

**Advances in Research**  
2(12): 730-739, 2014, Article no. AIR.2014.12.004

SCIECEDOMAIN *international*  
[www.sciencedomain.org](http://www.sciencedomain.org)



---

# Characteristics of Resistivity and Self-Potential Anomalies over Agbani Sandstone, Enugu State, Southeastern Nigeria

Austin C. Okonkwo<sup>1\*</sup> and Benard I. Odoh<sup>2</sup>

<sup>1</sup>*Department of Geology and Mining, Enugu State University of Science and Technology, Enugu, Nigeria.*

<sup>2</sup>*Department of Geosciences, Nnamdi Azikiwe University, Awka, Nigeria.*

## **Authors' contributions**

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

**Original Research Article**

**Received 17<sup>th</sup> December 2014**  
**Accepted 28<sup>th</sup> January 2014**  
**Published 8<sup>th</sup> July 2014**

---

## **ABSTRACT**

The characteristics of the Resistivity and Self-Potential (SP) anomalies over Agbani Sandstone have been carefully and painstakingly carried out. The study was aimed at investigating the possible rock types and their mineralogical potentials. Data was acquired using the high resolution versatile ABEM SAS 4000 resistivity meter, employing the profiling method. Datasets were analyzed using the Excel toolkits. Interpretation was basically qualitative. Based on the resistivity interpretation, Agbani Sandstone is laterally limited in extent while the mineralization potential is high as a result of the high negative SP anomalies. The negative SP values range is -200mV to -500mV. This is practically indicative of a sulphide orebodies – possibly pyrite (FeS<sub>2</sub>). Comparative profile plots show that the observed zones of sulphide orebodies are within the gradational contact of Agbani Sandstone with Awgu Shale. Stream sediment analysis and rock geochemical study are recommended. However, the study has shown that contact zones of sandstone deposits are possibly ore enrichment zones.

**Keywords:** *Self-potential; resistivity; pyrite; Agbani sandstone; enrichment zone.*

---

\*Corresponding author: E-mail: [austinoxdiol@yahoo.com](mailto:austinoxdiol@yahoo.com);

## 1. INTRODUCTION

Agbani is located in Nkanu west local government area of Enugu state (Fig. 1) Nigeria. The Agbani Sandstone is a stratigraphic unit that practically outcrops within Agbani town. It is a lateral equivalent of Awgu Shale. It is Coniacian in age. The surface feature of this sandstone is characterized by the gentle rolling high hills within and around Agbani town. In fact, the Agbani city centre is practically sitting on the Agbani Sandstone, when viewed from Enugu state university campus. Past studies on Agbani Sandstone have been stratigraphic [1] and hydro geological [2]. The present study investigates the mineralization potential of Agbani Sandstone. This is based on the fact that the area was tectonically active during the Santonian movements [3,4] and evidence of weathering is strong. Owing to the geologic importance of the Santonian movement, with particular reference to the way and manner the rocks were deformed and reworked, it is therefore believed that there is accumulation of certain minerals within the crustal layer beneath. Based on the result of the Santonian movements, mineralization process sets in. It is this mineralization process that causes characteristic spontaneous polarization potential anomalies within the subsurface [5,6].

