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Evaluation of 2d Electrical Resistivity Imaging and Self- Potential Anomalies over Agbani Sandstone, Southern Benue Trough: Implication for Sulphide Ore Enrichment

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Abstract
The evaluation of 2D electrical resistivity imaging and self potential anomalies over Agbani Sandstone has been carried out. The aim of the study was to investigate the possible/lateral extent of rock types, mineralization potential and their implication for sulphide ore enrichment. Data was acquired using the versatile ohmega resistivity meter, employing wenner configuration and the direct measurement method. Data set were analysed using the Res2dinv and Excel tool kits. Interpretation was basically qualitative. Based on the 2D electrical resistivity interpretation, Agbani sandstone is laterally limited in extent with fractures/joints, while the mineralization potential is high as the result of the high negative sp anomalies. The negative sp value range is -100mV to -500mV. This is practically indicative of a sulphide ore bodies- possibly Pyrite (FeS_2). Possible sulphide ore enrichment model is by gravity flow. The fractures/joints are possible ore enrichment zones. However, stream sediments analysis and rock geochemical studies are recommended.
Keywords:2D resistivity, Self potential, Mineralization potential, Pyrite, enrichment zone, Agbani sandstone.

1.0 INTRODUCTION

The Agbani Sandstone is a time equivalent of the Awgu Shale. It is of Coniacian age (Reyment, 1965). It marked the end of the second regional regressive cycle in the regional geology of Southeastern Nigeria (Obaje, *et al*, 1999). The Agbani Sandstone is not widespread but rather restricted within the Agbani town and part of Ugbawka. The Agbani Sandstone takes its name from the type locality, Agbani located in the Nkanu west local government area of Enugu state (Figure 1).

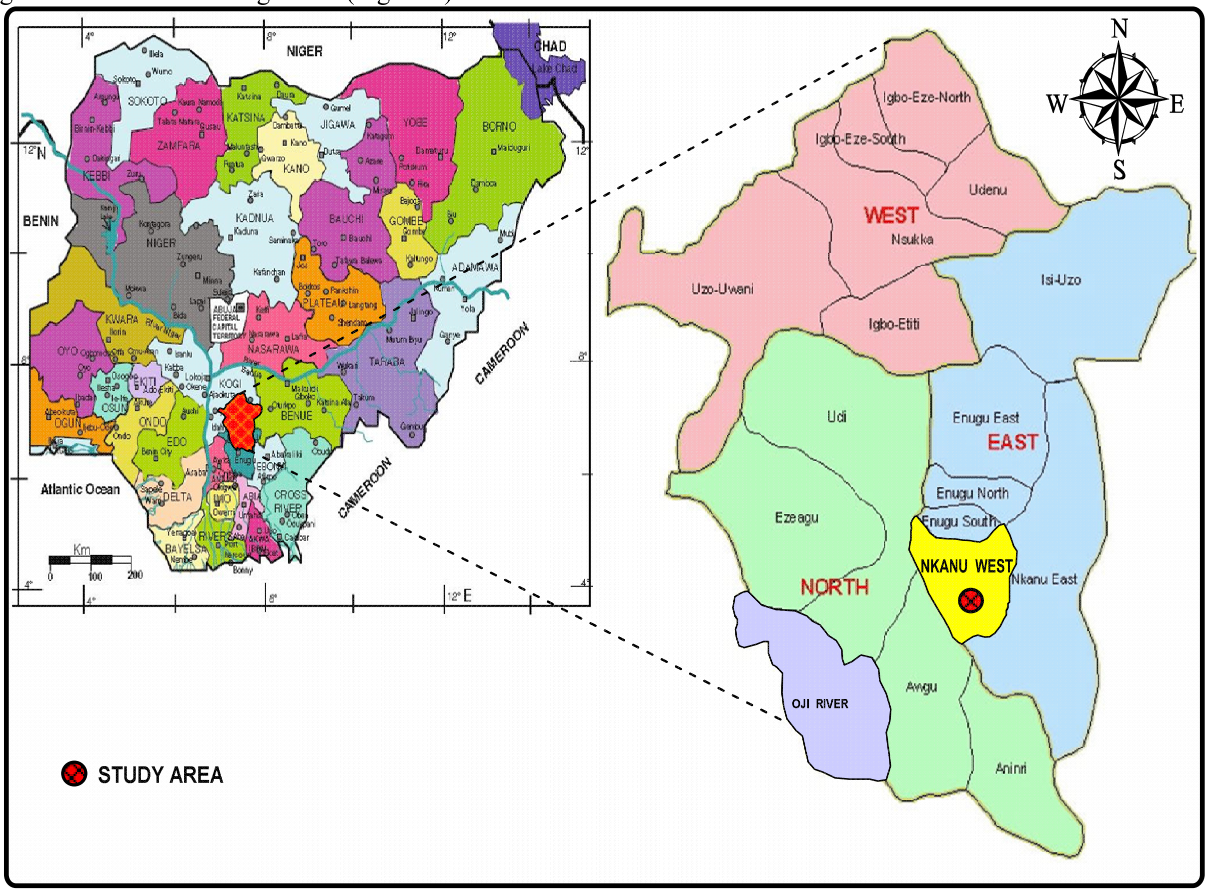

Figure 1: Map of Enugu state showing location of study area. Inset map of Nigeria (modified from Obaje, 2009).

In the study area, (Reyment, 1965) investigated the stratigraphic positioning of the Agbani Sandstone.

