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Geophysical Delineation of Barite-Galena Mineralization Using Coupled Electrical Resistivity (ER) and Induced Polarization (IP) Techniques. A Case Study of Iyamitet, Cross River State, South-South, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. All authors read and approved the final manuscript.

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ABSTRACT

A combined Electrical Resistivity (ER) and Induced Polarization (IP) techniques were carried out at Iyamitet, Cross-River State Nigeria with the aim of mapping the Barite-Galena mineralization zone within the area. Five traverses were established in orthogonal directions with length of 100 m. The traverses were established in grid format for better coverage of the study area and Dipole-Dipole electrode configuration was adopted for the data acquisition for both ER and IP. Res2Dinvx software was employed for the joint inversion of the data and the resulting 2D resistivity and chargeability images of the subsurface were interpreted qualitatively and semi-quantitatively to locate the mineralized zone. The result of the investigation revealed that the resistivity values of the suspected mineralized zones fall between 1023 ohm-m to 377599 ohm-m and the chargeability falls between 232 msec and 727 msec. The depth to the top of some of the mineralized zones is as shallow as 1.25 m and as deep as 19.8 m in other places. The results of the investigation have indicated the presence of the Barite-Galena ore within the area and this manifested as high

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resistivity and high chargeability zones along the traverses. The result of this investigation highlights the efficiency of combined geophysical techniques in locating mineralized zones in a basement area.

Keywords: Iyamitet; joint-inversion; dipole-dipole; mineralization; IP; resistivity.

1. INTRODUCTION

The importance of Barite and Galena, especially as vital natural resources for various industries globally and locally cannot be overemphasized [1]. Mineral is a crucial industrial mineral that's used extensively as a coefficient agent in well-drilling fluids and in lesser amounts for filler, chemical. Barite (BaSO4) as identified by Brobst [2] is widely distributed in the United States with the greatest production, obtainable from Arkansas, Missouri, Nevada, and Georgia. Moreover, nearly 1/2 the States have yielded some mineral or have potential resources. in addition, since war I, domestic production climbed steady, reaching over 1,000,000 tons in 1956. Moreover, ninetieth of mineral is employed in industry for lubricating substance and 100% in chemical and different industries in several processes and merchandise. in step with Oden [3], Benue trough is Nigeria's main, however not exclusive supply of mineral mineralization. moreover, there square measure a minimum of 10 mineral fields within the trough, every containing swarms of veins or concordant stratiform minerals flats of hydrothermal origin.

Additionally, there are only two vein trends in the trough: the NW-SE trend, which tends to be orthogonal to the axis of the trough; and the N-S to NNE-SSW trend, which is younger than the former. Both vein sets are formed from ac tension joints reflecting different post-sedimentary deformation phases in the trough. The NW-SE veins also are additional frequent than the N-S veins, virtually within the ration of 2:1. in step with Geosciences News and data of 2005- 2019, mineral (PbS) is that the world's primary ore of lead from an oversized range of deposits in several countries. It is found in igneous and metamorphic rocks in medium to low temperature hydrothermal veins. Additionally, in sedimentary rocks it occurs as veins, breccia cements, isolated grains, and replacements of limestone and dolostone. In Lead-acid batteries, the lead from Galena is used to start automobiles. It is pertinent noting that Lead from Galena is one of the metals used in energy storage systems associated with power generation and hybrid vehicles.

The aim of this study is to investigate some part of Iyamitet village for Barite-Galena mineralization [1].

2. THE STUDY AREA

2.1 Location of Study Area

Iyamitet is a settlement within Cross River State in Southern Nigeria. It is located between longitudes 5.8660390 and 5.8522070N latitudes 8.32661390 and 8.3449370E. Fig. 1 shows the location map of Iyamitet relative to the Cross-River state of Nigeria.

