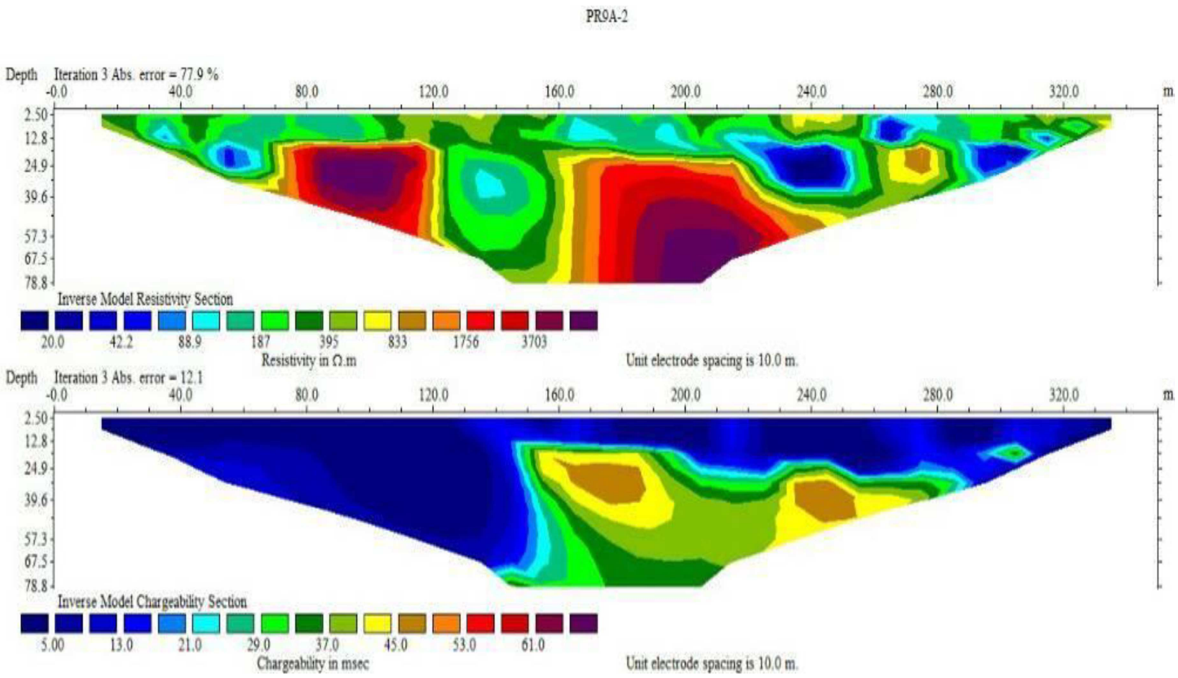


Figure 11. *2-D inverted IP-Resistivity mode plot of Profile 9A_West (285340 to 285988, 1053600).*