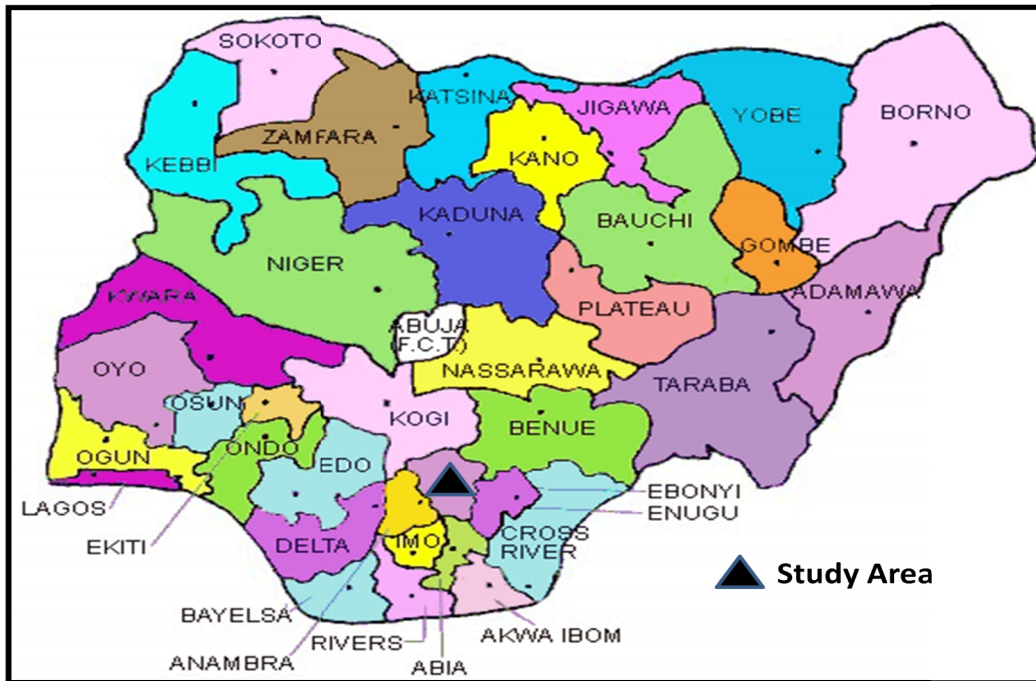


Fig. 1. Map of Nigeria showing the study area.

### 1.1 Location and Physiography

The case study area is the Enugu state university Agbani campus, located in Nkanu west local government, Enugu state (Fig. 1). Agbani is located roughly about 15.9km southeast of Enugu metropolis and about 6.85km northeast of Ozalla town. It is bordered at the west by the Udi highlands, about 5000ft (1524m) above sea level (ASL) and practically situated in

the lowland areas of Akpugo and Amurri about 250ft (76m) ASL. Locally, (Fig. 2) the topography is typically undulating with a maximum elevation of 633ft (193m) ASL.

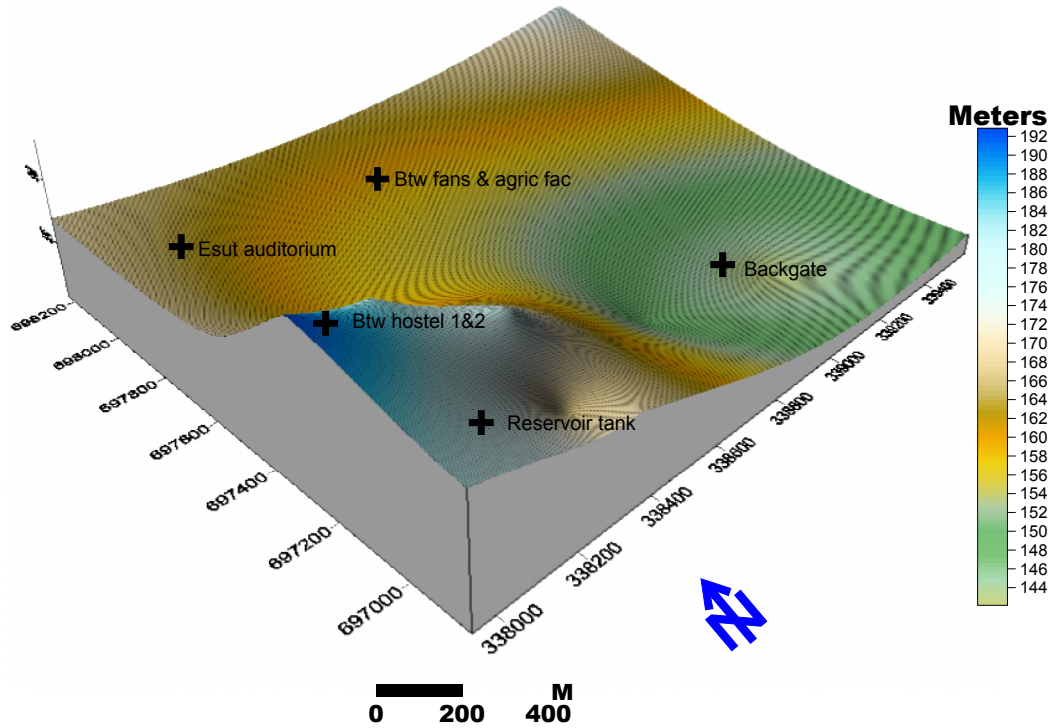


Fig. 2. Surface map of the study area.

