International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 15, Issue 1 [January 2026] PP: 136-145

Appraisal Of Ore Bodies in Abakaliki/Ikom Using Resistivity and Remote Sensing

[1]Christopher I. Effiong, [2]Allen Charles Andy, [3]Promise James Akpan
[1] Department of Geoscience, University of Uyo, Nigeria
[2] Department of Geology, Akwa Ibom State University, Ikot Akpaden
[3] Department of Physics, University of Uyo, Nigeria.
[1]Corresponding Author

ABSTRACT
This study examined the application of electrical resistivity and remote sensing techniques for the appraisal of ore bodies in Abakaliki/Ikom and its environs.The study area lies between latitudes 5°30′–6°30′N and longitudes 8°–9°E. Resistivity and remote sensing data were used for the study. The study was carried out to determine depth structural and tectonic features associated with the area and infer the effects of these features on the ore bodies prospectivity of the area. Resistivity and remote sensing data were subjected to various image, data enhancement and transformation routines. Maps such as drainage map of the area, lineament density maps, rose diagram and resistivity/profile maps of the study area were generated for the analysis. The dominant structural trend direction of the study area is in the N-S direction. Other lineament trend directions are in the E – W, NE – SW and NW- SE directions. The lineament density maps revealed the presence of highdensity fracture zones around Ikom, Boki and Akamkpa areas. The recovery of several tons of barite in the area shows that ore bodies occurrence in the area is high.

Date of Submission: 10-01-2026 Date of acceptance: 23-01-2026

I. INTRODUCTION:

Since the discovery of ore bodies in Abakaliki and Ikom areas, mining activities followed shortly. Mining companies have found good quality ore bodies like lead/zinc, magnetite manganese oxide and barite in this area.

Just as our society is critically dependent on petroleum products for its energy requirements, it is equally dependent on mineral supplies for maintenance of the industrial economy which is the basis of our modern civilization. The rate at which such mineral supplies are being extracted to suite the increasing demands of an ever-expanding economy has created great concern among economic geologists lest we run out of critically important minerals sooner than is generally realized. In the past many minerals were at times in troublesome surplus, it now appears that the world is about to enter a period when shortages of several minerals may well develop in the next decade

The use of satellite imagery for regional mapping of geologic units and structures has long been demonstrated as a vital tool for regional geologic mapping. This is as a result of its ease of operation, speed, accuracy, low cost and coverage. Acquisition of data by remote sensing is among the technological advancement that has been realized, and in geological aspect, the technique is normally used in acquiring earth's surface geological data for instance structural features, lithologies, lithogical sequences and relative age of rocks strata (Onuha et al 2011). Remote sensing is nowadays intensively used in mineral explorations(Effiong et al 2025). Example, Land sat Thematic Mapper (TM,) Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) images are some of the remote sensing data that are frequently used in geological exploration and mapping of hydrothermal alteration zones.

Near Infrared (NIR), Mid infrared (MIR) and Shortwave infrared (SWIR)electromagnetic windows in remote sensing are very useful in geological analysis. Example, for Land sat thematic mapper (TM) data, band-5 and band-7 have been proved to be more successful in discriminating different rock types and effective in identifying zones of hydrothermal alteration (Onuha et al 2011). Similarly, interpretation of satellite imagery has found application in producing new geologic maps as well as revision of old ones.

On the other hand vertical electrical sounding gives information on the vertical distribution of resistivity on a geologic section. This method is based on the fact that the fraction of electric current penetrating below any particular depth increases as the separation of current electrodes increases(Effiong et al 2025).

In the present study, integrated geophysical methods: Semote sensing and resistivity will be used to access the mineral prospectivity of the Abakaliki/Ikom and environs in the Lower Benue Trough of Nigeria

II. LOCATION AND GEOLOGIC SETTING.

The study area is part of the Lower Benue trough. It covers part of south eastand part of south south Nigeria. It is located between latitude $5^0 30'$ – $6^0 30$N and longitude 8^0 - 9^0 E as seen in figure 1. The area is bounded in the north by Gakem and Abuochiche communities in Cross River State and some southern communities in Benue State. The eastern part is bounded by Sankwala community in Obudu local government area of Cross River State and the Republic of Cameroun. The western part is bounded by parts of Afikpo, Onicha, Ishelu and Ezza North local government areas of Ebonyi State. The southern part is bounded by parts of Akamkpa and Odukpani local government areas of Cross River State. Accessibility seems to be highest in the dry season because by that time almost all streams are dried up, and seasonal streams are converted into temporary passable route to villages and farmlands.

The relief of the area is made up of high peaks and low lying ridges. Most of the ridges have been dissected by streams. The sandstone form dome structures. Other positive relief features are due to igneous intrusions at various locations, outcrop of basement and the Anticlinorium in Abakaliki area of the study area. The temperature ranges from 24.5^0C to 34.5^0C. The study area is characterized by an equatorial climate with a mean annual rainfall of between 2000 and 2500mm per year. (Effiong et at 2017). This abundant rainfall feed an extensive hydrogeological system. The hottest month of the year is February and March whose mean daily temperature exceeds 32^0C, while the coolest period is between July and August where mean daily temperature is about 26^0C. The relative humidity is usually high throughout the year; values above 70% are recorded for places like Nko while Ijiman, Idomi and Abakaliki have theirs ranging less than 70%. According to Effiong et al 2025 this value is observed to decline regularly towards the north. Vegetation in the area is dominated by tropical rain forest with tall trees of about 40 to 50m height.