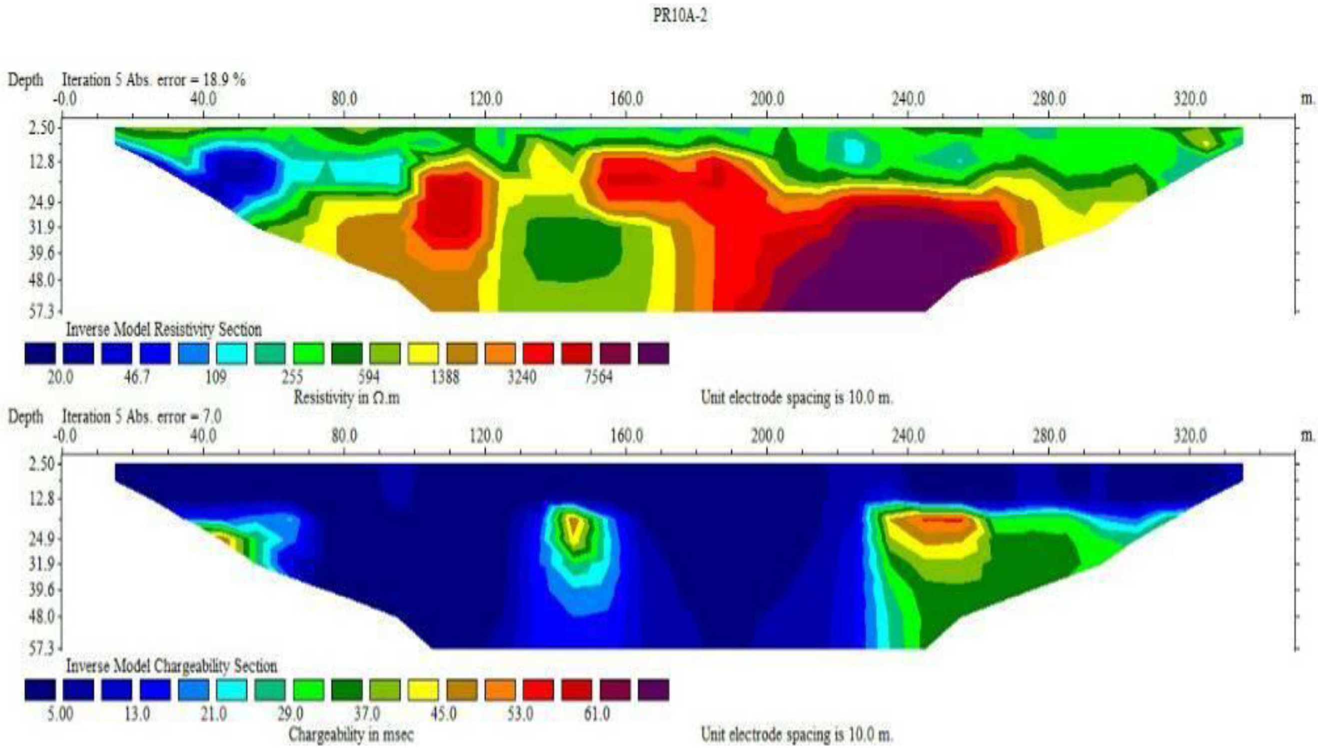


Figure 12. *2-D inverted IP-Resistivity mode plot of Profile 11A_West (285340 to 285987,1053400).*

