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

Austin C. OKONKWO*[1] and Benard I. ODOH[2]

*[1]Department of Geology and Mining, Enugu state university of science and technology, Enugu Nigeria.

[2]Department of Geosciences, Nnamdi Azikiwe University, Awka Nigeria

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_2). 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.

Introduction

Agbani is located in Nkanu west local government area of Enugu state (Figure 1) Nigeria. The Agbani Sanstone 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. Infact, 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 Past studies on Agbani Sandstone have been stratigraphic (Reyment, 1965) and hydrgeological (unpublished Ruwasa hydrogeologic technical reports, 2005). 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 (Murat, 1970; Short and Stauble, 1967) 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 (Chukwu, 1997; Okonkwo and Ezeh, 2012).

Location and Physiography

The case study area is the Enugu state university Agbani campus, located in Nkanu west local government, Enugu state (Figure 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, (Figure 2) the topography is typically undulating with a maximum elevation of 633ft (193m) ASL.

Geology

Agbani town, where the study area is located is practically underlain by Agbani Sandstone, (Figure 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 (Reyment, 1965).

Methodology

Data Acquisition and Interpretation

Data was acquired where the outcrops of Agbani Sandstone are distinctly exposed (Figure 3). The high resolution versatile ABEM SAS 4000 resistivity meter (Figure 4) was used. The two datasets were acquired simultaneously. Of the possible electrode configuration used (Figures 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 (ρ_a) was computed by using equation 1.

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

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.

Result and Discussions

The profile plots for the SP and resistivity from the study area are shown in Figures 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 (Figures 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 (Sato and Mooney, 1960). This is indicative of sulphide ore deposits. This observation is mostly predominant if sulphide orebodies mainly those that contain pyrite (FeS_2) and pyrrhotite (FeS) are present. These two mineral bodies are well-known for producing the most consistent and strong SP anomalies (Beck 1981). The large negative SP anomaly range (-200mV to -500mV) leads credence to the fact that the possibly suspected sulphide ore is pyrite (FeS_2). The geology of this area supports this prediction. At the outcrop locations of Agbani Sandstone, there is a strong presence of ferrugenization (the weathering of ironstones), owing to oxidation process (the ferrous ions (Fe^{2+}) which gives rise to the reddish colorations observed (Chukwu, 2013). Comparative plot of profiles B and F (Figure 14) shows that areas with high negative anomaly correspond to the flanks of the sandstone ridges.

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 (Chukwu, 2013). 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 your students of the department of geology and mining, Enugu state university for their immerse 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.

References

Beck AE (1981). Physical principle of exploration methods. Macmillan Press, London pp31-41.

Chukwu GU (2013). Charateristics of Self-Potential anomalies in Abakaliki Lower Benue Trough of Nigeria. Int. Res. J. Geo. Min. 3(7): 257-269.

Chukwu GU (1997). SP anomalies around Abakaliki area of Southern Nigeria. M.Sc dissertation (Unpublished), University of Port-Harcourt, Port-Harcourt.

Geophysical and Hydrogeological investigation for groundwater at Agbani, Nkanu West Local Government Area, Enugu State (2005). Unpublished Ruwasa hydrogeologic technical reports.

Murat RC (1992). Stratigraphy and Paleography of the cretaceous and Lower Tertiary in Southern Nigeria. African geology. University of Ibadan press. pp635-641.

Okonkwo AC, Ezeh CC (2012). A ground Integrated geophysical exploration for sulphide ore deposits. Case study: EPL A40 mine field Lower Benue Trough, Nigeria. Int. Res. J. Geo. Min. 2(8) : 214-221.

Reyment RA (1965). Aspects of the Geology of Nigeria. University of Ibadan press. 165p.

Sato M, Mooney HM (1960). The electrochemical mechanism of sulphide Self-Potentials. Geophysics. 25 : 226-249.

Short KC, Stauble AJ (1967). Outline of geology of Niger Delta. AAPG Bulletin 51: 645-656.

World Gazette (2011). Colourful map of Nigeria with 36 states. www.world-gazette.com

List of figures

Figure 1: Map of Nigeria showing the study area (World Gazette, 2011).

Figure 2: Surface map of the study area.

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

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

Figure 5: Wenner array configuration.

Figure 6: Potential gradient technique (SP Survey).

Figure 7: Profile A – Along faculties of social sciences, Agric and Environmental sciences axis.

Figure 8: Profile B – Along Exams and Records Axis.

Figure 9: Profile C – Along the entrance to Admin block.