(RUWASA, 2005) investigated the ground water potential while (Okonkwo and Odoh, 2014) investigated the mineralization potentials using 1D resistivity and Self-potential (SP) profile plots. The present study however investigates in a larger and more defined scope the mineralization potentials and ore emplacement/enrichment using 2D electrical resistivity imaging and SP profile plots.

1.1 LOCATION AND PHYSIOGRAPHY

The study area is within the Enugu state university, Agbani campus, located in Nkanu west local government, Enugu state (Figure 1). Agbani is located roughly 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 Amuri about 250ft (76m) ASL. Locally, the topography is typically undulating (Figure 2) with a maximum elevation of 620.4ft (188m).

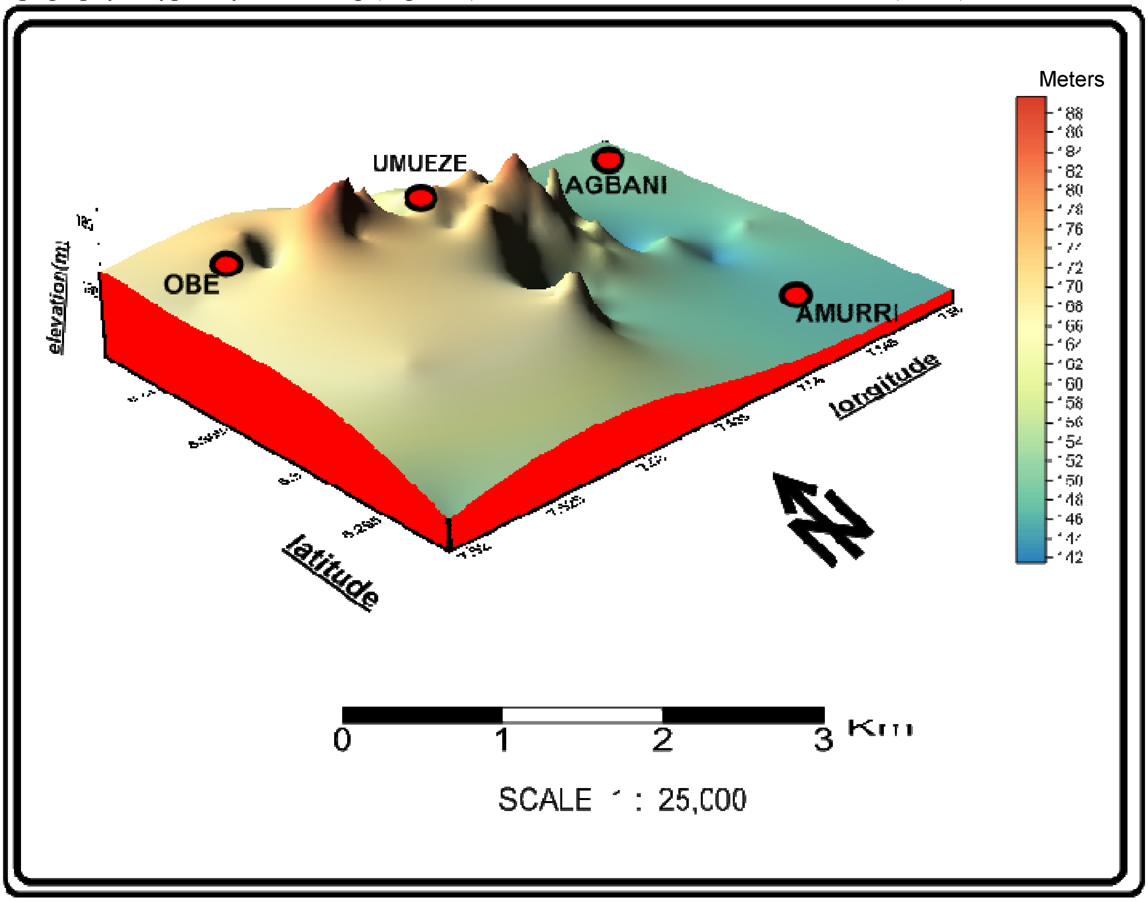

Figure 2: Surface map of study area.

2.0 GEOLOGY

The study area is underlain by Awgu Shale and Agbani Sandstone (Figure 3). The Agbani Sandstone ranges from Milky to reddish brown and yellowish white colour. The sandstone is medium to coarse grain at outcrop locations and moderately to highly consolidate in depth (Okonkwo and Odoh, 2014). The Agbani Sandstone is not very extensive as it outcrops only in Agbani town and Ugboka where it is very coarse and whitish. Outcrops/exposures of the Awgu Shale are not found in the study area except in hand dug wells, boreholes and areas where erosion activities expose it.