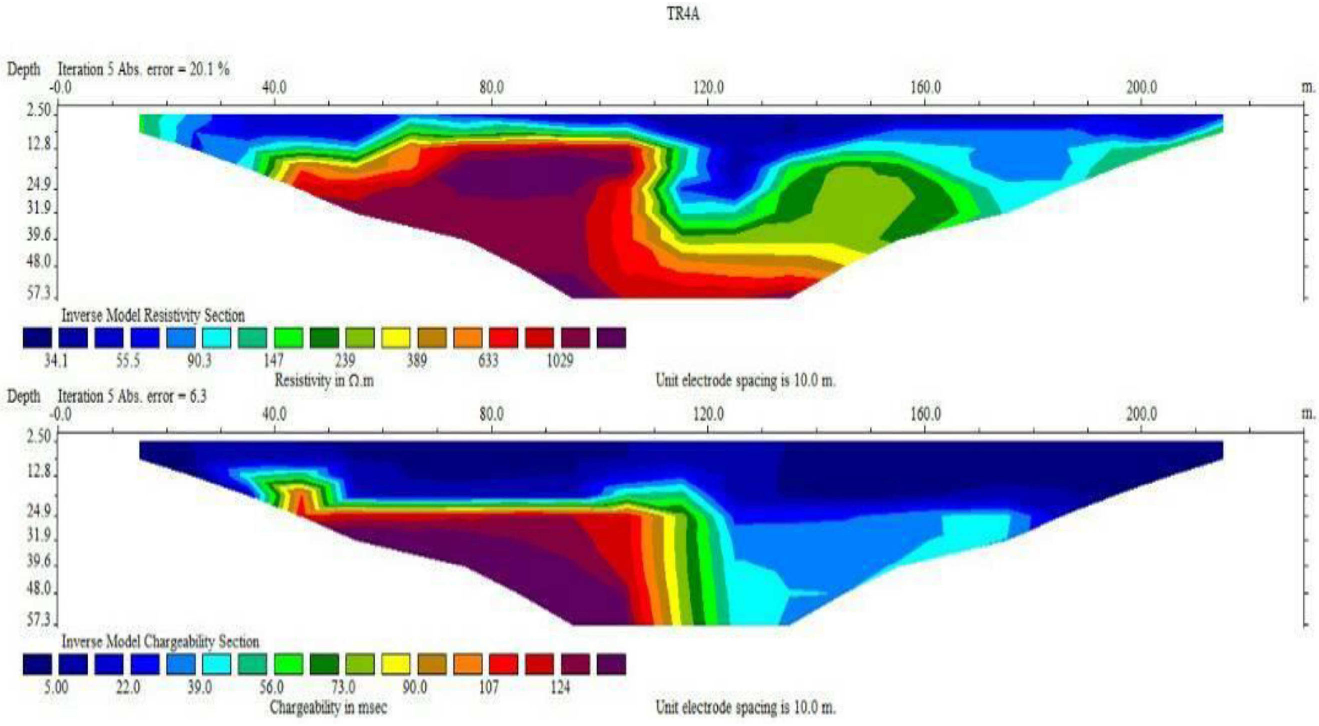


Figure 13. *2-D inverted IP-Resistivity mode plot of Profile 4A_East (286360 to 286600, 1054070).*