## 1.2 Geology

Agbani town, where the study area is located is practically underlain by Agbani Sandstone, (Fig. 3) which is a lateral equivalent of Awgu Shales. It is of Coniacian in age. Agbani Sandstone is quite laterally not extensive, as it outcrops only within the country around Agbani. It consists of medium to coarse grained, white to reddish brown, moderately consolidated at depth and highly consolidated at outcrop areas. Thickness variation is predominant in areas (towns) far from Agbani town centre. The Agbani Sandstone is the reservoir aquifer at Agbani and environs [7].

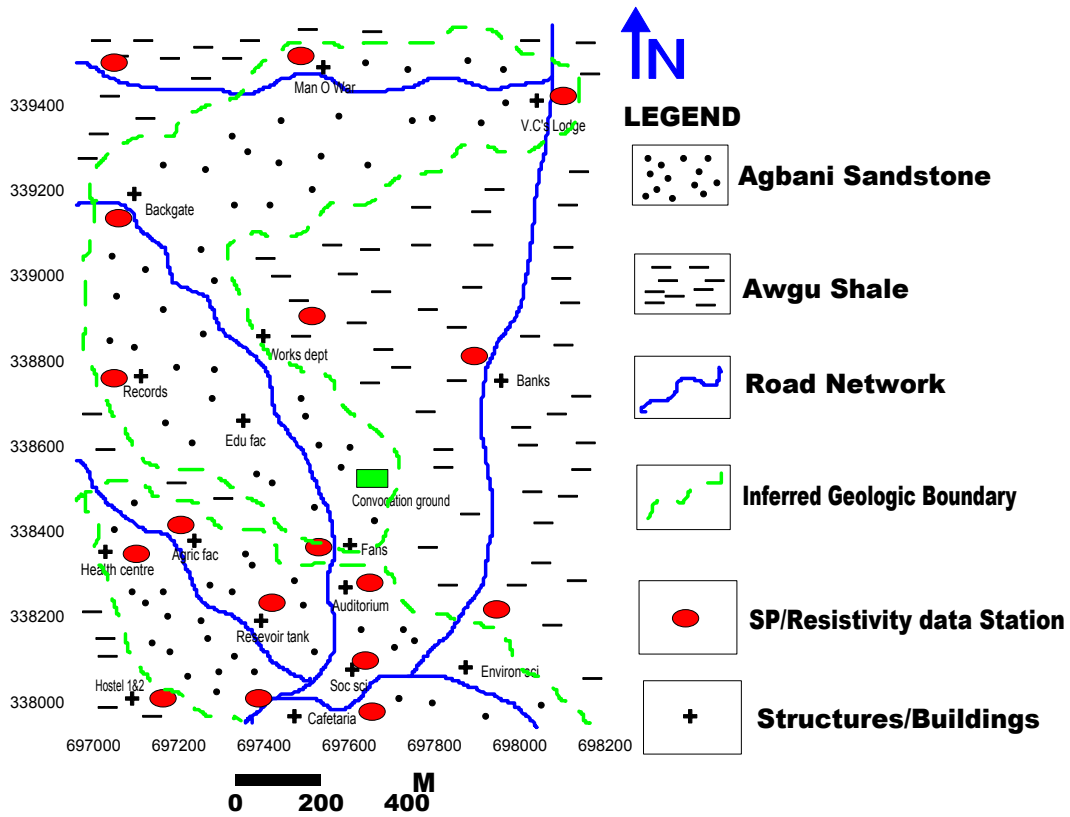


Fig. 3. Geologic map of the study area and SP/Resistivity data station.