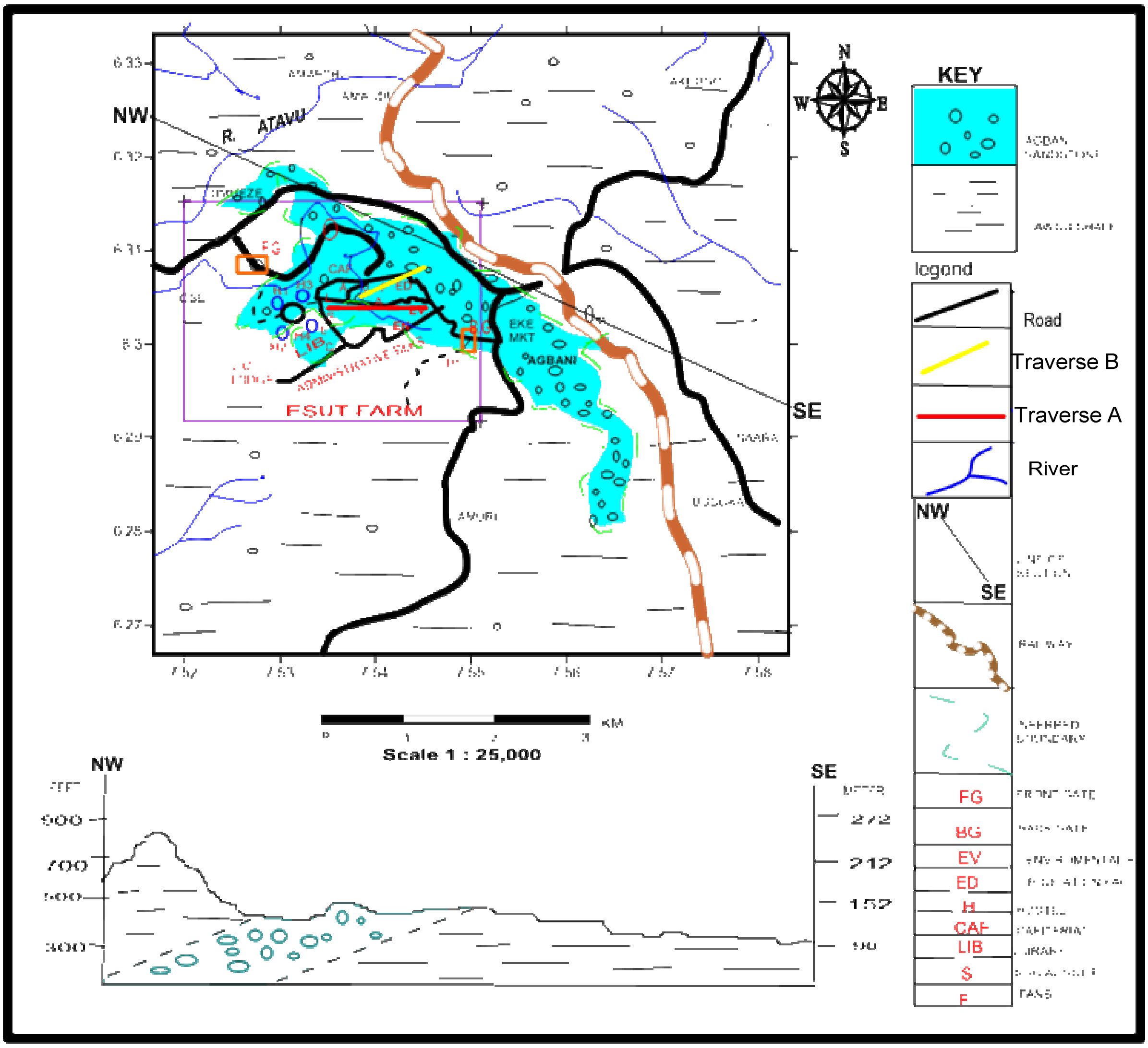

Figure.3: Geologic map of study area.

3.0 METHODOLOGY

DATA AQUISITION, PROCESSING AND INTERPRETATION

Data was acquired along two major traverses (Traverse A and B) where the outcrops of Agbani Sandstone are distinctively exposed (Figure 3). The high resolution versatile Ohmega resistivity meter was used. The 2D resistivity imaging and Self Potential (SP) data sets were acquired simultaneously. Of the possible electrode configuration used (Figures 4 and 5) in obtaining the 2D resistivity and SP data, the Wenner configuration and the Potential gradient technique was employed in the present study respectively. Data was acquired at different depth probe (electrode separation) of 10meters, 20meters, 30meters and 40 meters at station distance of 10meters (Traverse A) and 20 meters (Traverse B). The 2D resistivity data was acquired first. After that, the current electrodes were removed. Then adjusting the mode to SP, reading for SP was taken by using two potential electrodes, and then the whole equipment setup was moved to the next station distance. The apparent resistivity (ρ_a) was computed by using equation 1 below:

$$\rho_a = 2\pi a R \qquad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - 1$$

Where "a" is the electrode separation and "R" is the Resistance

Computed apparent resistivities were processed using the Res2Dinv software. The SP values were plotted against the station distances using Excel tool kits. Data were interpreted qualitatively.

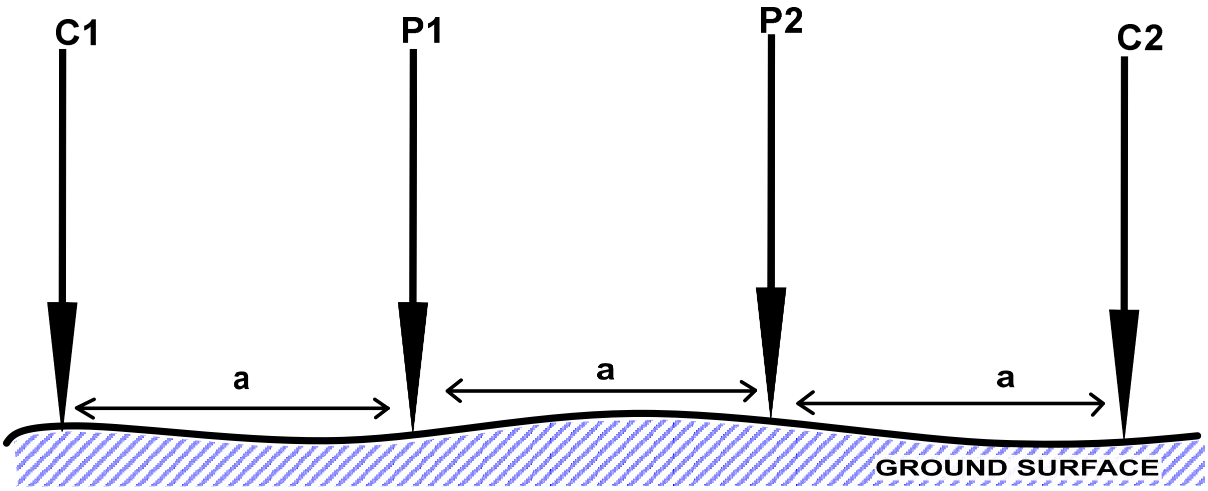

Figure 4: Wenner array configuration (Resistivity survey).