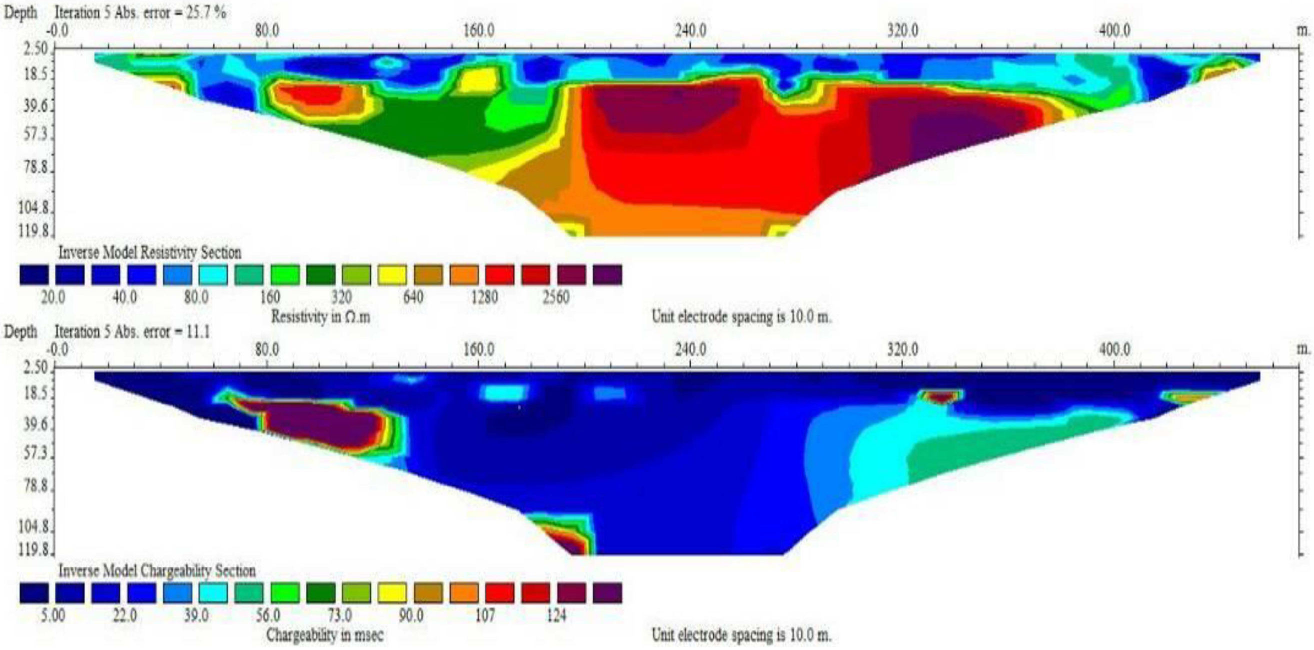


Figure 14. *2-D inverted IP-Resistivity mode plot for Profile 5A_East (286360 to 286835, 1054000).*

P6A

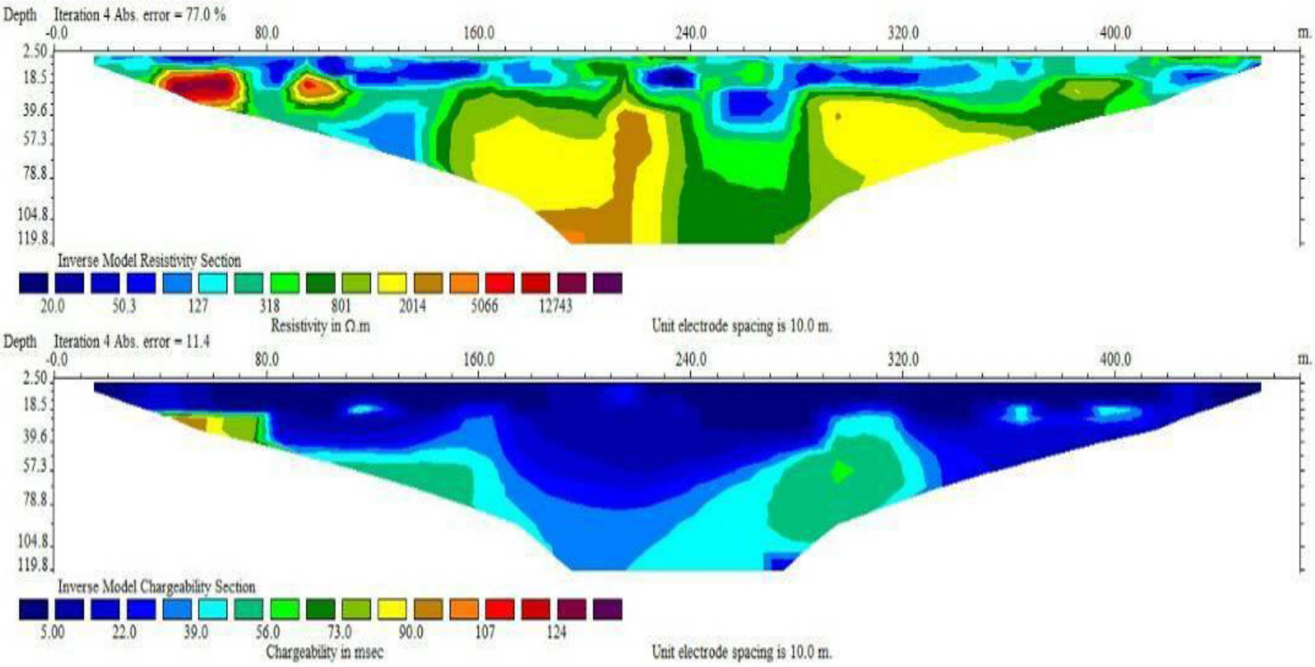


Figure 15. *2-D inverted IP-Resistivity mode plot for Profile 6A_East (286350 to 286814, 1053900).*