## 2. METHODOLOGY

### 2.1 Data Acquisition and Interpretation

Data was acquired where the outcrops of Agbani Sandstone are distinctly exposed (Fig. 3). The high resolution versatile ABEM SAS 4000 resistivity meter (Fig. 4) was used. The two datasets were acquired simultaneously. Of the possible electrode configuration used (Figs. 5 and 6) in measuring resistivity and SP, the Wenner configuration and potential gradient technique was employed in the present study respectively. A total of seven (7) datasets were acquired – four (4) for SP and three (3) for resistivity. Minimum of 50 data points per profile. The electrode separation was 10m while the station distance was 20m. The resistivity data was acquired first. After that the current electrodes were removed. Adjusting the mode to SP, reading for SP was taken by using the two potential electrodes, and then the whole equipment set-up was moved to the next station. The apparent resistivity ( $\rho_a$ ) was computed by using equation 1.

$$\rho_a = 2\pi a R \dots \dots \dots (1)$$

Where “a” is the electrode separation and “R” is the Resistance.

Computed apparent resistivity and SP values were plotted against the station distances using Excel toolkits. Data were interpreted qualitatively.



Fig. 4. The versatile ABEM SAS 4000 – High resolution resistivity meter. Positioned at probe point.

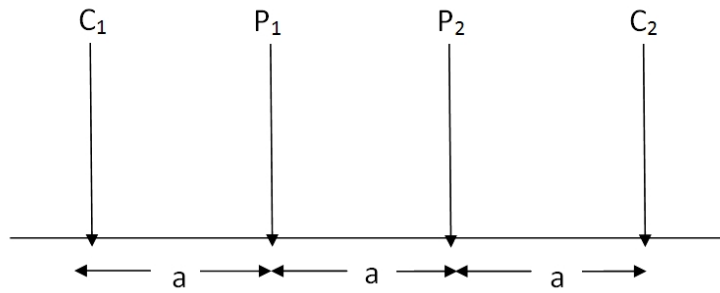


Fig. 5. Wenner array configuration.

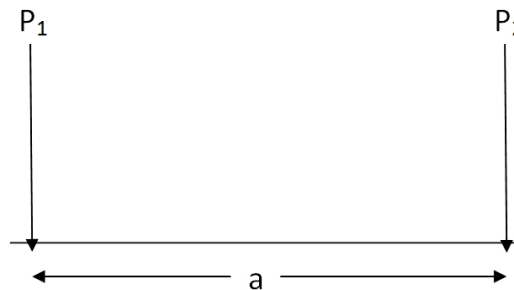
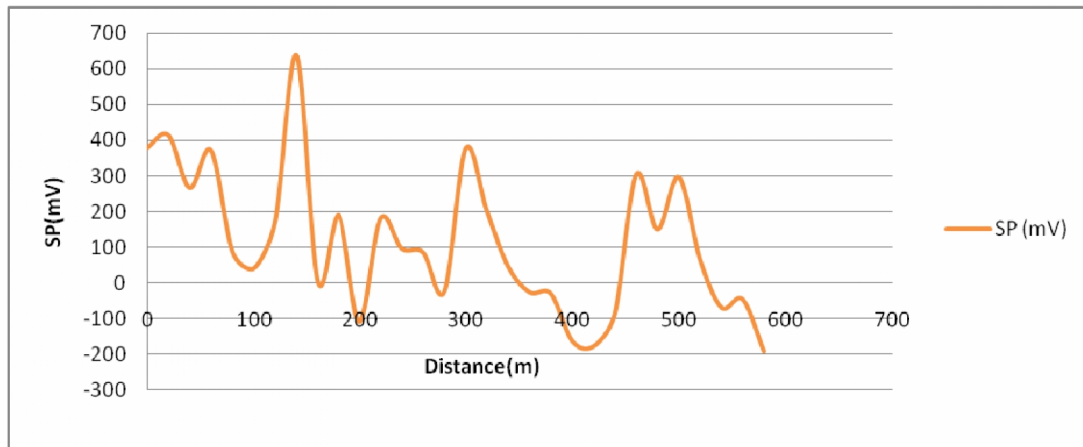


Fig. 6. Potential gradient technique (SP Survey).

