Application of Electrical Resistivity and Ground Magnetic Investigation of Ironstones Deposits in Abiati Akamkpa Lga Cross River State, Nigeria

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ABSTRACT
Ironstones form part of production materials for cement production and is locally sourced in abaiti village as supply materials for nearby Dangote Cement Company. Geophysical investigations using vertical Electrical sounding technique and ground magnetic survey were employed to investigate the depth of occurrence of the suppose iron or deposits. Two profiles each of VES and ground magnetic data were acquired using ABEM SAS 1000 and GSM-19T magnetometer.The data sets were processed using manual and computer processed techniques. The magnetic data were corrected manually for diurnal variation corrections and plotted as anomaly profiles while the VES data was processed using the zoody software programme plotted as modelled plots. The magnetic depth results indicate that the iron ores are between 4-5m with magnetic susceptibilities of -40nT to -160nT. While the VES results indicate that the iron ore is exposed from surface to depth of 7.0m with resistivity values ranging between 4090.7 ohm/m - 5295.1 ohm/m . The study reveals a thin occurrence of about 7.0m of ironstone deposit and will require a more detail investigation in computing the volume of deposit in place.

1.0 INTRODUCTION

The study location is within latitude 5^0 06’ 04’’N and longitude $08^0$30’25’’E in Abiati Village Fig.1 geophysical surveys involving the use of a Gen Advance magnetometer GSM -19T, nuclear precision magnetometer and AbemTerameter (SAS 1000) was employed to investigate the presence of a supposed iron ore deposit. The iron ore is said to be ferruginous and occurs as small boulders scattered around the community. Both methods have been used effectively in mapping subsurface ore bodies (Reynold, 1990).

The study is designed to delineate the contact and determine the depth of occurrence of the ore deposit in the study area using interpreted resistivity modelled plots obtained from intractive computer modelling (Zoody, 1989) and magnetic profile data interpretation using the source to magnetic basement computation of Petters half width, maximum Stope, and Stanley methods (Dobrin and Savit, 1988). Though Aeromagnetic work has been done in basin analysis of the Calabar Flank and environs (Obi et al., 2008), Ground magnetic work for mineral exploration has not been done within these environs. This study will serve as a pioneer work in delineating subsurface iron ore deposits.

2.0 GEOLOGY OF THE STUDY AREA

The study area Abiati (South Eastern Nigeria) is under the Oban massif basement Complex, consisting of Precambrian rocks which include migmatites, Gneisses, Charnockites, Granulites, Schist, Amphibolites and Phyllites intruded by rocks of acidic, intermediate, and ultrabasic compositions (Ekwueme, 2003, Ekwueme and Ekwere 1989, Ekwueme and Oyeagocha 1985).

The area is characterized by a sloppy topography and has ferruginous sandstones occurring as boulders, this is due the weathering of the basement Schist which formed the ore deposits . Some of the Schist are bounded and associated with pegmatite intrusions (Ekwueme, 2004). Fig. 1.0.