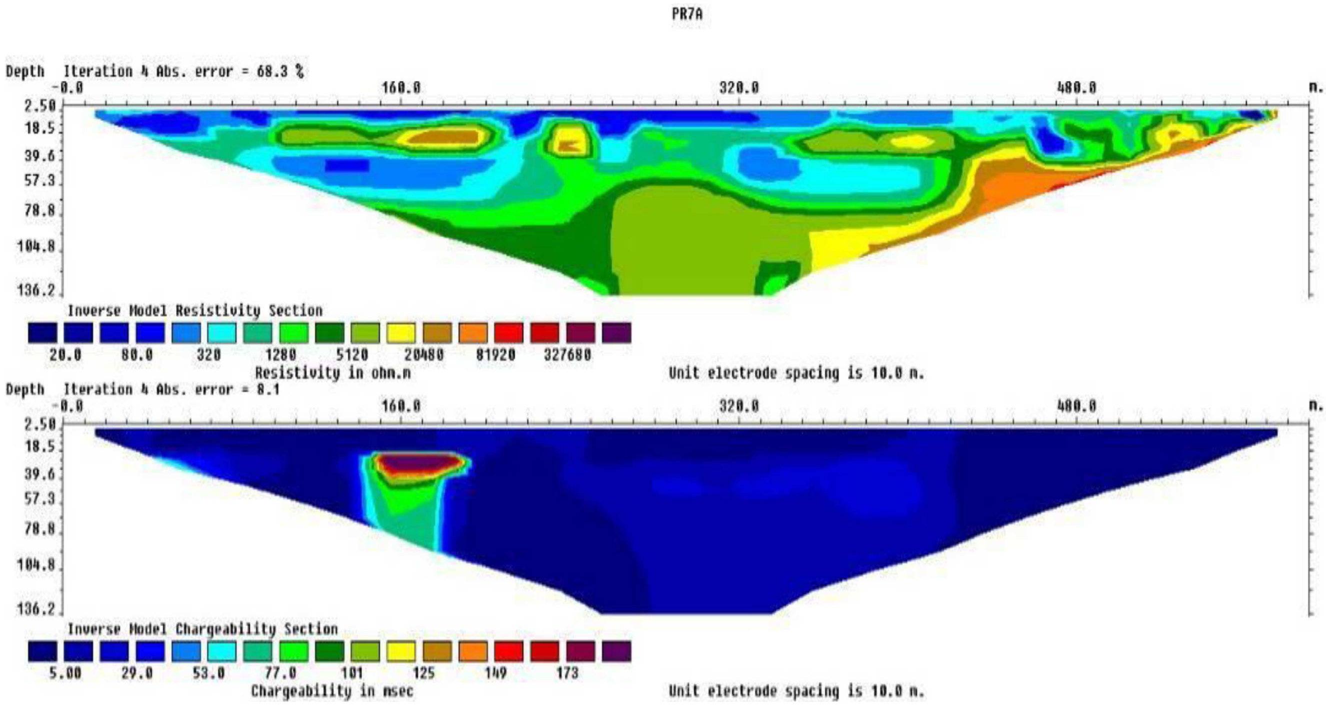


Figure 16. *2-D inverted IP-Resistivity mode plot of Profile 7A_East (286300 to 286890, 1053800).*