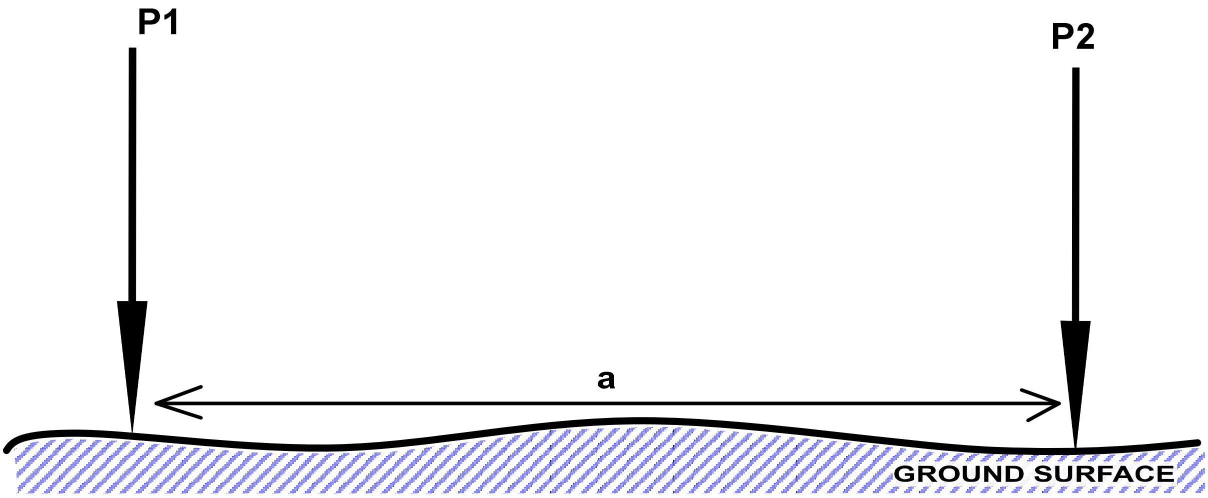

Figure 5**:** Potential gradient technique (SP survey)

4.0 RESULT AND DISCUSSIONS

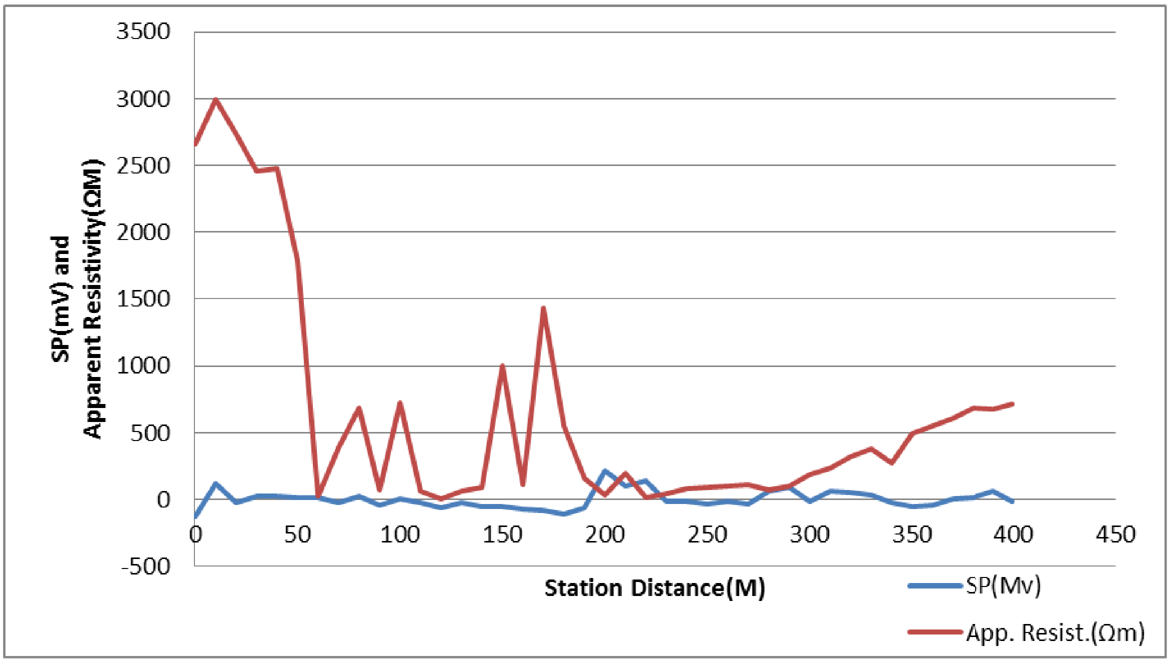

Figure 6: Traverse A - SP (mV) and Apparent Resistivity plot (Ωm) at a = 10m.