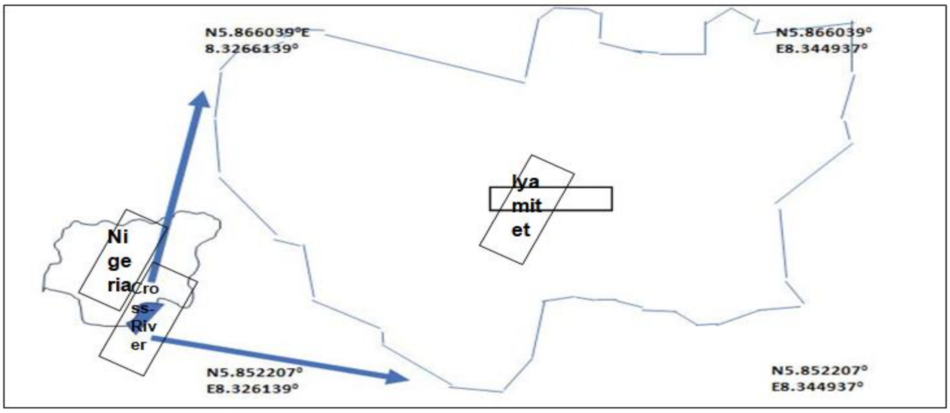

Fig. 1. Location map of the study area showing Iyamitet [1]

2.2 Geology of the Study Area

The geology of the study area (Fig. 2) is very diverse. It can be classified into structural units comprising; Calabar flank, Mamfe embayment, Oban massif and Obudu plateau. The Calabar flank and Mamfe embayment are sedimentary basins of Cretaceous-Tertiary age which lie unconformably on the Oban massif and Obudu plateau constituting part of the Pre-Cambrian basement complex of Nigeria (Fig. 2). The Calabar flank occurs within the southernmost region of the area and bounded in the North by the Oban massif and by the Calabar hinge line which delineates it from the Niger Delta in the west. The basin is associated with crustal block faults which resulted in a horst and graben structure trending NW–SE (Simpson, 1954). Deposition in the area was controlled by the tectonics of the horst and graben structure, and by eustatic sea level changes within the Southern Atlantic Ocean. Sedimentary rocks within the Calabar flanks include sandstones, limestones, calcareous sandstones, Shales, marls, siltstone, etc. Most of these rocks are highly fossiliferous, and this is attributed to the location of the Calabar flank on the Southern Atlantic Sea board, which was under constant marine transgression [4]. [5] recognized 3 carbonate lithofacies in the Calabar flank which include basal limestone, fossiliferous limestone and dolomitic limestone associated with calcareous limestone of the area. These carbonate lithofacies are most likely members of the Albian Asu River Group, while the associated calcareous sandstone belongs to the Turonian Eze-Aku formation. Sedimentation in the Calabar flank started with the initial deposition of fluvio–deltaic cross-bedded sands of Awi formation [6] in early cretaceous. This was followed by the first marine incursions that resulted in the deposition of the platform Mfamosing limestone [7] [8] during the middle Albian. During the Cenomanian and Turonian, subsidence of faulted blocks and widespread deposition of black to dark grey shales occurred with minor intercalations of marls and impure limestone [9]. The Coniacian witnessed continued deposition of thin dark shale beds. These sediments are uncomformably overlain by a dominantly shale lithology with occasional mudstones and thin gypsum beds during the Campannian to Maastrichtian [9].