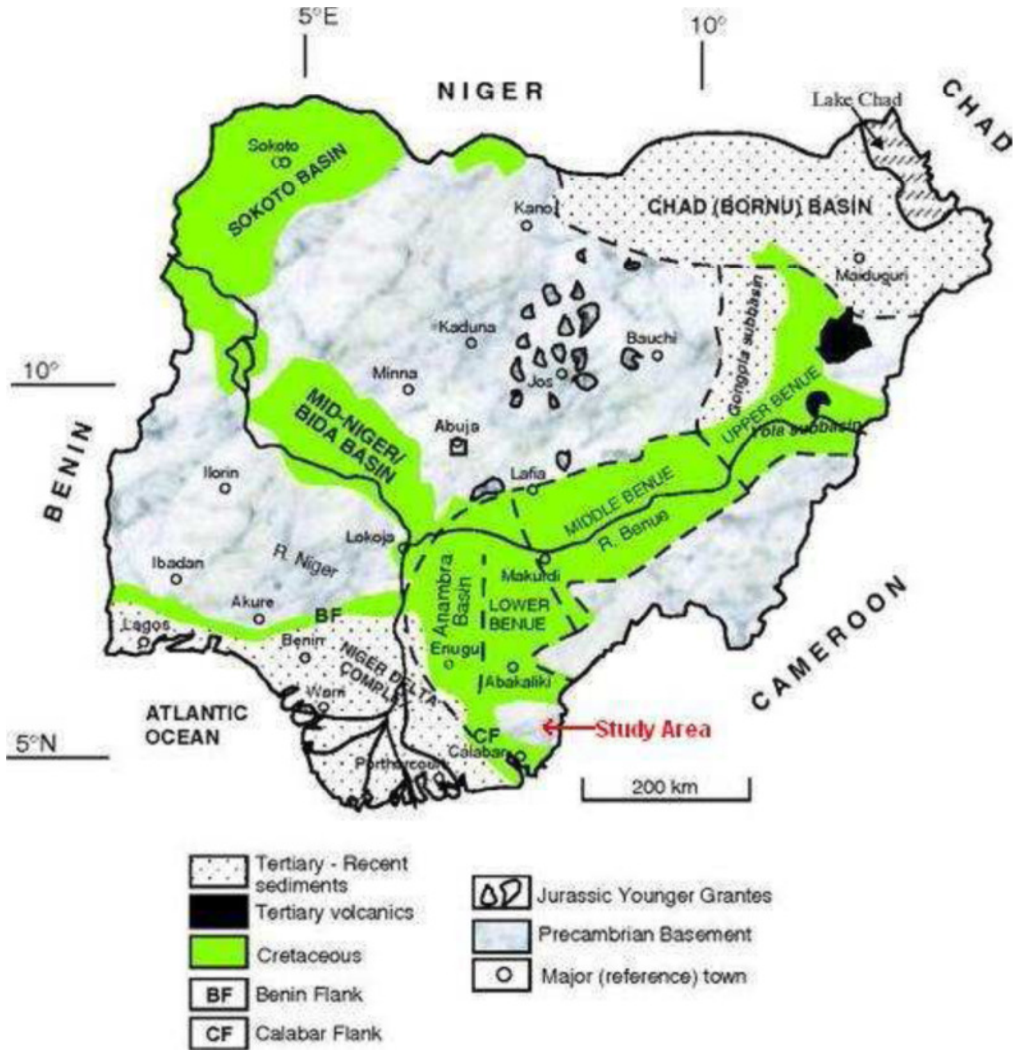

Fig. 1 Sketch Geological map of Nigeria showing the study area. (Source: Geology and Mineral Resources of Nigeria by Obaje,2009).

THEORETICAL BACKGROUND

Geoelectrical surveys have successfully been used in mineral exploration in situations where significantly resistivity contract exist between the ore and their surrounding formations (Salawu, 2015). Since iron ore deposits has much higher resistivity contrast compared to the surrounding Schist the electrical resistivity method was preferred to be used along with the magnetic method to delineate the iron ore deposits. The Schlumberger array was used during the vertical electric sounding . The Schlumberger array consists of four collinear electrodes. Two outer electrodes are current (Source) and two inner electrodes are installed at the center of the electrode array with a small separation, typically less than one fifth of the spacing between the current electrodes (Dobrin and Sarrit 1988, Burgar, 1992). The current electrodes are increased to a greater separation during the survey while the potential electrodes remain in the same position until the observed voltage becomes too small to measure. Usually the apparent resistivity is often computed and converted using computer software to the true earth resistivities (Grifilths and Kings, 1981). The apparent resistivity for a Schlumberger array may be computed from the equation below

$$p_a = \pi \frac{(S^2 - a^2/4)}{a} \Delta \frac{V}{I} \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad (1)$$

Where S is half of the current electrode separation a between the potential electrode MN. (Dobrin and Sawrt, 1988, Burger, 1992). Magnetic method has been used extensively in delineating subsurface iron ore deposits since there is always a great significant contrast of the total magnetic field intensity between the ore body and their surrounding environment.

The magnetometer is very sensitive and can measure magnetic susceptibilities to 0.1nT, where changes in flux intensity will depend on the amount of magnetic minerals present (Grifiths and Reynolds, 1990, Kings, 1981). During field data collection base stations are often created in a loop pattern and actual field data also collected using a loop pattern which serve useful in diurnal variation correction. Once the field data is corrected for diurnal variations, anomaly separation using simple filtering techniques could separate the data into residual anomaly plots from where depths estimate to the source of magnetic anomalies are determined.