### 3. RESULTS AND DISCUSSIONS

The profile plots for the SP and resistivity from the study area are shown in Figs. 7-13. The anomaly variation in SP is both positive and negative. In resistivity profiles, a marked differentiation was observed in the level of the resistivity anomalies. Resistivity was employed in order to investigate the possible rock types and its lateral variations. While the SP method investigates the mineralogical potentials. Hence in the resistivity profiles (Figs. 11-13), three rock types were differentiated. There is a facie change up slope from shale to shaly-sandstone/sandy shale to sandstone. The shales and shaly-sandstone were obviously found at the valley sections (low land areas) while the sandstone occupies the cliff areas (high land areas). The sandstone is limited in extent. Based on the qualitative interpretation, the negative SP anomaly is most diagnostic [8]. This is indicative of sulphide ore deposits. This observation is mostly predominant if sulphide orebodies mainly those that contain pyrite ( $\text{FeS}_2$ ) and pyrrhotite ( $\text{FeS}$ ) are present. These two mineral bodies are well-known for producing the most consistent and strong SP anomalies [9]. The large negative SP anomaly range (-200mV to -500mV) leads credence to the fact that the possibly suspected sulphide ore is pyrite ( $\text{FeS}_2$ ). The geology of this area supports this prediction. At the outcrop locations of Agbani Sandstone, there is a strong presence of ferruginization (the weathering of ironstones), owing to oxidation process (the ferrous ions ( $\text{Fe}^{2+}$ ) which gives rise to the reddish colorations observed [10]. Comparative plot of profiles B and F (Fig. 14) shows that areas with high negative anomaly correspond to the flanks of the sandstone ridges.



**Fig. 7. Profile A – Along faculties of social sciences, Agric and Environmental sciences axis.**

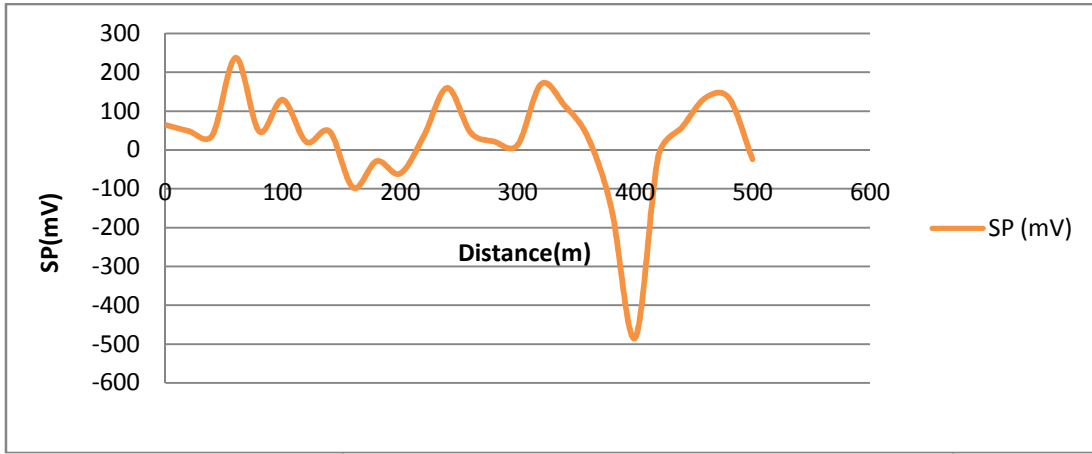


Fig. 8. Profile B – Along Exams and Records Axis.