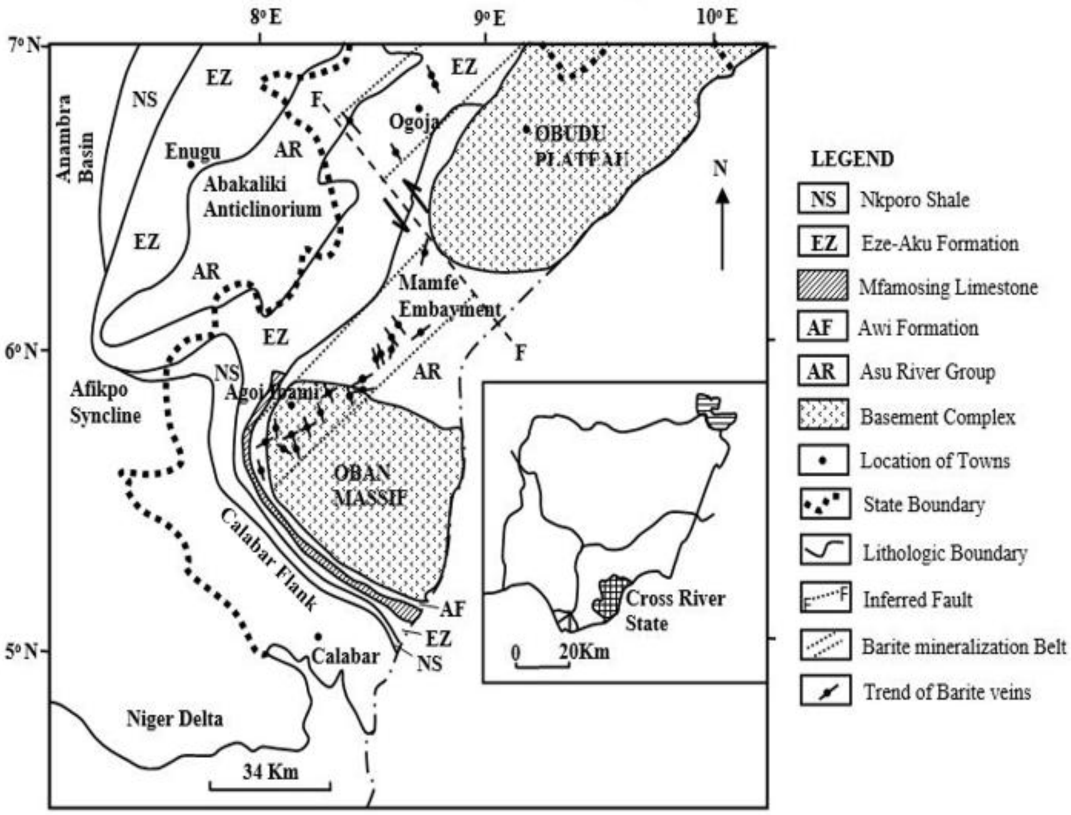

Fig. 2. Geology of the study area [10]

3. METHODOLOGY

Electrical resistivity techniques have over the years being employed for measuring the true resistivity of the subsurface. Ground apparent resistivity is related to various geological parameters such as mineral and fluid content, porosity and degree of water saturation present in rock. Resistivity-related investigations are conducted by passing current into the subsurface using two current electrodes, while the ground response i.e. potential difference is measured using two inner electrodes called potential electrodes. To investigate the subsurface for mineral exploration, it is best to employ both the electrical resistivity and induced polarization (IP) method.

The common electrode array used in resistivity and IP survey includes: Wenner array, dipole-dipole array, schlumberger array, pole-pole array and gradient array.

For this study, five traverses were established in orthogonal directions with 100 m long as shown in Fig. 3. The Dipole-dipole configuration was adopted and the Res2Dinvx software was used for joint inversion of the resistivity and IP data to generate the 2D resistivity and IP image of the subsurface. The images were then interpreted qualitatively and semi-quantitatively to map out the possible mineralized zones within the area.

4. RESULTS AND DISCUSSION

The 2D Electrical Resistivity (ER) and Induced Polarization (IP) models generated from the inversion of the acquired resistivity and IP data are shown below.