DATA ANALYSIS/RESULTS

Groundmagnetic data was performed along two profiles across the study area using the Gen advance magnetometer GSM-19t. The separation distance between the two profiles was about 20m and intervals between sampling points along profiles were spaced at 5m intervals with profile length reaching 300m.

The data was collected in a loop pattern; base station data were first collected and then followed by the station intervals data to close the loops. The filed data was then corrected manually for diurnal variation correction by computing the drift rate and difference in drift correction to obtain the residual anomaly field from the observed field data.

The observed total magnetic field intensity was plotted against station intervals to obtain the total magnetic field intensity profiles (Fig.2.0, 3.0). The separated computed residual field (Anomaly) was plotted against distance to obtain the residual anomaly plot. Fig. 4.0 and 5.0. Depth to source of magnetic anomaly was performed using Petter's half width and maximum slope methods. The results from the plot of the observed total magnetic field intensity (Fig. 2.0 and 3.0) indicate major significant drops in three locations with intensity values of the low magnetic fields 33028 gamma against a high of 33070 gamma and another low at 33043 gamma against a high of 33055 gamma. These areas were also conspicuous in the anomaly plot (Fig. 4.0) which indicated magnetic lows ranging between -20 gamma to -40 gamma within a regional background 10 – 30 gammas. Also the total magnetic field plot fig. 3.0 indicates two major magnetic lows 32895 against a high 8 33045 and another low at 32970 against a high of 33075 (Fig. 3.0). These areas were also conspicuous in the anomaly plot (Fig. 5.0) which indicated magnetic lows ranging between -60 gamma to -140 gamma within a regional background of 20 – 30 gammas. Computed depths to magnetic basement at these points were between 4-5m. These magnetic throws were typical magnetic oreintrusives (Salawu 2015, Grifiths 1981).