The area is drained by six major rivers which are Okwo, which drains from east to west, the Uhuru, Calabar and Ebonyi rivers which runs north through south of the mapped area, another one is the Lokpoi, which trends in the northeast direction and the major one being the River Cross running in the northeast -southwest direction of the study area. The drainage density in the area is 0.53 and frequency is 0.87.The drainage pattern in the mapped area is dendritic, rectangular and angular. Stream flows occurs along structural planes and other planes of weakness. The most striking feature in the mapped area is the occurrence of numerous dry gullies in the field. These gullies contain water during the wet season and thus serve as streams where farmers collect their drinking water.

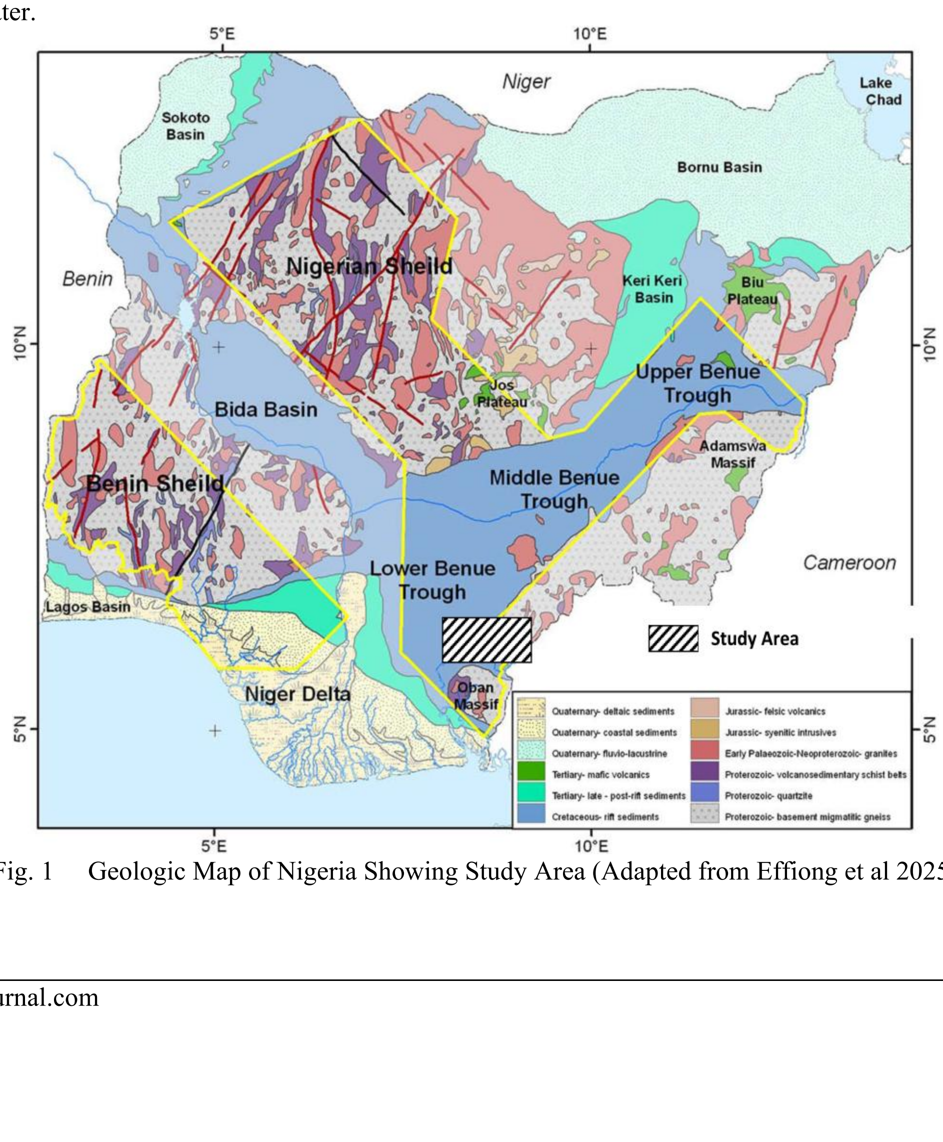


Fig. 1 Geologic Map of Nigeria Showing Study Area (Adapted from Effiong et al 2025)

III. METHODOLOGY

Resistivity and land sat data were used for this study.

Land sat Thematic Mapper (Land sat -TM) imagery acquired from NASRDA, Nigeria was used to map linear structures in the study area. The raw data were geoinferenced using the coordinates of the topographic sheets in the study area. The geoinferencing was carried out using the Universal Transverse Marcator (UTM). Image processing enhancement and analysis were carried out using ILWIS 3.1 Academic software. Image enhancement operations carried out on the imagery include contrast stretching, spatial filtering and edge detection. Also Arc View 9.3 software was used to extract lineaments and carry out statistical analysis of the interpreted lineaments in the area. Several maps such as geologic map, lineament map, lineament density map, drainage map, rose diagram were produced

The resistivity meter employed in this study was the Abem SAS 300 Terrameter calibrated with a 33 ampere resistor. This was powered by a 12-volt DC power source. It has a digital, self averaging instrument for DC resistivity work and can display directly the value of resistance. The instrument is capable of storing and recalling signals. The ABEM Terrameter is capable of compensating automatically for self – potential, its drift and polarization at the electrodes. The current used in the survey was tapped from the DC power source which was attached at the bottom of the Terrameter. The output of this current from the Terrameter was then introduced into the earth through the electrodes. Most resistivity meters utilize low frequency alternating current sources rather than direct current. This is because such low frequency alternating currents with periodic alterations of current prevent accumulation of ions thereby overcoming polarization by electrolysis. Secondly such frequency alternating current overcomes the effect of telluric currents which are naturally occurring electric currents in the ground that flows parallel to the earth's surface causing regional potential gradients(Aka et al 2022).