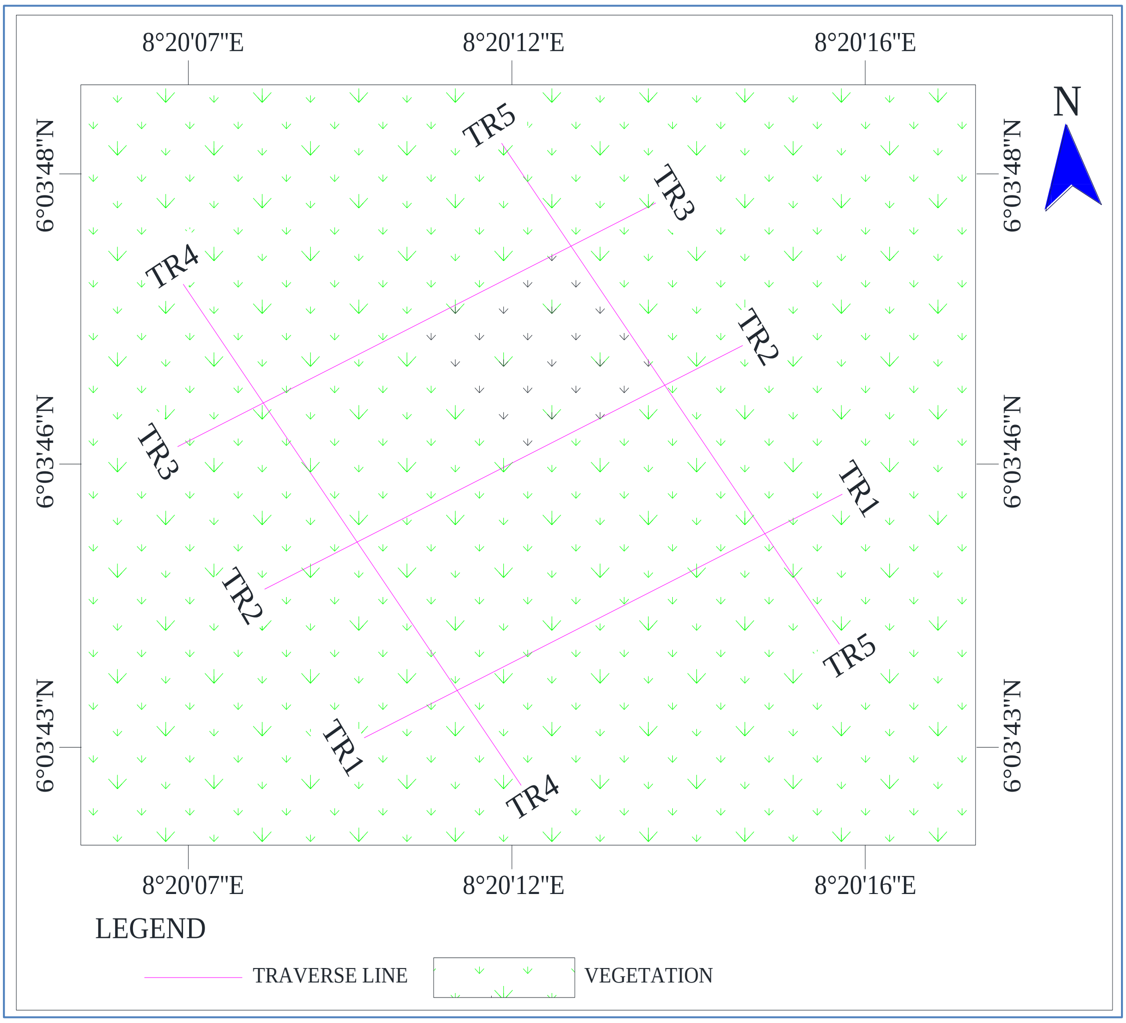

Fig. 3. Basemap of the study area showing the traverse lines

Fig. 4 (a and b) shows ER and IP cross-sections along traverse one. The ER shows values ranging from < 3ohm-m to > 10069 ohm-m while the IP values ranges from < -76.4 mV/Sec to >354 mV/Sec. The total depth of penetration is 24.0 m. The resistivity section shows that the subsurface along the traverse is majorly made of three layers including the topsoil, the weathered layer (yellow – green colour) and the fresh basement with the highest resistivity (red – purple colour). The sections show that the mineralized zone is within the weathered layer and also within the partly fractured basement. The arrows indicate the mineralized zone. The zones are characterized by high resistivity (1023 ohm-m to >10069) and high chargeability (232 mV/sec to >356 mV/sec) at lateral distance of 39 – 55 m.

The ER and IP cross-sections along traverse two are shown in Fig. 5 (a and b). The ER shows values ranging from < 5.6 ohm-m to > 78179 ohm-m while the IP values ranges from < -47.3 mV/Sec to >727 mV/Sec. A total depth of 24.0 m was imaged. The resistivity section shows that the subsurface is highly inhomogeneous from top to a depth of about 15.9 m. This region of high inhomogeneity is thought to represent the topsoil and the weathered layer which serves as host for the barite-galena ore. A zone of high resistivity value at lateral distance of 38 – 42 m which also correspond to high chargeability though with little lateral shift is suspected to be the mineralized zone. The depth to the top and bottom of this anomalous zone falls at 1.25 m and 9.26 m respectively.