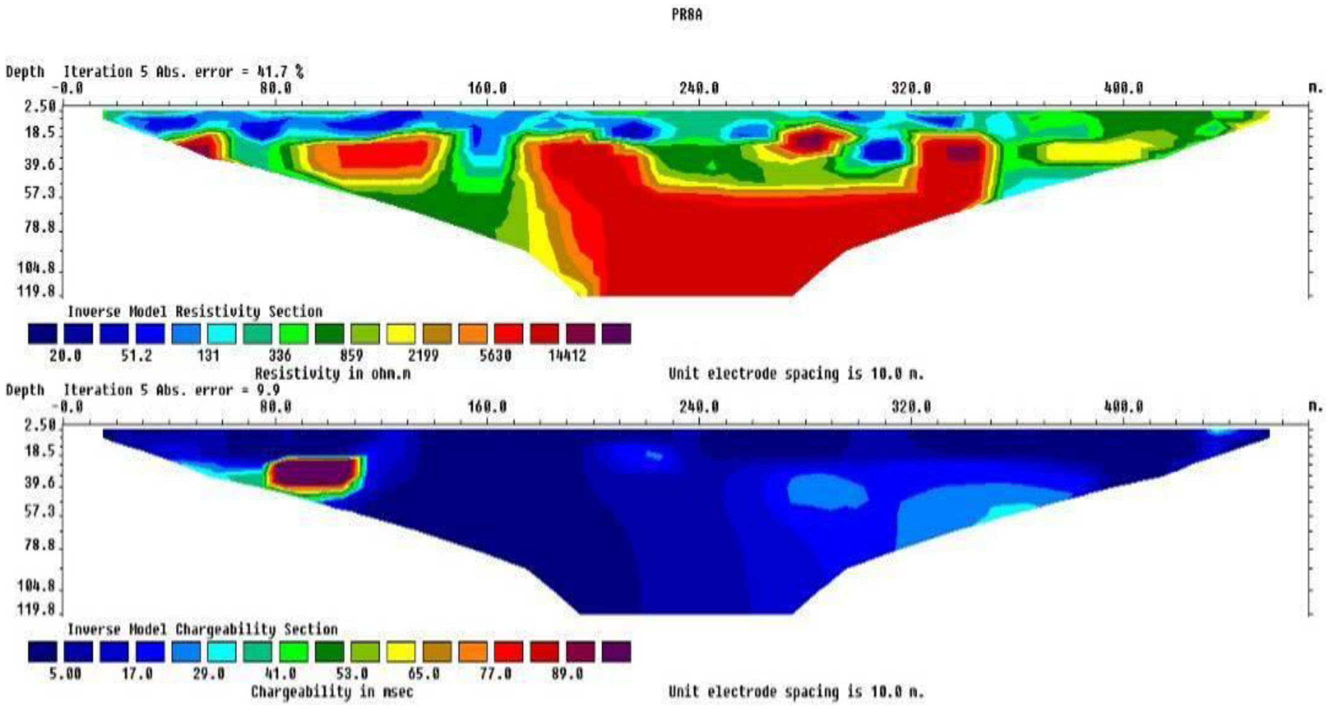


Figure 17. *2-D inverted IP-Resistivity mode plot for Profile 8A_East (286300 to 286888, 1053700) 120m was removed.*