4. **Appraisal Of a Baryte Mineralization Site in The Study Area –Akpet Central ($8^0$06'E – $8^0$09'E and $5^0$35'N - $5^0$39')**

Both vertical electrical sounding and horizontal resistivity profiling were performed in conjunction with surface geological mapping in the area. The measured data were interpreted using conventional curve matching techniques and iterative computer modeling. Results show that barite occur in the area within a depth of 5m in the subsurface at the site. There is mining activity in the area and the recovery of about 12 tones of baryte shows that the ore bodies prospectivity in the area is high. Figure 7 shows a graph of apparent resistivity against stations at the baryte site. Table 7 shows thickness estimate of baryte bodies based on vertical electrical sounding data while table 8 shows width of baryte bearing zones based on horizontal resistivity profiling data. The plot of apparent resistivity against stations shows the lateral extent of baryte occurrence in the area and AB/2 shows the depth of the different layers..

The vertical electrical stations 1, 2,3 and 4 were located in horizontal resistivity profiling line number 4. This gave a volume of 56.4m^3 of baryte occurrence in that line.

Table 1: Thickness estimate of baryte mineralization based on VES data

VES	Layer Number	Depth Larger	Thickness
1	2	4.6-16.8	12.0
2	2	2.6-9.4	6.8
3	2	1.5-12.0	11.5
4	2	1.6-13.0	16.4

Vertical scale 1cm = 500 Ωm

Horizontal scale 1cm = 1m

Table 2: Width estimate of baryte mineralization based on HRP

Line	Range of Stations	Width of Zones (m)
HRP 1	13-29	16
HRP 2	7-27	20
HRP 3	11-28	7
HRP 4	9-29	20

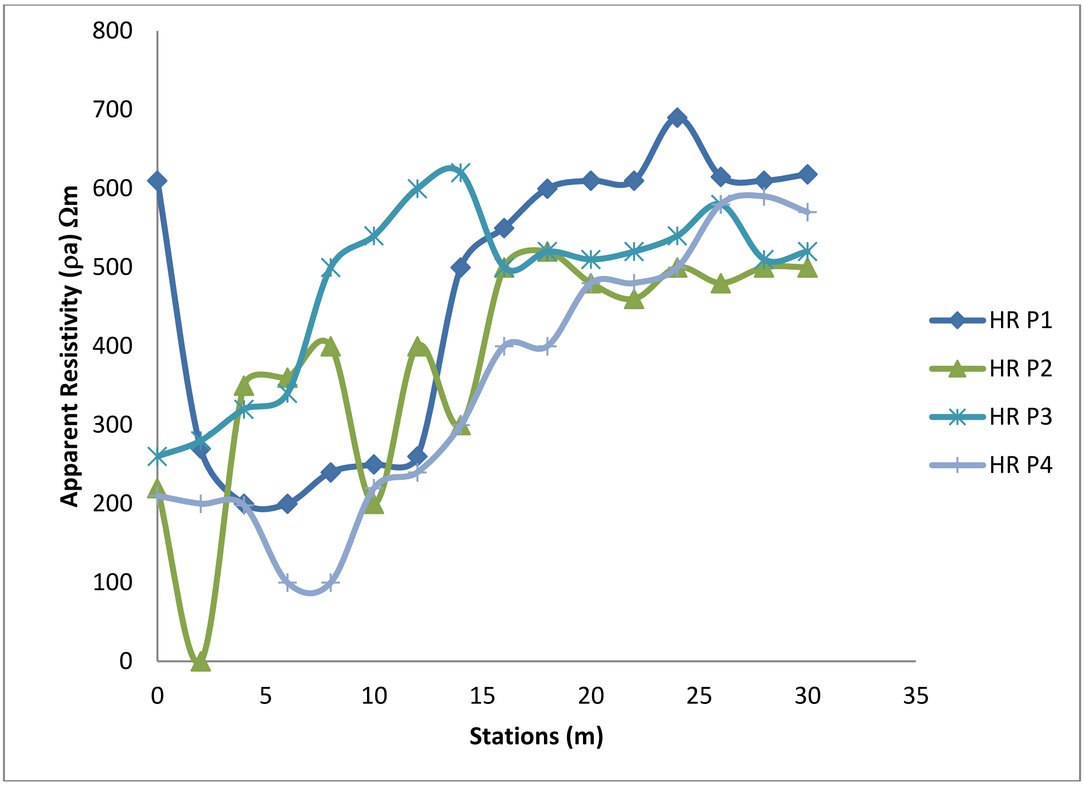


Fig. 7: Graph of Apparent Resistivity (ρa) Against Stations for HRP 1, 2, 3, and 4