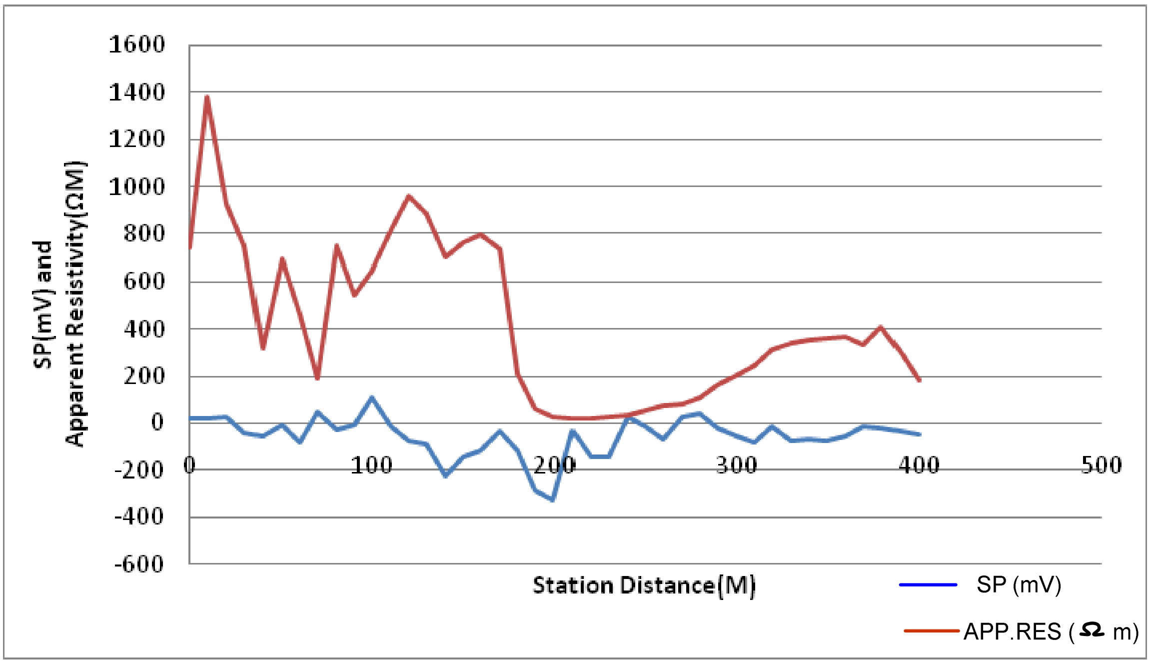

Figure 7: Traverse A - SP (mV) and Apparent Resistivity plot (Ωm) at a = 20m.

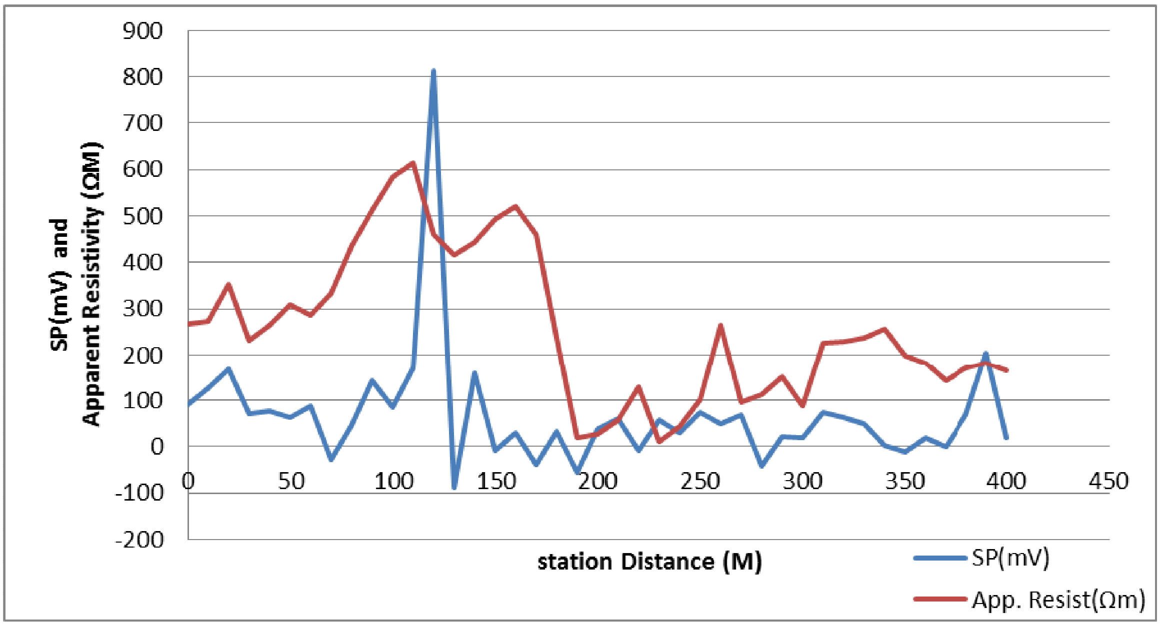

Figure 8: Traverse A - SP (mV) and Apparent Resistivity plot (Ωm) at a = 30m.