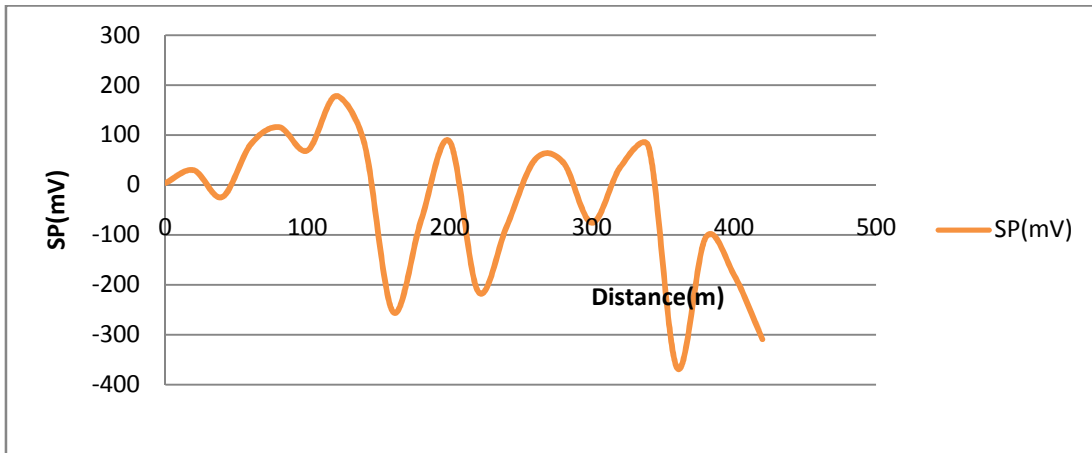


Fig. 9. Profile C – Along the entrance to Admin block.

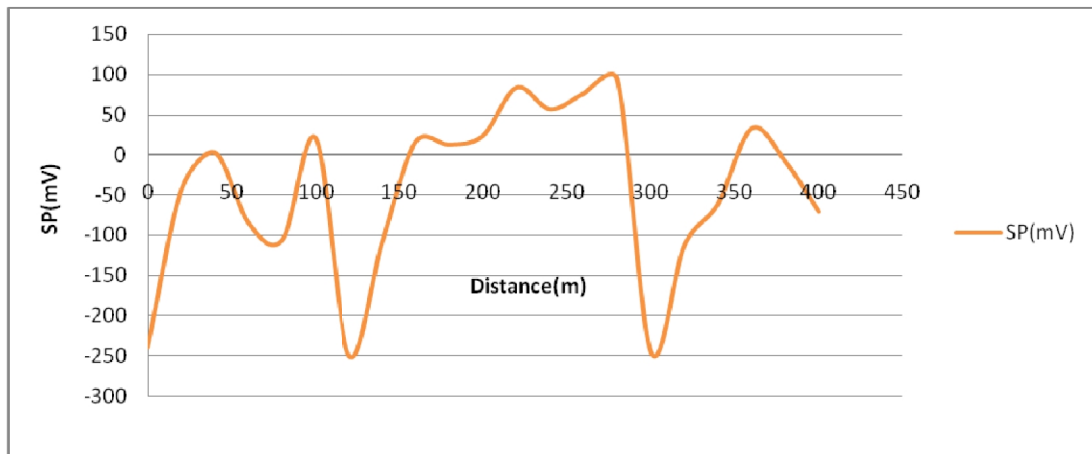


Fig. 10. Profile D – Along faculty of natural sciences and Education axis.

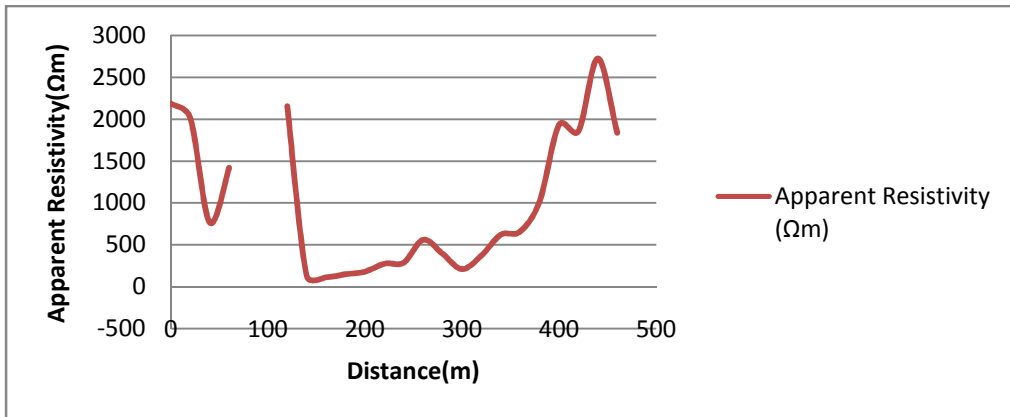


Fig. 11. Profile E – Behind law faculty, Auditorium, Admin Block, Agric and front of Education faculty.