IV. RESULT AND DISCUSSION

Lineaments are surface expression of subsurface deformation that reveals the hidden architecture of the basement rock (Effiong et al 2017). However Ekwueme 2004 and Ekott et al 2021 defines lineament as a mapable, simple or composite linear feature of a surface whose parts are aligned in a rectilinear or slightly curvelinear relationship and which differ from the pattern of adjacent features and presumably reflects some subsurface phenomenon. The lineament and lineament density maps (figures 2 and 3) reveal high concentration of lineament within the basement rocks. Lineaments in this area cross – cut each other and some run parallel to each other. This implies that the area has gone through many tectonic events(Petters 2010). The concentration of lineament in an area indicates the level of tectonic activity in the area (Nedal 2014, Aka et al 2022). The lineaments image of the study area reveals that lineaments traces are seen along the drainage channels which suggest that they may be lineaments of hydrographic origin and that the river may be structurally controlled as seen in the drainage map of the study area in figure 4(Ekott et al 2021). There is dense concentration of lineaments around Ikom, Etung, Akamkpa, Yala and Obubra (figures. 4 and 5). This suggests that these areas are strongly deformed and has a good prospect for ore bodies(Effiong et al 2017, Aka et al 2022).Lineaments quantification and statistical analysis were done regarding the orientation and frequency of these lineaments to reconstruct a rose diagram. The rose diagram (figure 6) shows a peaks of preferential direction, N-S

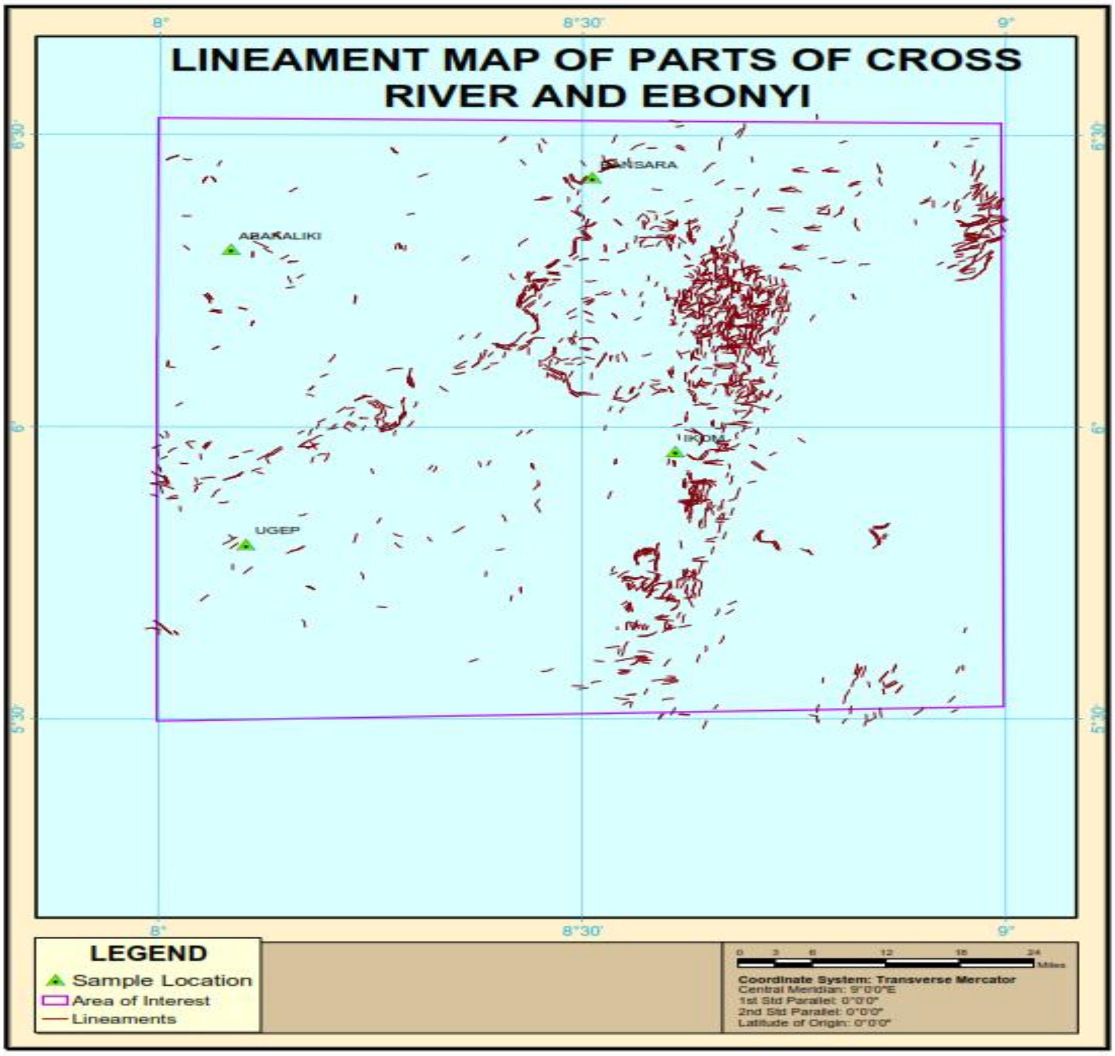


Fig.2 . Lineament Map of the Study Area.