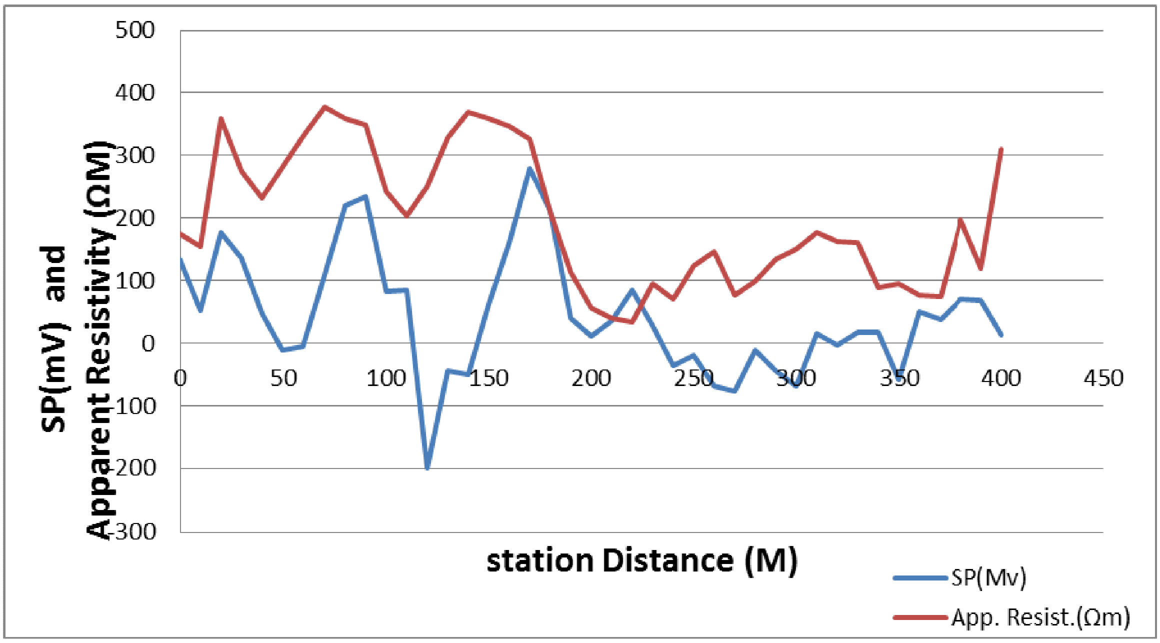

Figure 9: Traverse A - SP (mV) and Apparent Resistivity plot (Ωm) at a = 40m.

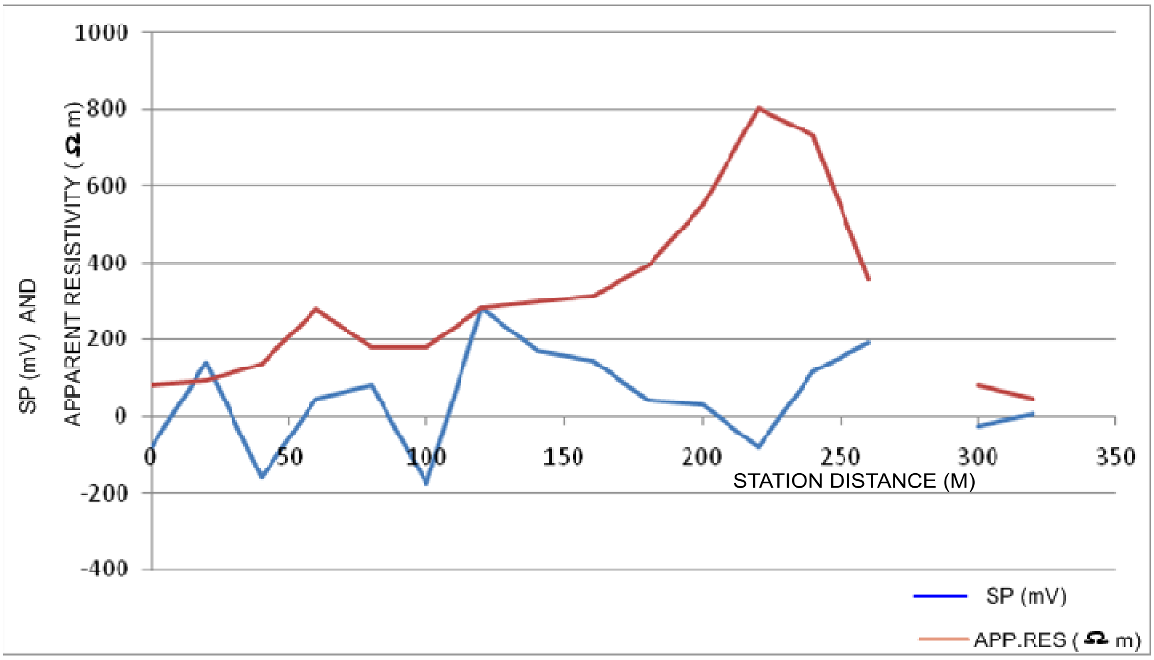

Figure 10: Traverse B - SP (mV) and Apparent Resistivity plot (Ωm) at a = 10m.