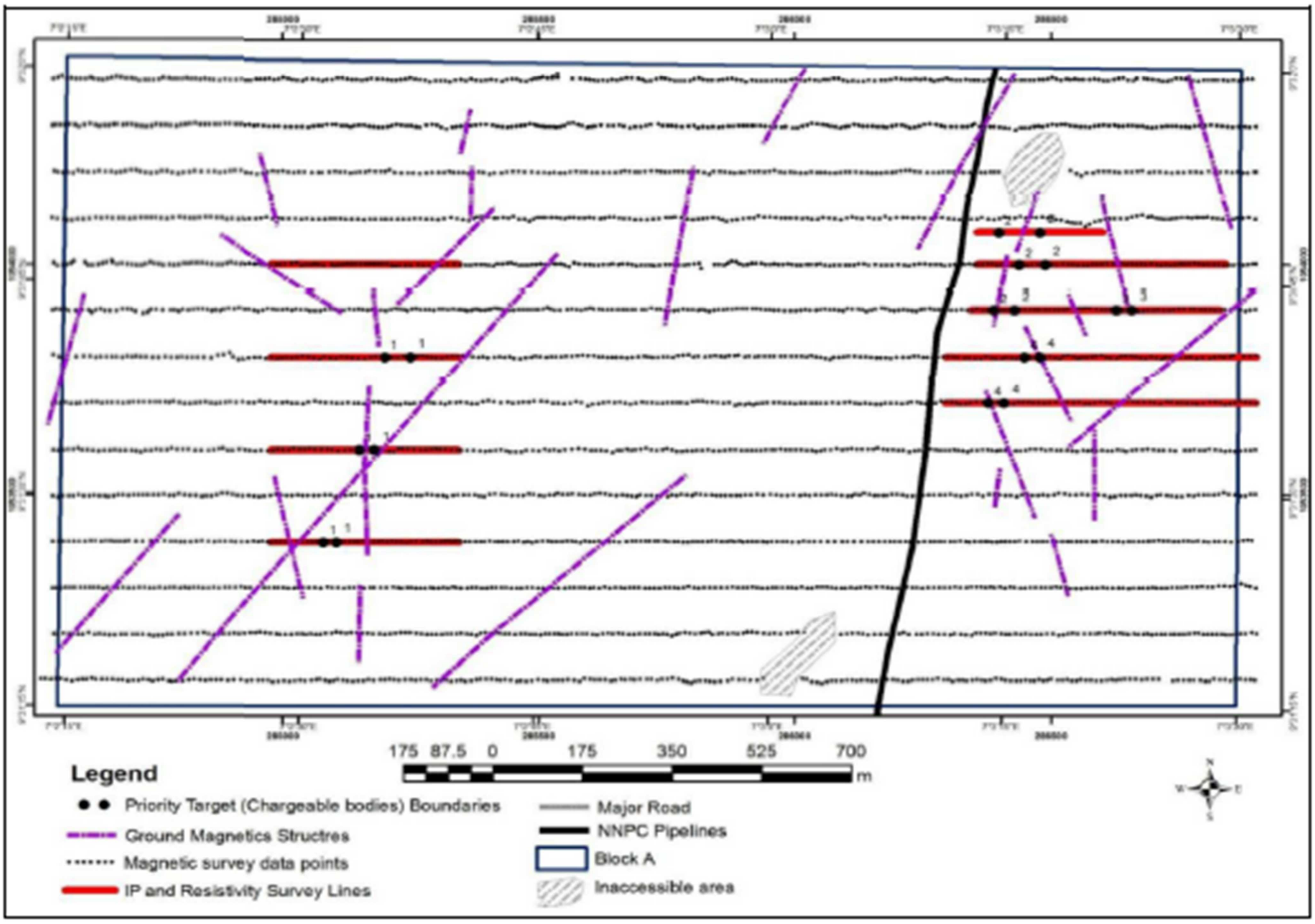


Figure 18. *Mineral target map of the study area.*

Table 1. *Characteristics of the identified chargeable bodies/veins.*

				BLOCK A					
No	**Profile**	**Easting from**	**Easting to**	**Northing**	**Depth to top**	**Magnetic response**	**Chargeability level**	**Resistivity level**	**No**
1	TR7A_W	285200	285250	1053800	13m	Good	Very High	Very High	1
2	TR9A_W	285150	285180	1053600	13m	Good	Medium	High	1
3	TR11A_W	285080	285105	1053400	13m	Good	High	Very High	1
4	TR4A_E	286400	286480	1054070	25m	Good	Very High	High	2
5	TR5A_E	286440	286490	1054000	27m	Good	Very High	High	2
6	TR6A_E	286390	286430	1053900	25m	Good	Very High	High	2
7	TR6A_E	286630	286660	1053900	40m	Good	High	High	3
8	TR7A_E	286450	286480	1053800	25m	Good	Very High	Medium	4
9	TR8A_E	286380	286410	1053700	25m	Good	Very High	Very High	4

5. Conclusion

Wide ranges of linear structures which are believed to host gold ore mineralization were identified in the area. Through careful interpretation and technical assessment of the results, it can be inferred that some of these structures are probably mineralized quartz veins with varying degrees of characterization. Their responses to physical parameters also revealed that some of the structures delineated from the magnetic data are conductive while others are non-conductive. Some are within a resistive host while others are within a conductive host. Most of the structures trends in the NE-SW and N-S direction.

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