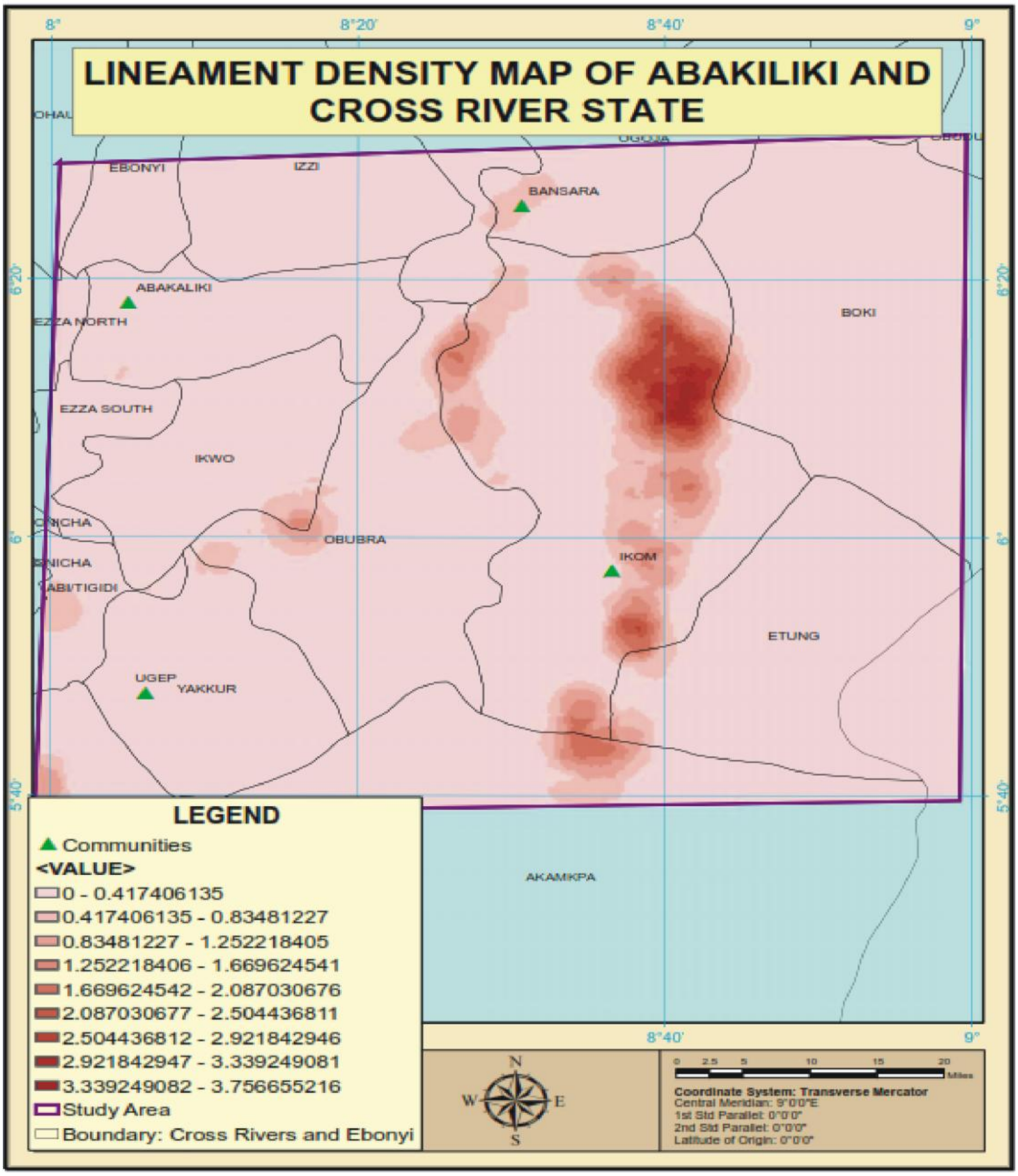


Fig3. Lineament density map of the study area

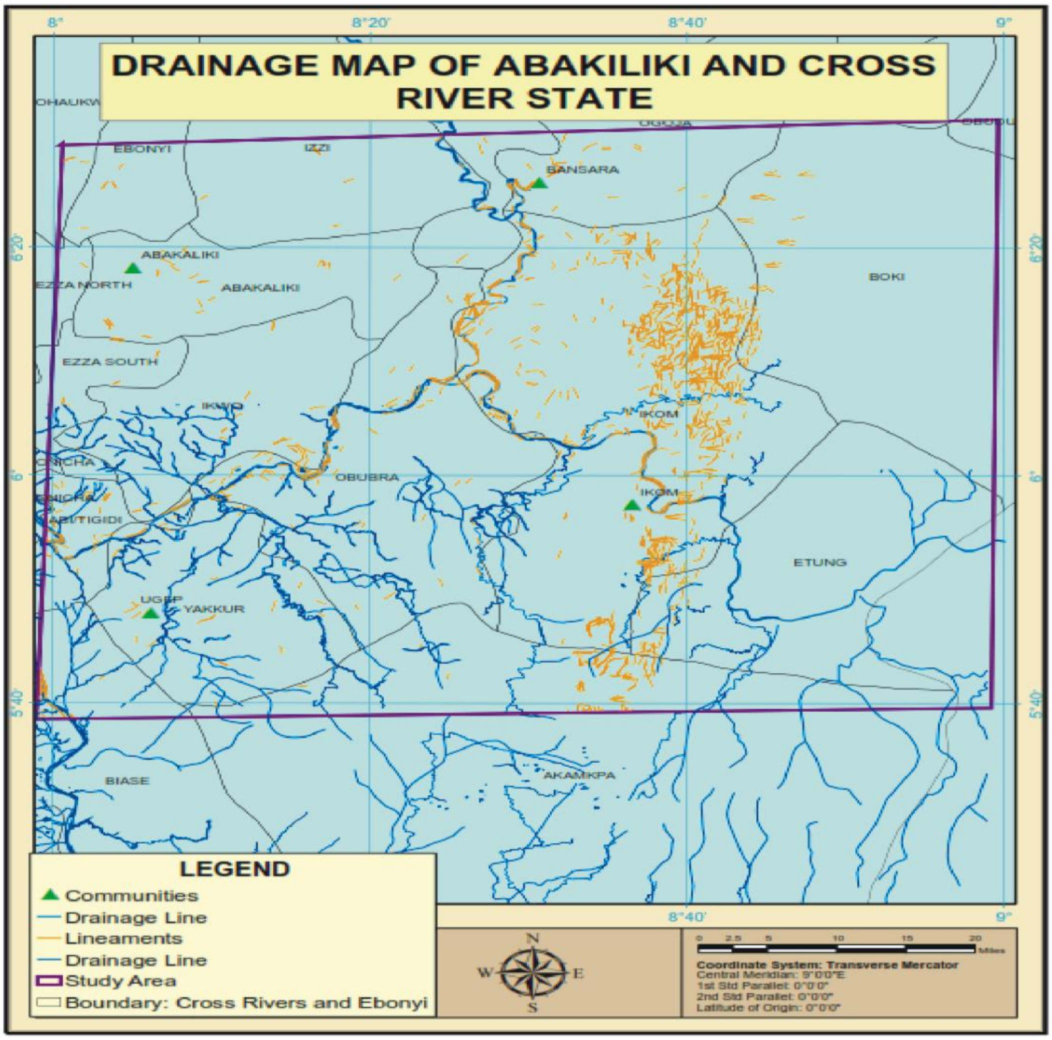


Fig.4 Drainage map of the study area.