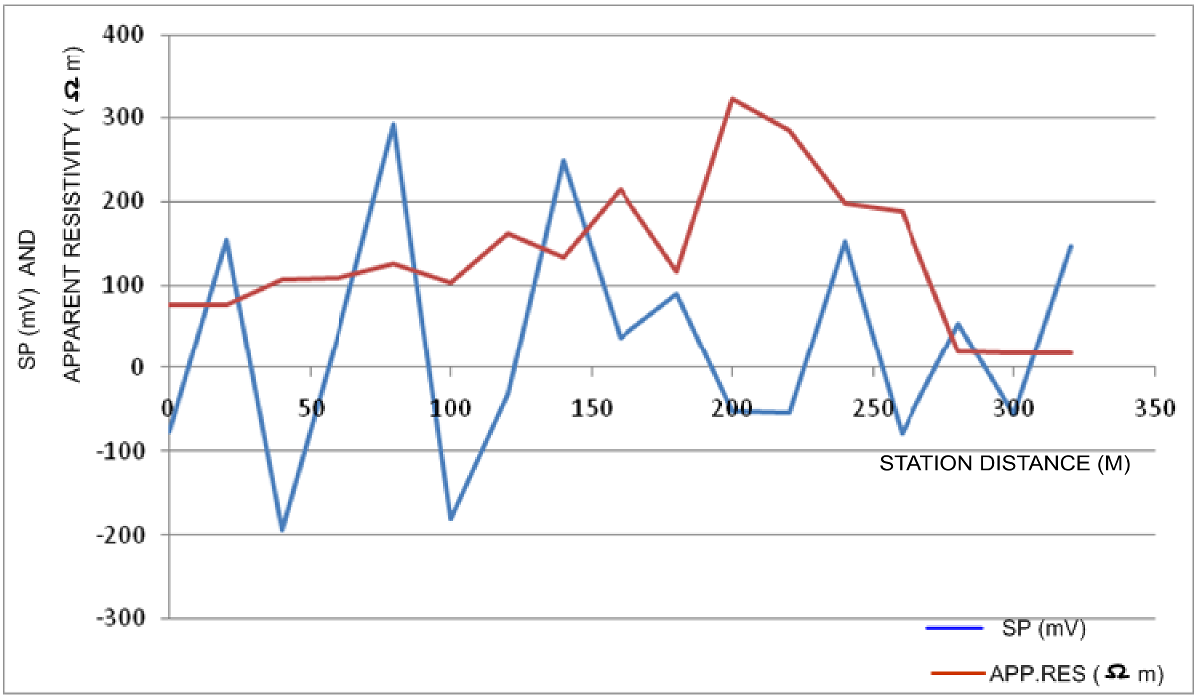

Figure 11: Traverse B - SP (mV) and Apparent Resistivity plot (Ωm) at a = 20m.

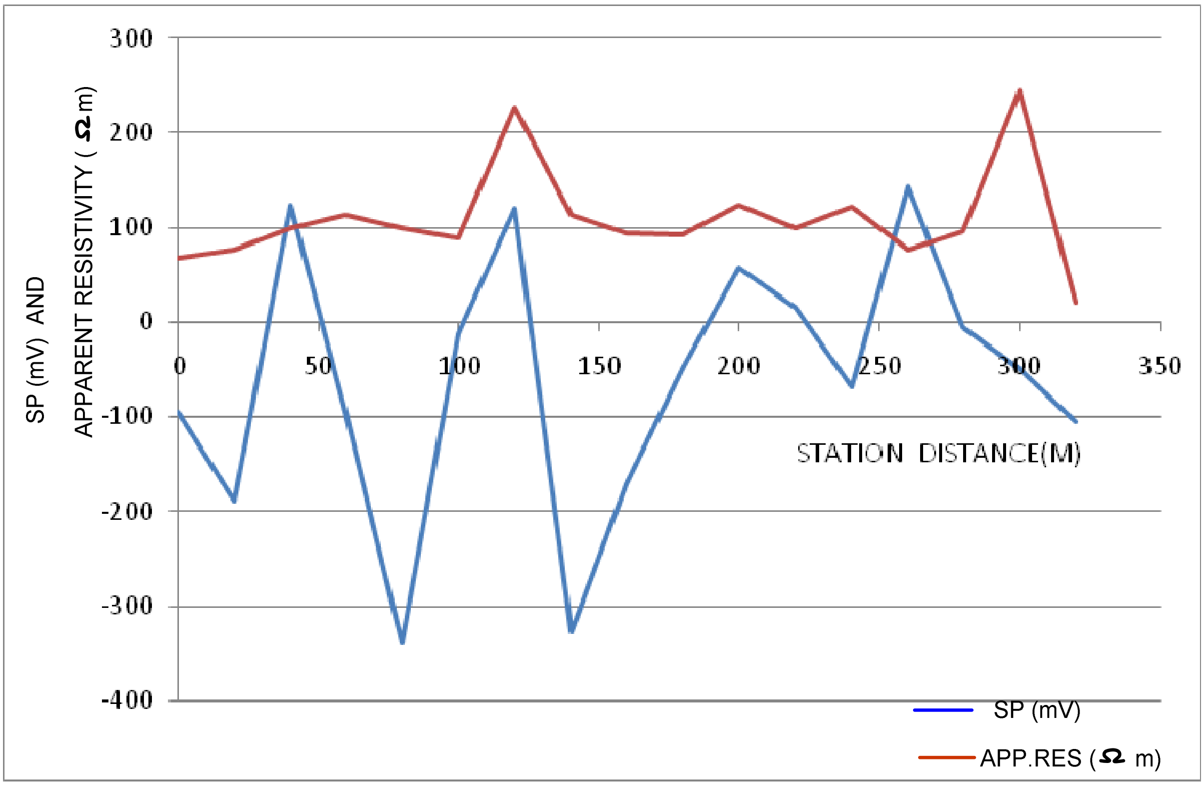

Figure 12: Traverse B - SP (mV) and Apparent Resistivity plot (Ωm) at a = 30m.