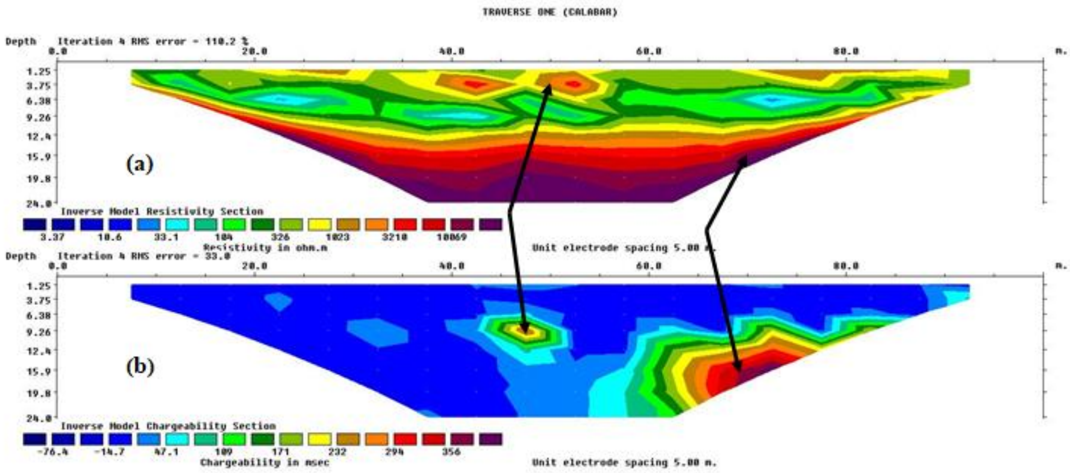

Fig. 4. 2D Resistivity and chargeability section along traverse one

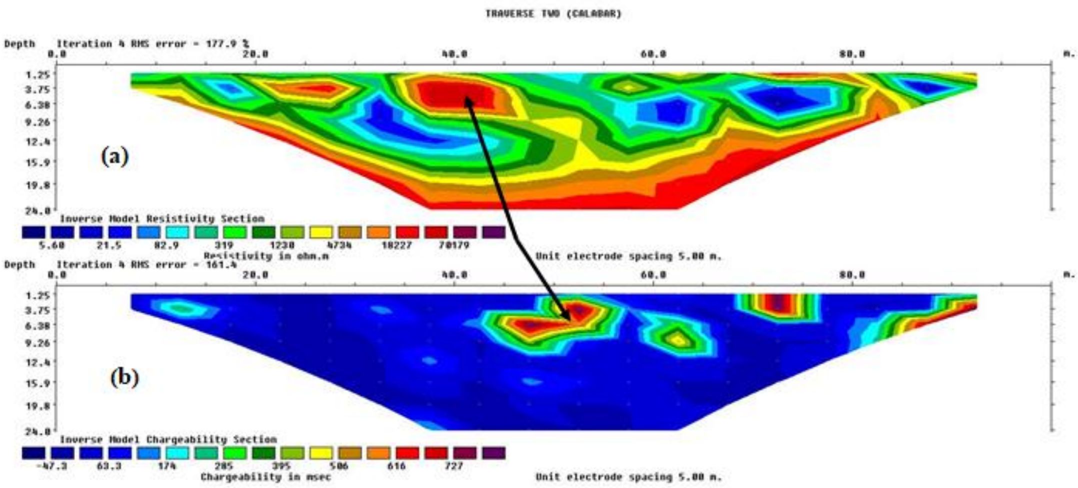

Fig. 5. 2D Resistivity and chargeability section along traverse two

The inverted ER and IP data generated along traverse three are displayed in Fig. 6 (a and b). The resistivity values ranges from < 0.218 ohm-m to > 54923 ohm-m while the IP values ranges from < -81.1 msec to >402msec. A total depth of 24.0 m was imaged. The resistivity section shows that the subsurface is highly inhomogeneous from top to a depth of about 15.9 m. The barite-galena ore is suspected to be located within the region of high inhomogeneity thought to represent the topsoil and the weathered layer. A lateral distance of 40 – 50 m on both ER and IP sections and depth of about 3.75 m having resistivity value of about 1573 ohm-m and chargeability of about 402 msec is suspected to represent the mineralized zone as indicated by the arrows.

The inverted ER and IP data along traverse four is given in Fig. 7 (a and b). The resistivity distribution beneath this traverse is as low as < 1.31 ohm-m and as high as > 111742 ohm-m showing the level of inhomogeneity of the subsurface. The IP values fall between < -63.8 msec to >725msec. A total depth of 24.0 m was imaged. The barite-galena ore is suspected to be located within the region indicated by the arrows. These fall at regions of high resistivity and high chargeability. The depth of occurrence ranges from 1.25 m to as deep as 24.0 m. The mineralized zone falls with lateral distance of 22 – 62 m on both ER and IP sections.