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

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

Figure 12: Profile F – Along Exams and Records Axis.

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

Figure 14: Comparative plot of profile B and profile F.

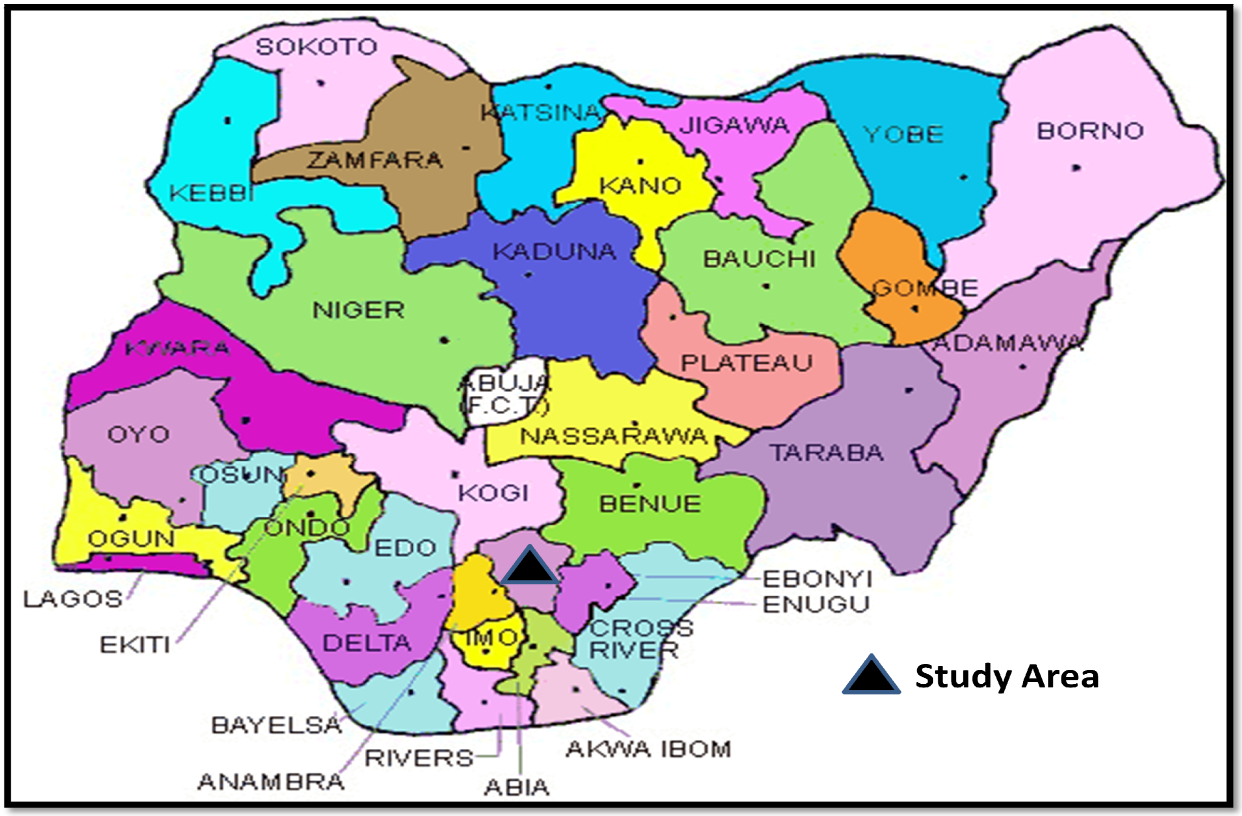

Figure 1: Map of Nigeria showing the study area (World Gazette, 2011).