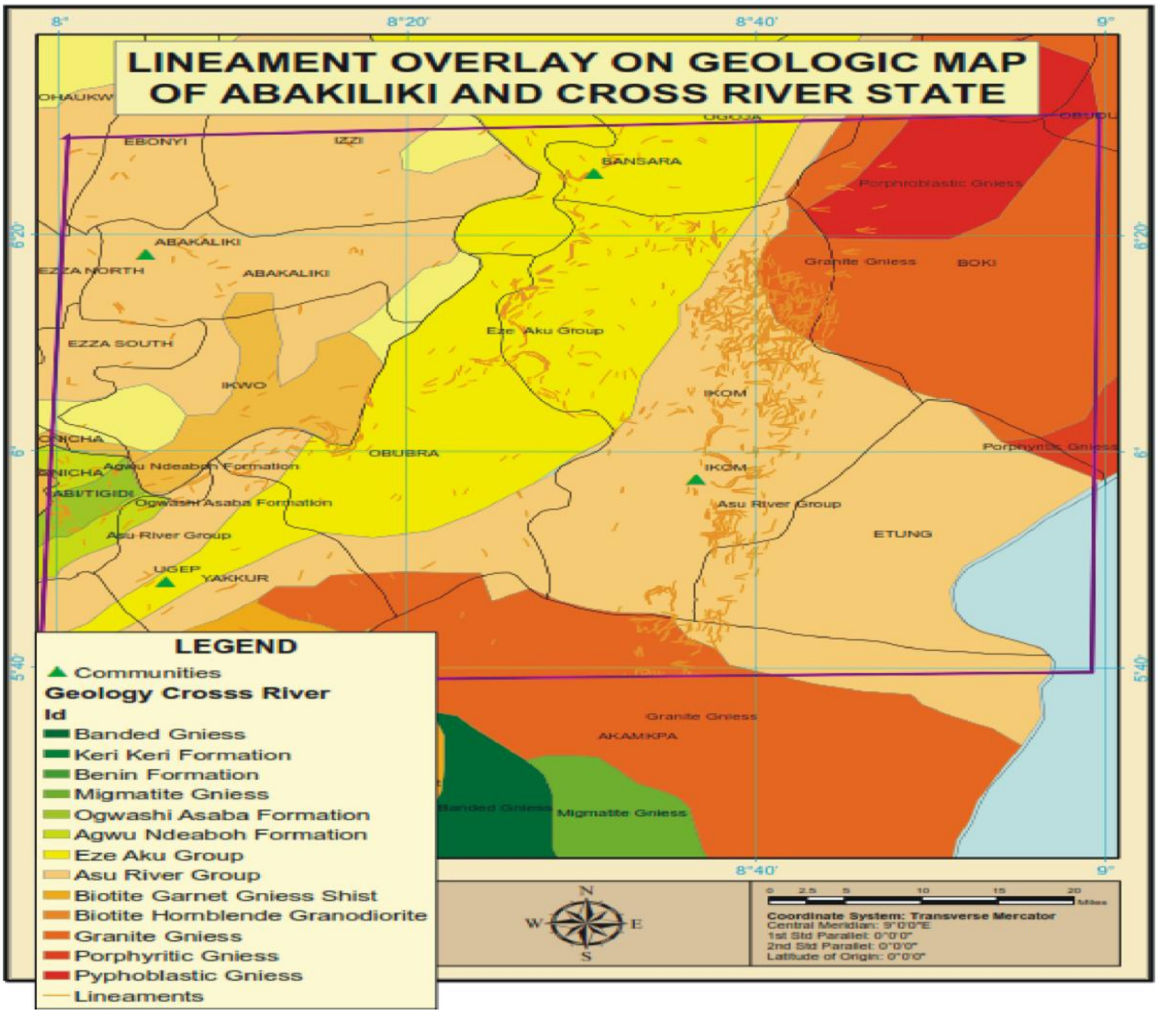
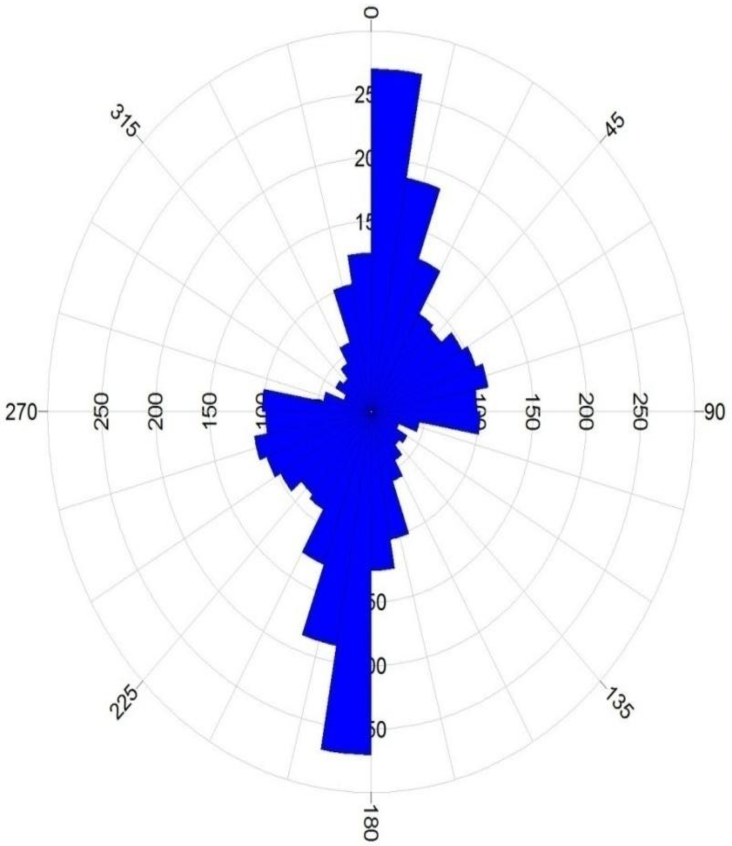


Fig. 5 Lineament overlay on Geologic Map



Rose Diagram

Statistical Summary	
Calculation Method:	Frequency
Class Interval:	10.0 Degrees
Azimuth Filtering:	Deactivated
Data Type:	Bidirectional
Population:	1,741
Total Length of All Lineations:	3,482.0
Maximum Bin Population:	270.0
Mean Bin Population:	96.72
Standard Deviation of Bin Population:	58.36
Maximum Bin Population (%):	7.75
Mean Bin Population (%):	2.78
Standard Deviation of Bin Population (%):	1.68
Maximum Bin Length:	270.0
Mean Bin Length:	96.72
Standard Deviation of Bin Lengths:	58.36
Maximum Bin Length (%):	7.75
Mean Bin Length (%):	2.78
Standard Deviation of Bin Lengths (%):	1.68
Vector Mean:	21.6 Degrees
	201.59 Degrees
Confidence Interval:	4.4 Degrees
	(80 Percent)
R-mag:	0.28

Fig.6. Rose diagram of the study area.

V. Discussion

A detailed geophysical study of the solid mineral prospectivity of Abakaliki/Ikom and environs was carried out using aeromagnetic, remote sensing and resistivity data. The presence of intrusive bodies and faults in some areas shows that these areas are more tectonically active than others(Effiong et al., 2017). The tectonism is believed to have been initiated during the separation of African and South American land masses (Akanbi and Udensi, 2006).

According to Ekwueme 2004,Pb–Zn mineralization is farther away in the zoning of minerals around an igneous intrusion while tin and copper are closer. The occurrence of Pb– Zn, copper and tin related minerals shows the presence of intrusions in which the minerals are of hydrothermal processes. This is in agreement with the result of investigations carried out by Ekwueme (2004) of various rock samples in Oban and Obudu massifs.

Lineament quantification and statistical analysis were done regarding the orientation frequency of these lineaments to construct a rose diagram. From the rose diagram N–S trend is dominant. Other trends are NE–SW and NW–SE. The NE–SW trend in the study area is in conformity with Opara et al. (2012) suggests a relationship between the Younger Granite of Nigeria and the Benue Trough. This event suggests that the tectonic activity that took place in the Benue trough may have extended to the Younger Granite of Nigeria. However, several other trends are observed which have low frequency on the diagram.