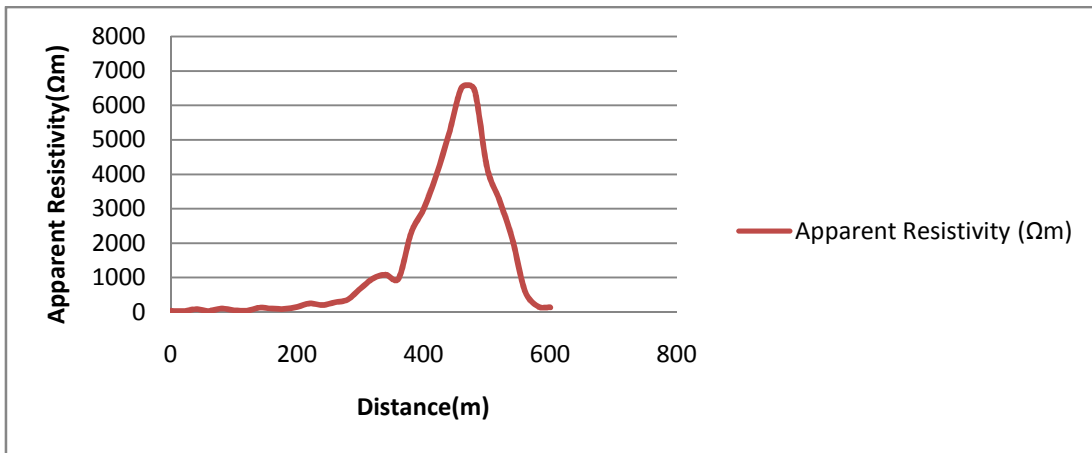


Fig. 12. Profile F – Along Exams and Records Axis.

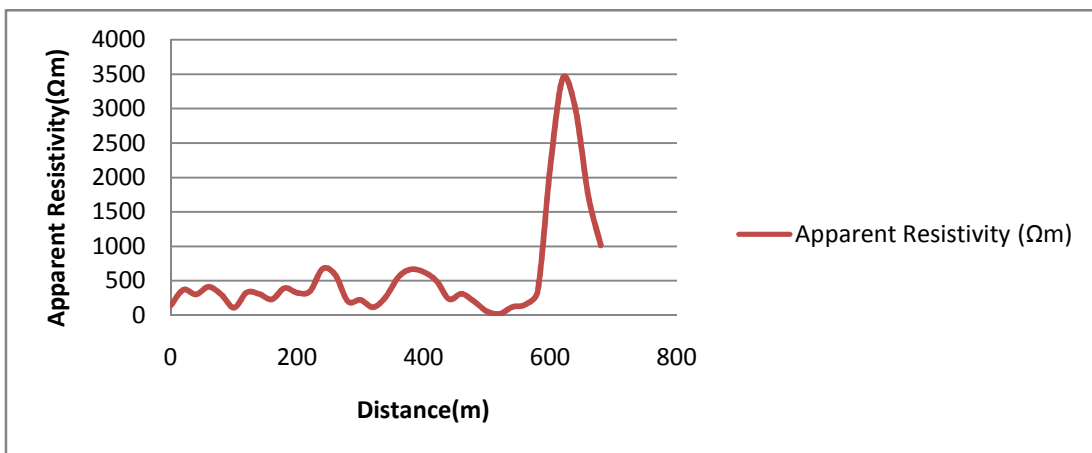
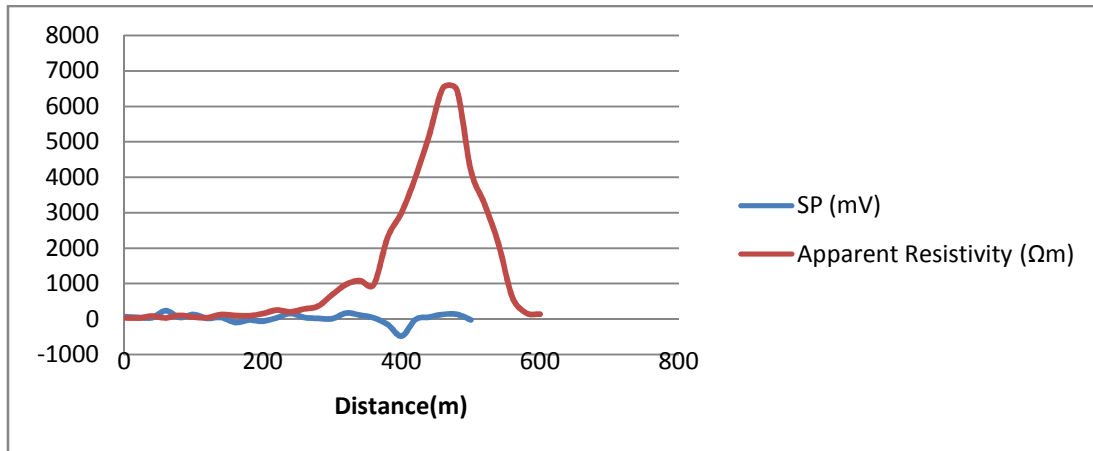