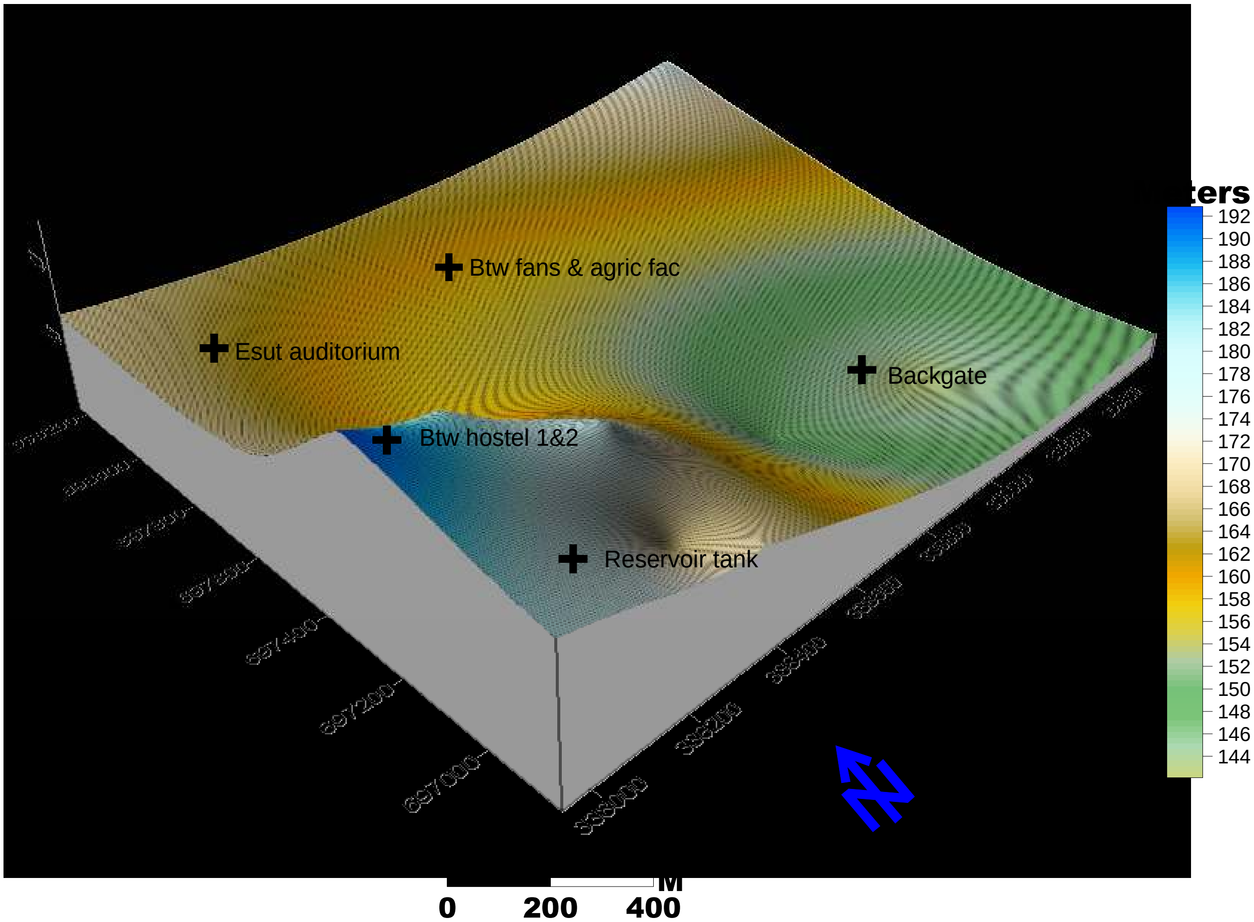

Figure 2: Surface map of the study area.