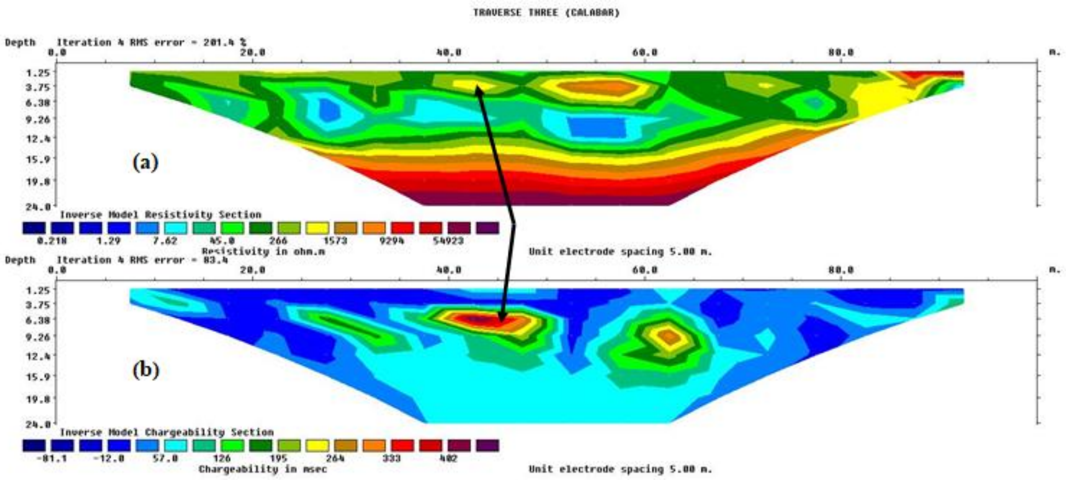

Fig. 6. 2D Resistivity and chargeability Section along Traverse Three

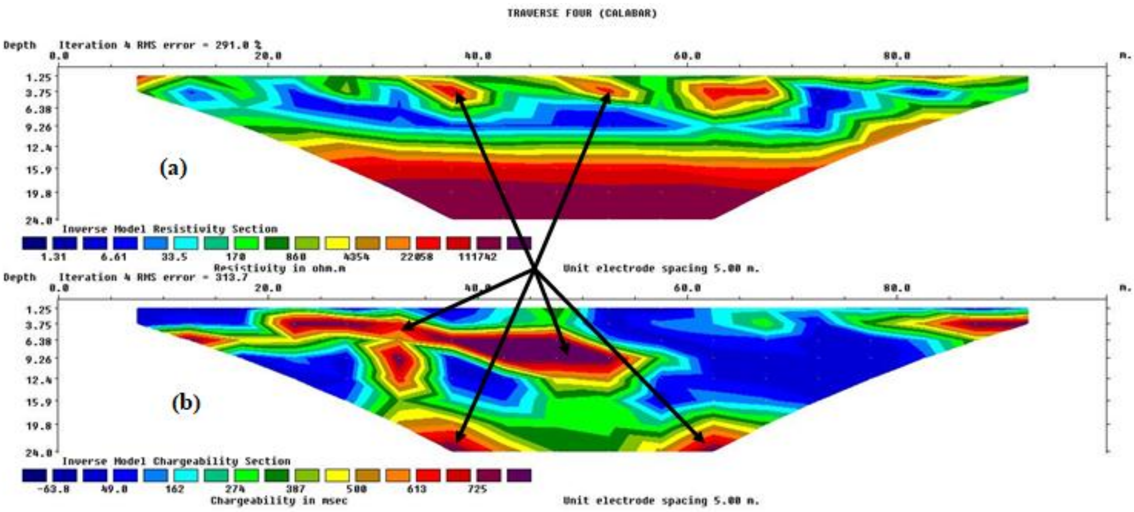

Fig. 7. 2D Resistivity and chargeability section along traverse four

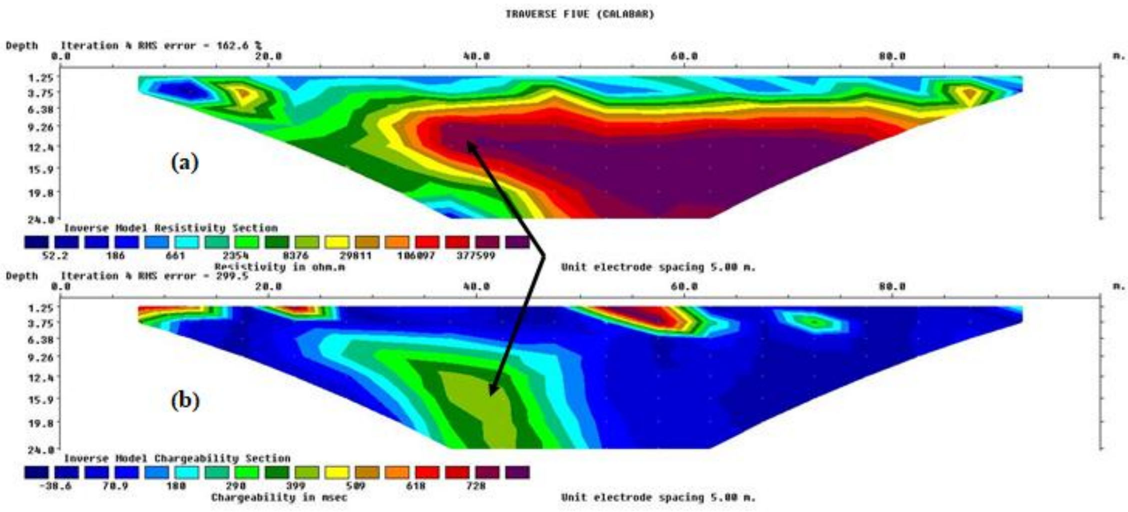

Fig. 8. 2D Resistivity and chargeability section along traverse five

The resistivity and induced polarization structure beneath traverse five displayed in Fig. 8 (a and b) shows the resistivity value beneath this line ranges from 52.2 ohm-m to 377599 ohm-m while the IP values fall between <38.6 msec to >728 msec. A total depth of 24.0 m was imaged. The barite-galena ore is suspected to be located within the region having high resistivity and high chargeability as indicated by the arrow. The mineralized zone is located at lateral distance of 30 – 45 m on both ER and IP sections and depth to top of the mineralized zone of 6.38 m.

5. CONCLUSION

The electrical method of geophysical prospecting involving 2D electrical resistivity and Induced Polarization techniques has been employed for characterizing the subsurface at Iyamitet area of Cross-River State of Nigeria to delineate the emplacement of mineralized veins within the area. The Dipole-Dipole electrode configuration was adopted and Res2Dinvx software was used for joint inversion of both the resistivity and Induced Polarization data. The result of the study highlighted the presence of the Barite-Galena ore which manifested as high resistivity and high chargeability along the traverses. The resistivity values of the suspected mineralized zones fall between 1023 ohm-m to 377599 ohm-m and the chargeability falls between 232 msec to 727 msec.