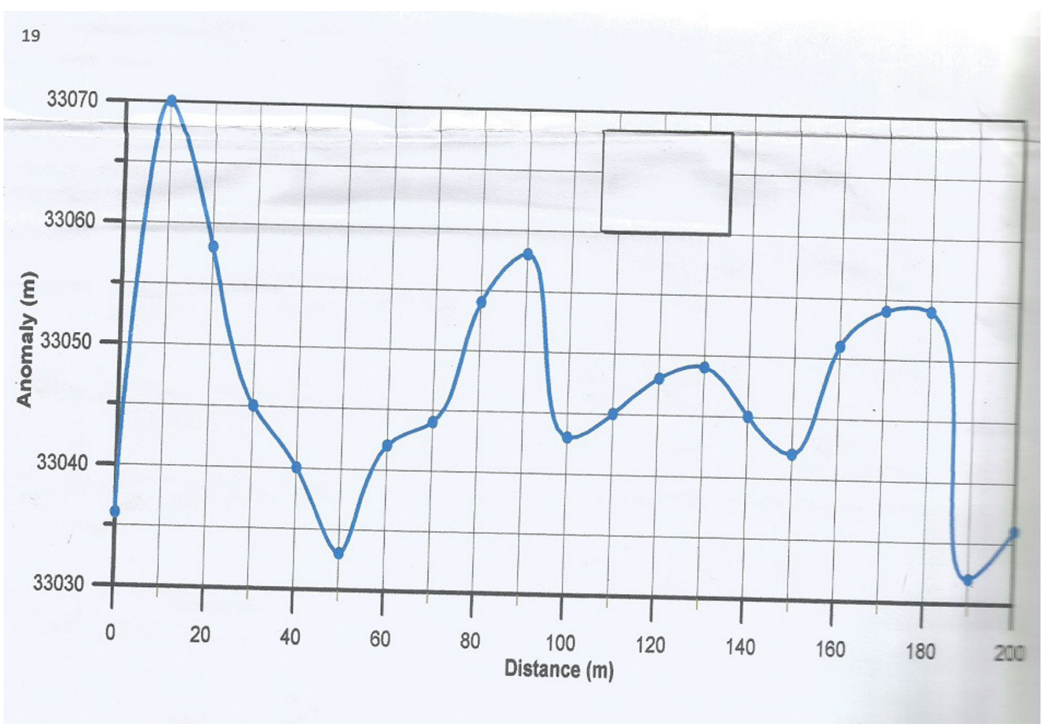

Fig.2 Total Magnetic Field intensity plot for Survey 1

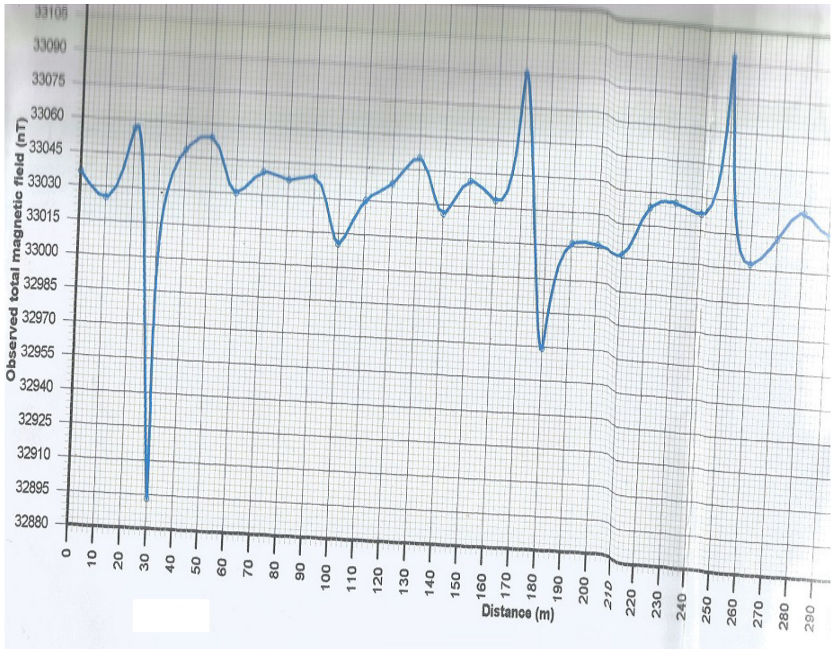

Fig.3 Total Magnetic Field intensity plot for Survey 2

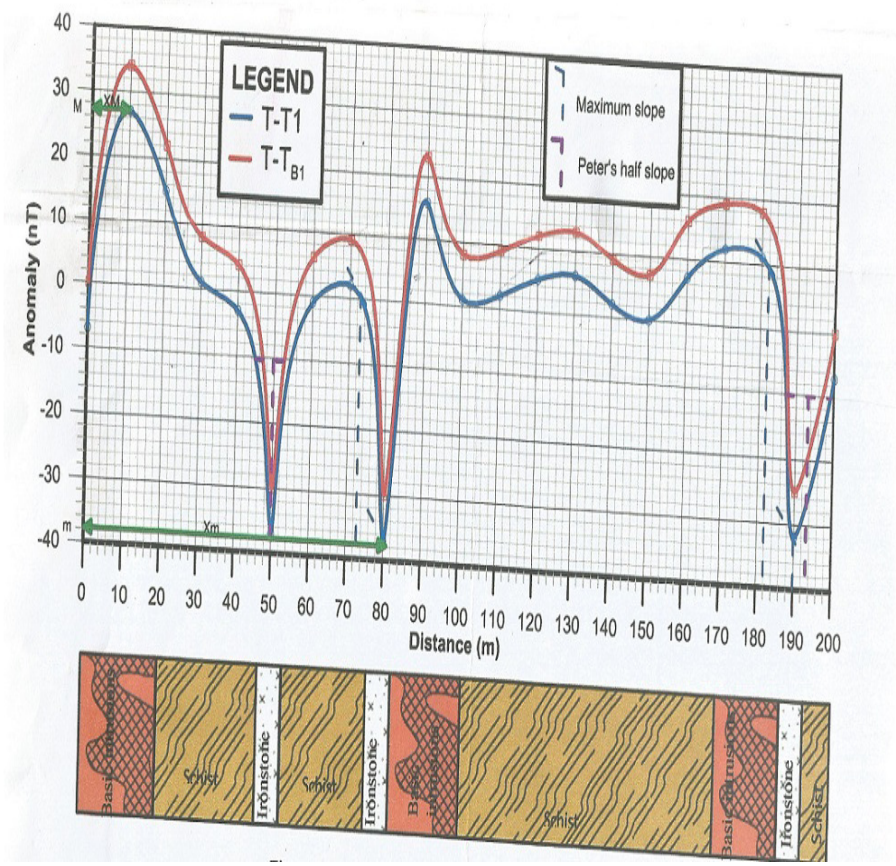

Fig.4 Residual magnetic plot of survey line 1

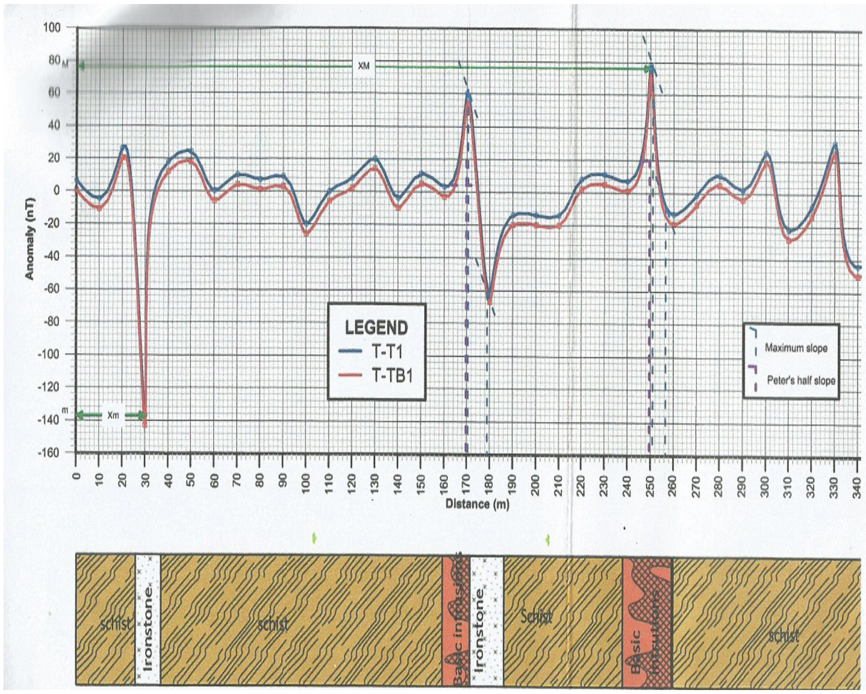

Fig.5 Residual magnetic plot of survey line 2

The resistivity data was collected along the same magnetic profiles such that the data can be compared. The ABEM Terameter (SAS 1000) was used for data collection along the two profiles with the current electrodes AB/2=200 and potential electrodes MN/2 =20. The field resistivity data was multiplied by the geometric factor (K) to obtain the apparent resistivity values used for modelling. The modelling was performed using the Zoody software programme (Zoody, 1981) where modelled resistivity plots were used for interpretation (Fig. 6.0 and 7.0). Geomodels were obtained from the results of the modelled plots and the apparent resistivitiesvalues . The results indicate top resistive materials at VES 1 with high values ranging between 4090 – 5205 ohm/m against an underlying layer with lower resistivitie less than 301 ohm/m .Also VES 2 has a top resistive value of 1267 ohm/m against an underlying layer of 627 ohm/m. These top resistive layer are probably the resistive ironstones which had depth ranging between $2.0m - 6.6m$ in VES 1 and $0 - 7m$ in VES 2.