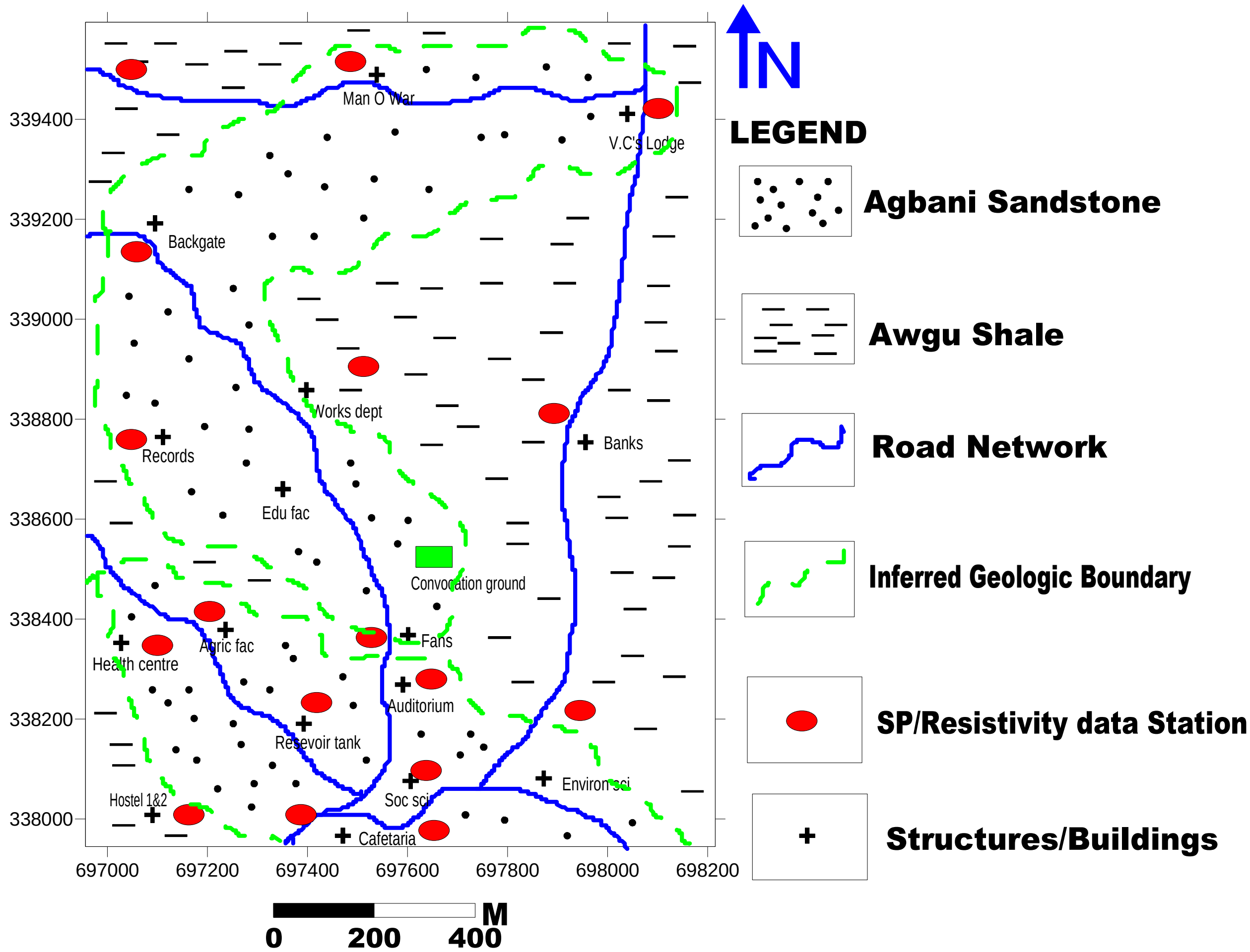

Figure 3: Geologic map of the study area and SP/Resistivity data station.

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

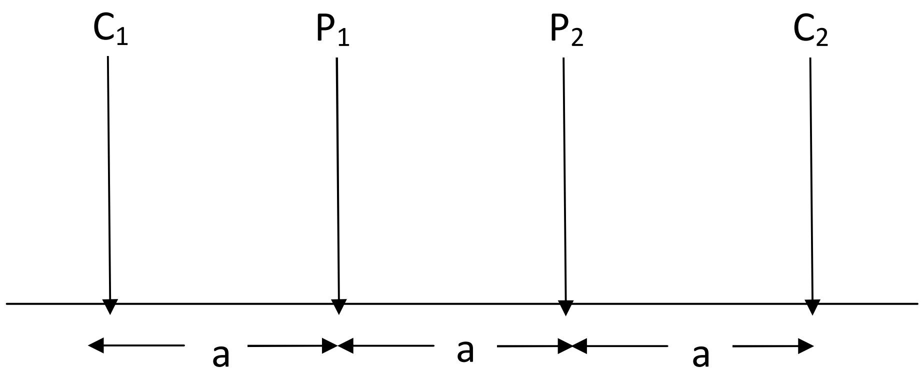

Figure 5: Wenner array configuration.

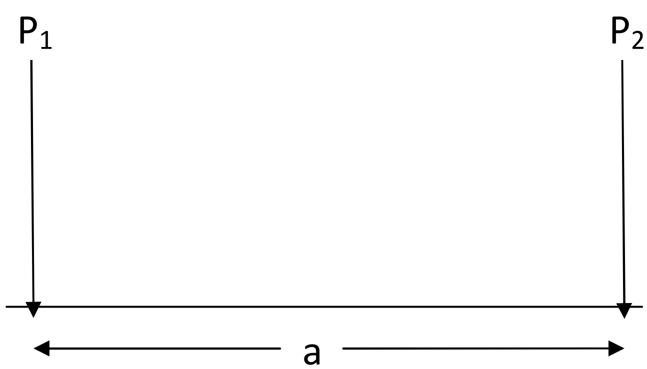

Figure 6: Potential gradient technique (SP Survey).