The high magnetic intensity observed around Ikom and Obubra suggest the existence of a relatively deep-seated basement structure. The presence of this structure confirms that the area has been subjected to both regional stress and strain fields.

The present study is therefore in agreement with previous studies which suggested that Nigeria has a complex network of fractures and lineaments with dominant trends of N–S, NE–SW, NW–SE and E–W directions. These linear structures running NE-SW observed from the study are suggested as the continental extension of the known pre-Cretaceous oceanic fracture zones viz; Charcot and Chain fracture zones which run along the trough axis beneath the sedimentary cover (Petters 2010). Therefore, the structural and tectonic facts put in were in accordance with those of previous workers.

VI. Conclusion

The integrated application of remote sensing and electrical resistivity methods proved effective in delineating structural controls and assessing mineral prospectivity in the Abakaliki–Ikom area. Dominant N–S–trending lineaments, with subsidiary NE–SW, NW–SE, and E–W trends, reflect intense tectonic deformation that strongly influences ore localization. High lineament density zones around Ikom, Akamkpa, and adjacent areas indicate favorable conditions for hydrothermal mineralization. Resistivity results confirmed shallow barite occurrences with significant lateral continuity, supported by ongoing mining and substantial recovery. Overall, the structural and geophysical evidence demonstrates high solid mineral potential in the study area and supports the use of integrated geophysical techniques for effective mineral exploration in the Lower Benue Trough.

REFERENCES

[1]. Aka, M. U., Effiong, C. I.,Dianabasi N. A. (2022). Assessment of Nkporo shales in Calabar flank to ascertain its hydrocarbon potentials, South south*Nigeria. Journal of Geology and Geophysics*11 (4):10001027

[2]. Aka, M.U., Ekpa, M. M.,Effiong, C. I. Osu, A. D. Ibout, J. C. (2022). Integration of seismic refraction and laboratory test techniques for slope stability analysis South–South Nigeria. *Earth Sciences Malaysia* 6(1): 50-55

[3]. Akanbi, E. S., Udensi, E.E. (2006). Structural trends and structural depth analysis of the residual field of Pategi Area, Nigeria; using aeromagnetic data. *Nigeria Journal of Physics*, *18*(21): 271-276

[4]. Effiong, C. I, Ekott, A. E., Bassey, C. E and Udoh, A.C. (2017). Utilization of aeromagnetic and Land Sat data for structural interpretation: acase study of Ikom-Mamfe Embayment Southeastern Nigeria. *American Journal of Engineering Research.*6 (9):232-247.

[5]. Effiong, C. I, Ekott, A. E., Bassey, C. E and Udoh, A.C. (2017). Magnetic Basement Depth Re-Evaluation of Abakaliki/Ikom and Environs Southeastern Nigeria Using 3-D Euler Deconvolution. *Global Scientific Journals*5 (9):120-138.

[6]. Effiong, C. I., Allen, C. A.(2025). Resistivity and magnetic mapping of sediment basement contact between Calabar flank and Oban massif South-south Nigeria. *International Journal of Research Publications and Reviews* 6 (10):2221-2227

[7]. Ekwueme, B. N (2004). *The Precambrian Geology and Evolution of the Southeastern Nigeria Basement Complex.* 7 -14

[8]. Nedal, Q. (2014). Utilization of Space-Borne Imagery for Lithologic mapping; case study of from Um Had area, Central Eastern Desert, Egypt. *Journal of Geography and Geology* 6(2), 113 – 123.

[9]. Okereke, C. N., Ananaba, S. E., (2006). Deep crustal lineament inferred from aeromagnetic anomalies over the Niger Delta, Nigeria. *Journal of Mining and Geology,* 42,127-131

[10]. Okereke, C. S., Onwumesi, G. A (1989). Gravity anomalies in the Nigerian sector of the Mamfe basin. *Journal of Minning and Geology* 25(1 & 2): 211–214.

[11]. Onyedim, G.C., Awoyemi E. A. (2006). Aeromagnetic mapping of the basement morphology in the part of the middle Benue Trough. *Journal of Mining and Geology* 42(2). 157 -163.

[12]. Onyedim, G. C., Awoyemi, E.A. (2006). Aeromagnetic imaging of the basement morphology in the part of the middle Benue trough. *Journal of mining and Geology*, *42*(2), 157-163.

[13]. Opara, A. I. (2011). Estimation of the depth to magnetic basement in part of the Dahomey basin, southwestern Nigeria. *Australian Journal of Basic and Applied Sciences*, *5*(9), 335 – 343.

[14]. Opara, A. I., Ekwe, A. C., Okereke, C. N.,Oha, I. A.,Nosori, O. P. (2012). Integrating airborne magnetic and land sat data for geological interpretation over part of the Benin basin, Nigeria. *The Specific Journal of Science and Technology. 556 - 571*

[15]. Opara, A.I (2011). Estimation of the depth to magnetic basement in part of the Dahomey basin South Western Nigeria. *Australian Journal of Basic and Applied Sciences* 5(9), 335-343.

[16]. Petters, S.W. (2010). Southern Benue trough and Ikom-Mamfe embayment. Geological Excursion Guide Book to Oban Massif, Calabar flank and Mamfe Embayment. Southeastern Nigeria. Pu. Dec Oxford Publications. Calabar.