The result of this investigation gives the efficiency of joint geophysical techniques in locating mineral deposit in a basement area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Akinde AS, Dikedi PN, Ogharandukun MO. Adopting Geo-electric Approach in Mineral Characterization of Iyamitet Settlement. J Geol Geophys. 2019;8(4):466
2. Brobst DA. Mineral resources of the United States, Geological survey bulletin 1072-b, United States government printing office, Washington; 1958.
3. Oden, MI. Barite veins in the Benue trough: Field characteristics, the quality issue and some tectonic implications. Environ Nat Resour J; 2012.
4. Ekwueme BN. The Precambrian Geology and evolution of the southeastern Nigerian Basement Complex. University of Calabar Press. 2003;135.
5. Ekwueme BN. Structural orientations and Precambrian deformational episodes of Uwet area Oban massif, SE Nigeria. Precambrian Research. 1987;34(3-4):269-289.
6. Adeleye DR, Fayose FA. Stratigraphy of the type section of Awi formation, Odukpani area, southeastern Nigeria. J. Min. Geol. 1978;15:33-37.
7. Foster R. Evidence of an open seaway between northern and southern proto-Atlantic in Albian times. Nature. 1978;272: 158-159.

8. Petters SW. Central West African Cretaceous – Tertiary benthic foraminifera and stratigraphy paleontographical. Abt A. 1982;179:1-104.
9. Nyong EE, Ramanathan RM. A record of oxygen-deficient paleo-environments in the Cretaceous of the Calabar Flank, SE Nigeria. Journal of African Earth Sciences. 1985;3(4):455-460.
10. Ajadi J, Adeleke RA. An appraisal of the barite resources of cross river state, southeastern Nigeria: origin, distribution and economic potentials. International Journal of Current Research. 2017;9(06): 52338-52347.

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