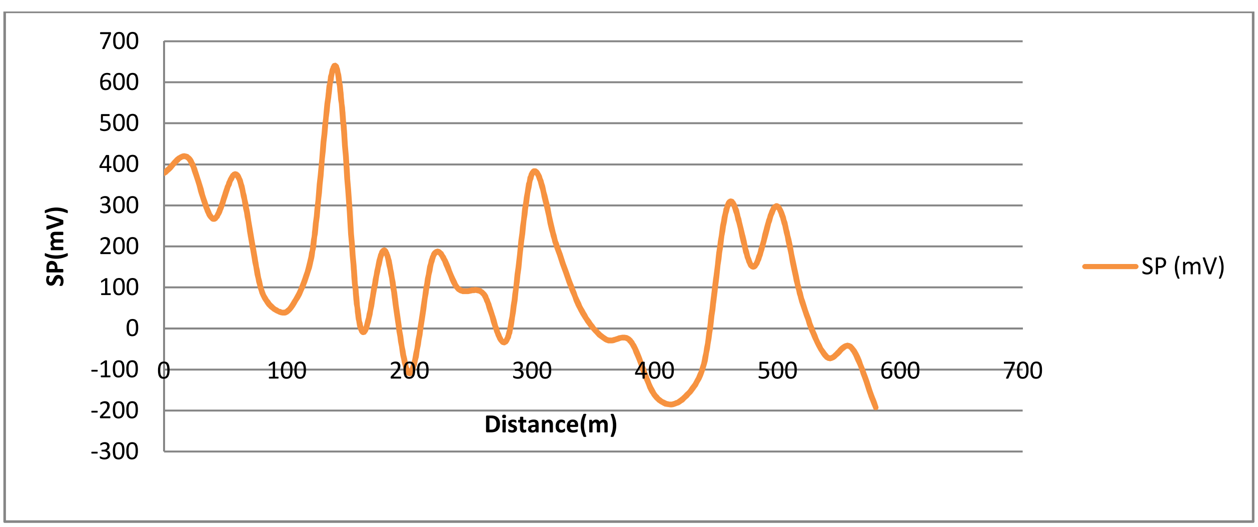

Figure 7: Profile A – Along faculties of social sciences, Agric and Environmental sciences axis.

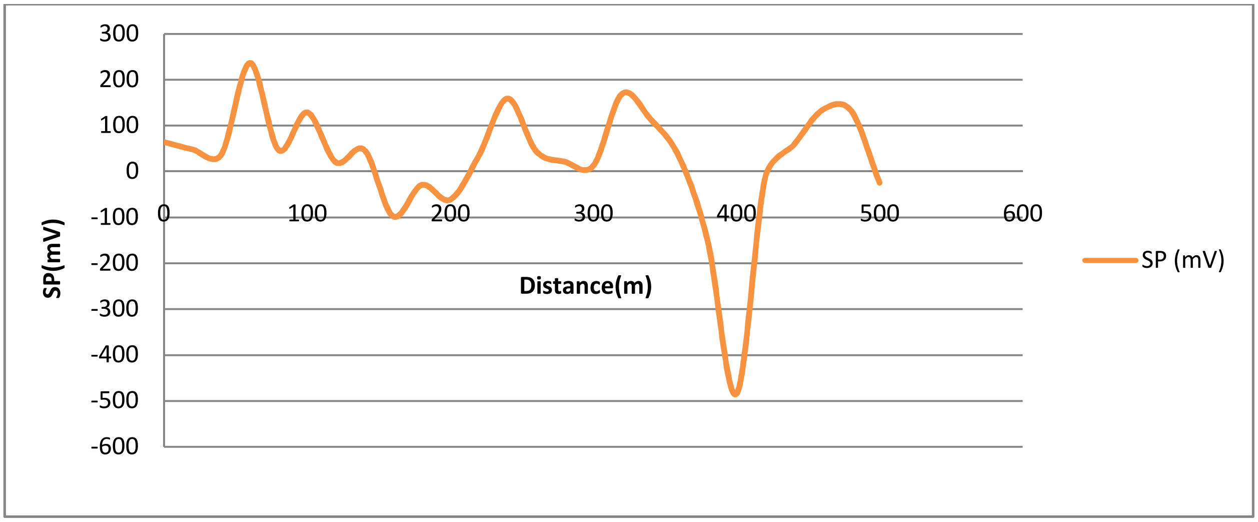

Figure 8: Profile B – Along Exams and Records Axis.