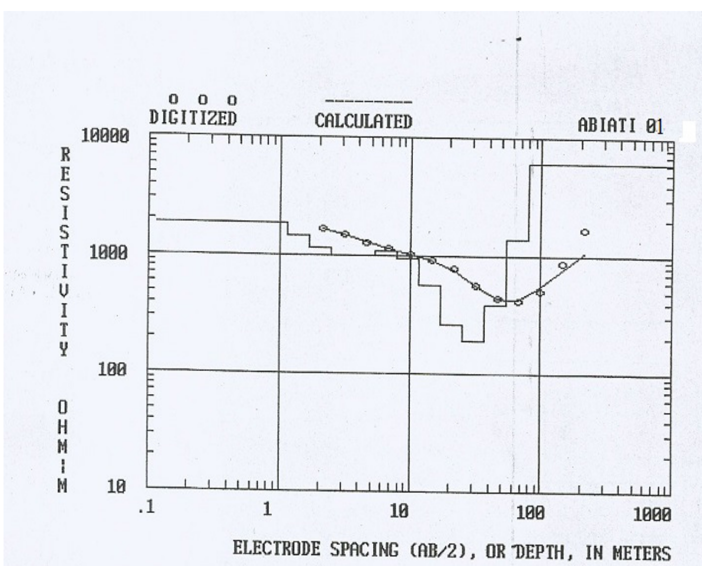

Fig.6 Modeled resistivity plot along Abaiti line 1

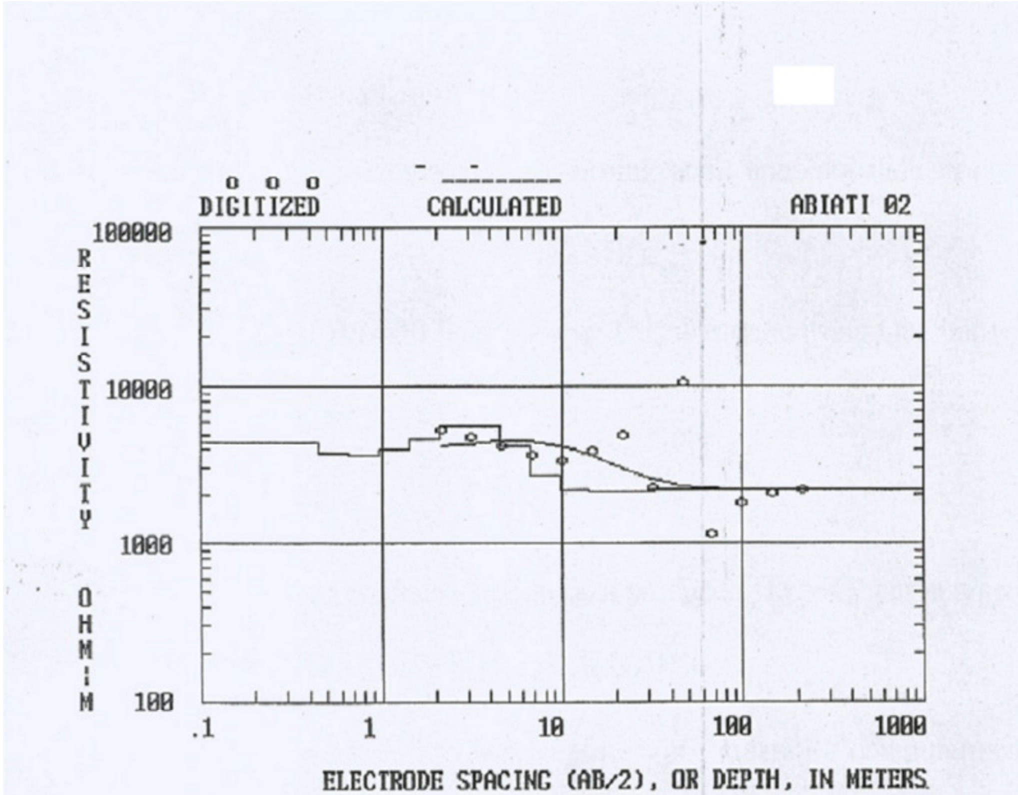

Fig.7 Modeled resistivity plot along Abaiti line 2

DISCUSSION OF RESULTS AND CONCLUSION

Geomodeling of resistivity data was integrated with ground magnetic data to evaluate the occurrence of iron ore deposits in the study area. The locations of inflection points where depths to source of magnetic anomaly were computed (4-5m) corresponds to the computed depths from resistivity geomodel (2-7m) these areas are interpreted as intrusion of iron ore deposits. They are recognized by their high resistivities $5205\ ohm/m$ from the adjacent layers which also corresponds to their low magnetic susceptibility (-140 gammas) values from their host rocks. The results from both magnetic and resistivity investigations has successfully characterized the presence of iron ore deposits in the study area.

Conclusively, since these deposits are already being mined by locals and this study has revealed its depth of occurrence, a detail gridded subsurface geophysical survey should be conducted to quantify the reserve estimation of the iron ore deposit.

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