Fig. 13. Profile G – Along V.C's lodge axis.





**Fig. 14. Comparative plot of profile B and profile F.**

#### **4. CONCLUSION**

The characteristics of the resistivity and self-potential (SP) anomalies of Agbani Sandstone has been carefully and painstakingly carried out. Based on the resistivity interpretations, Agbani Sandstone is laterally limited in extent while the mineralization potential is high as a result of the high negative SP anomalies. The high negative SP anomalies are indicative of the fact that pyrite is the primary sulphide orebody at the subsurface. The ore deposition pattern is not yet defined. But the ore shape appears near trapezium [11]. Evidence of intrusive and extrusive events is not observed. Minability ratio is considerably low. A further geophysical integration approach, using gravity, magnetic and electromagnetic is needful to better confirm the assertion above. A higher geologic condition is necessary in order to increase the mineralogical trend. Stream – sediment analysis and rock geochemistry are recommended in order to check the percentage concentration of the pyrite ore and its accessory sulphide ores.

#### **ACKNOWLEDGEMENT**

The authors are grateful to the 2012 final year students of the department of geology and mining, Enugu state university for their immense contributions during the data acquisition stage. Many thanks to Prof. P.O Okeke for his professional contributions during the data interpretation. Finally to God Almighty for the strength and wisdom to put up this work.

#### **COMPETING INTERESTS**

Authors have declared that no competing interests exist.

#### **REFERENCES**

1. Reyment RA. Aspects of the Geology of Nigeria. University of Ibadan press. 1965;165.
2. Geophysical and Hydrogeological investigation for groundwater at Agbani, Nkanu West Local Government Area, Enugu State 2005. Unpublished Ruwasa hydrogeologic technical reports.

3. Murat RC. Stratigraphy and Paleogeography of the cretaceous and Lower Tertiary in Southern Nigeria. African geology. University of Ibadan press. 1992;635-641.
4. Short KC, Stauble AJ. Outline of geology of Niger Delta. AAPG Bulletin. 1967;51:645-656.
5. Chukwu GU. SP anomalies around Abakaliki area of Southern Nigeria. M.Sc dissertation (Unpublished), University of Port-Harcourt, Port-Harcourt; 1997.
6. Okonkwo AC, Ezech CC). A ground Integrated geophysical exploration for sulphide ore deposits. Case study: EPL A40 mine field Lower Benue Trough, Nigeria. Int. Res. J. Geo. Min. 2012;2(8):214-221.
7. Reyment RA. Aspects of the Geology of Nigeria. University of Ibadan press. 1965;165.
8. Sato M, Mooney HM. The electrochemical mechanism of sulphide Self-Potentials. Geophysics. 1960;25:226-249.
9. Beck AE. Physical principle of exploration methods. Macmillan Press, London. 1981;31-41.
10. Chukwu GU. Characteristics of Self-Potential anomalies in Abakaliki Lower Benue Trough of Nigeria. Int. Res. J. Geo. Min. 2013;3(7):257-269.
11. Chukwu GU. Characteristics of Self-Potential anomalies in Abakaliki Lower Benue Trough of Nigeria. Int. Res. J. Geo. Min. 2013;3(7):257-269.

---

© 2014 Okonkwo and Odoh; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<http://www.sciencedomain.org/review-history.php?iid=591&id=31&aid=5248>