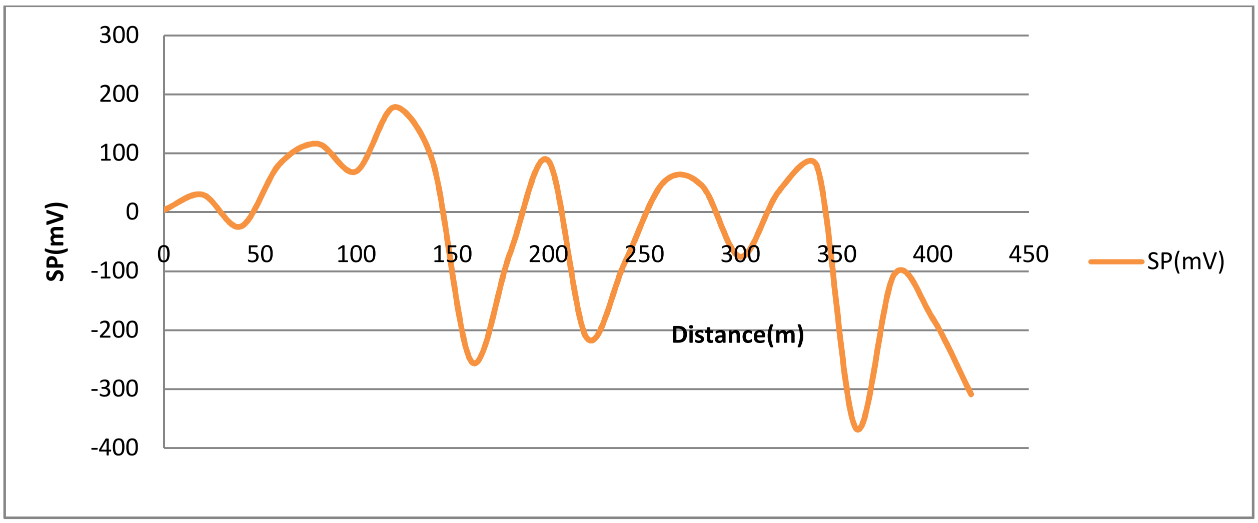

Figure 9: Profile C – Along the entrance to Admin block.

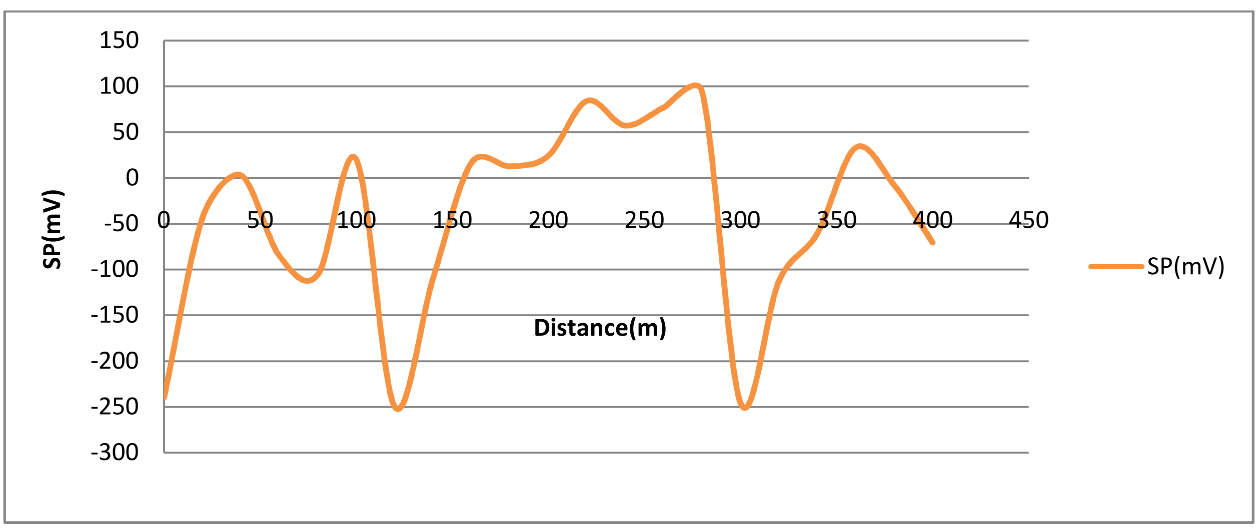

Figure 10: Profile D – Along faculty of natural sciences and Education axis.

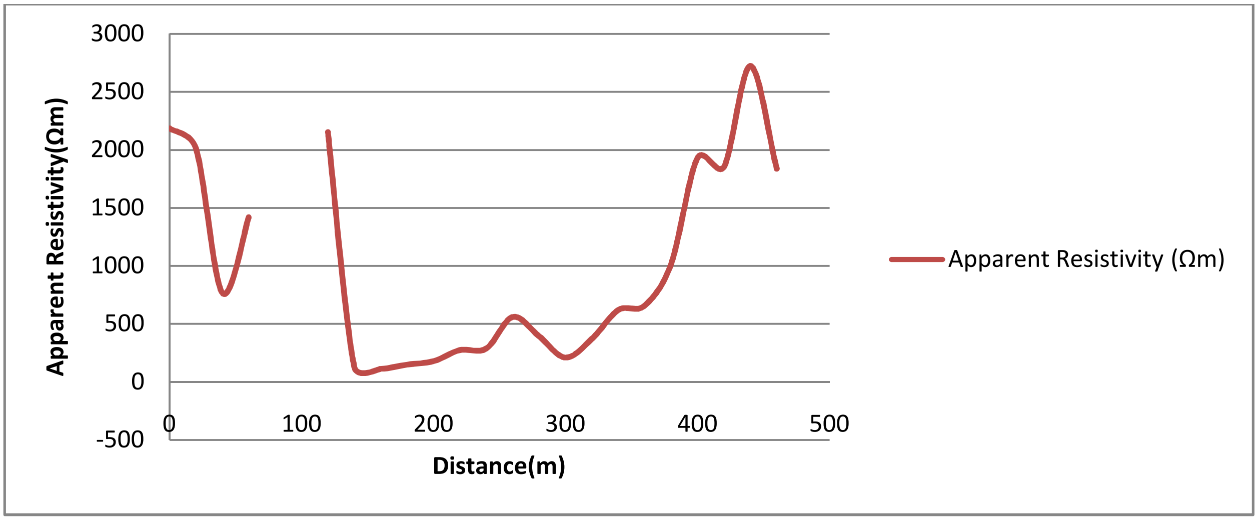

Figure 11: Profile E – Behind law faculty, Auditorium, Admin Block, Agric and front of Education faculty.

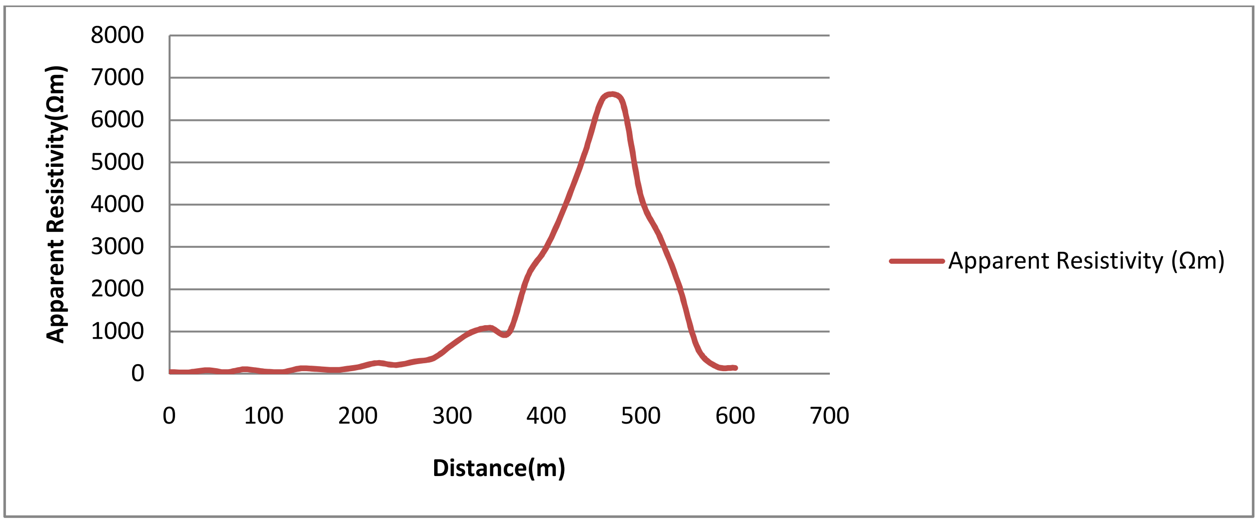

Figure 12: Profile F – Along Exams and Records Axis.

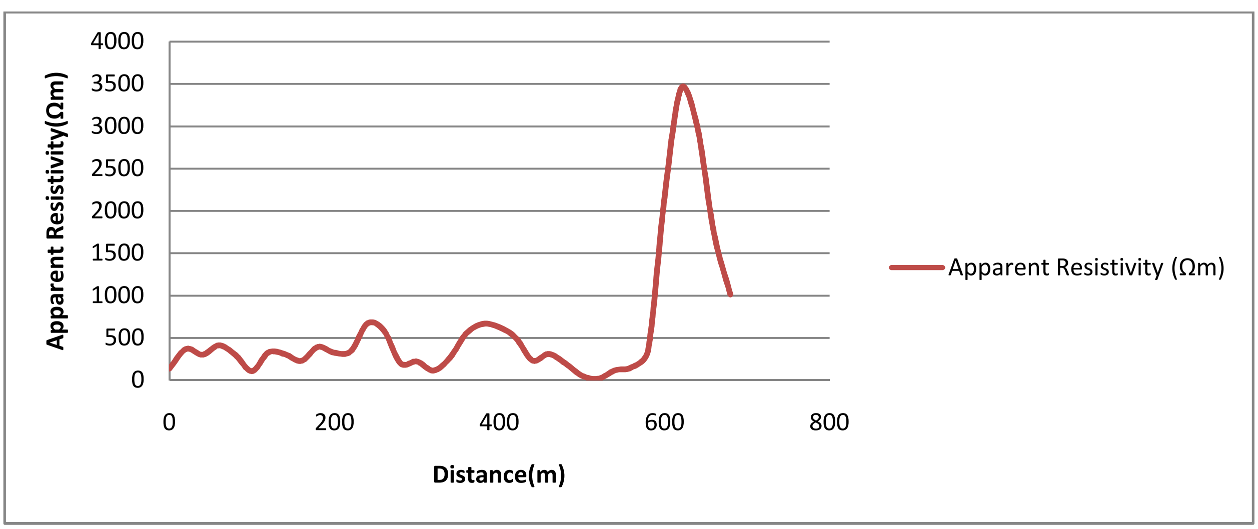

Figure 13: Profile G – Along V.C's lodge axis.

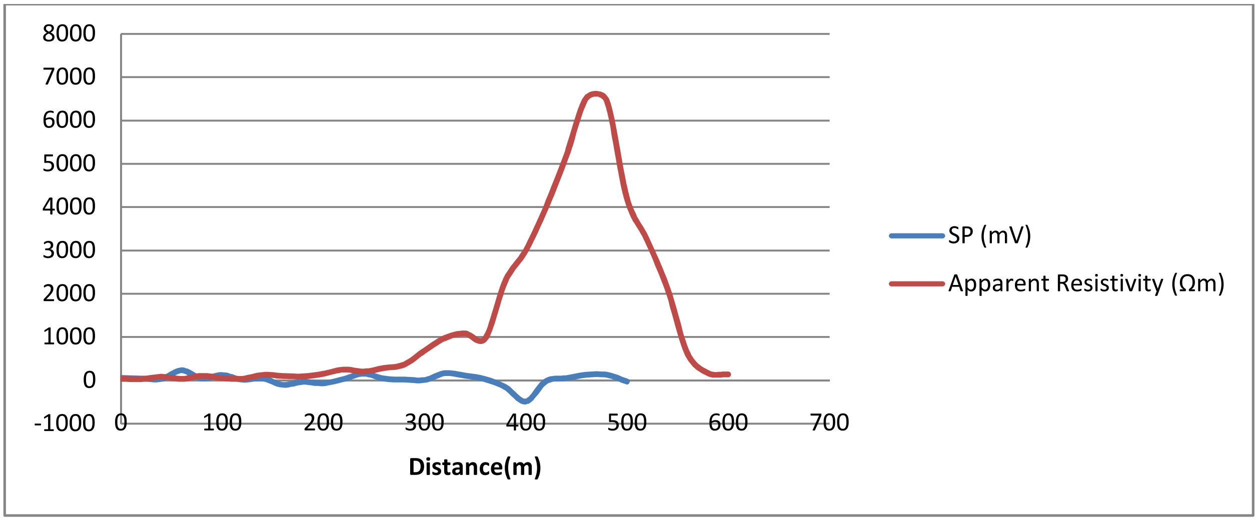

Figure 14: Comparative plot of profile B and profile F.