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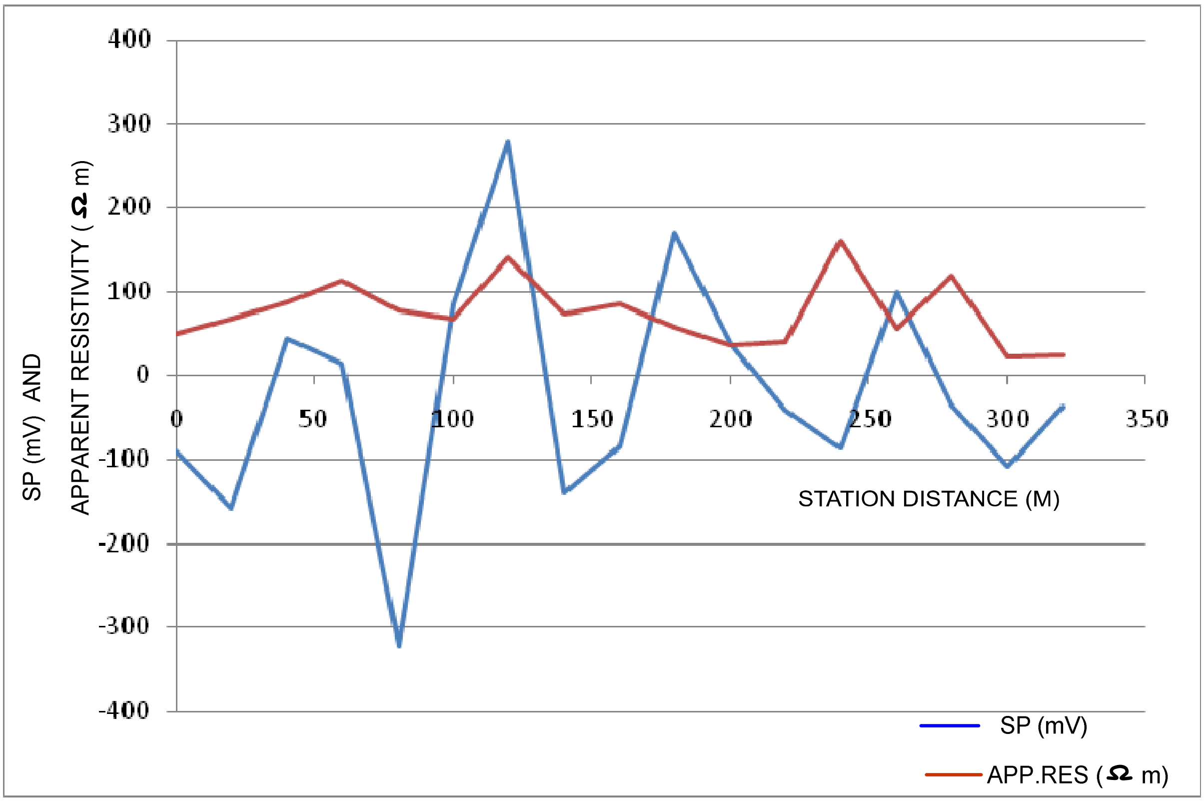

Figure 13: Traverse B - SP (mV) and Apparent Resistivity plot (Ωm) at a = 40m.

The profile plots for SP and Resistivity from the Study area are shown in Figures 6-9 (Traverse A) along Faculty of Social Sciences, Agric and Environmental Sciences axis and Figures 10-13 (Traverse B) behind the axis of Admin block, Tetfund Hall A and front of Faculty of Education. The 2D resistivity pseudo sections for traverses A and B are shown in Figures 14 and 15 respectively.

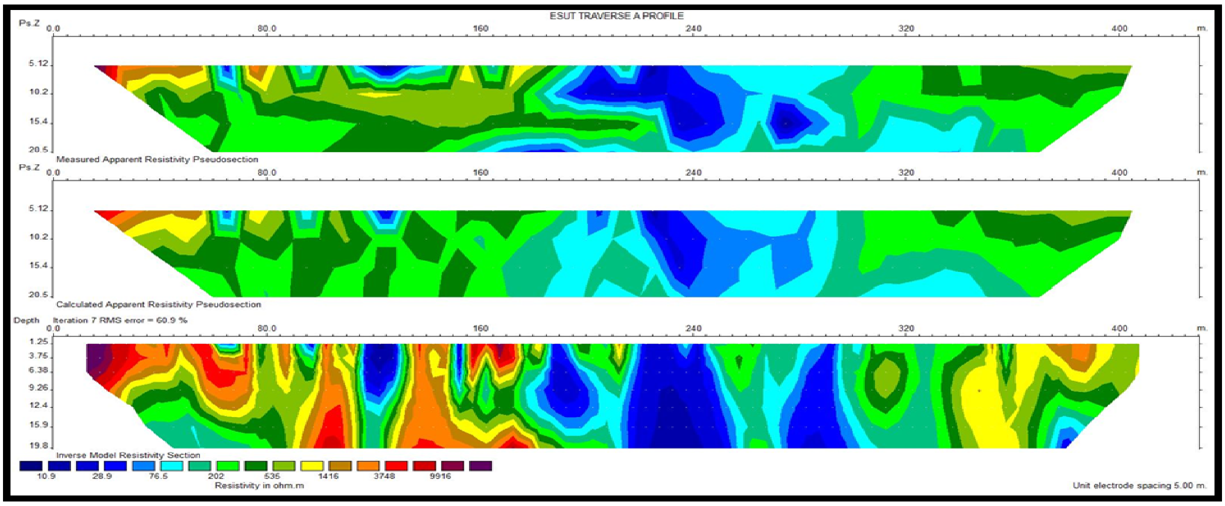

Figure 14: Apparent resistivity pseudo section for traverse A

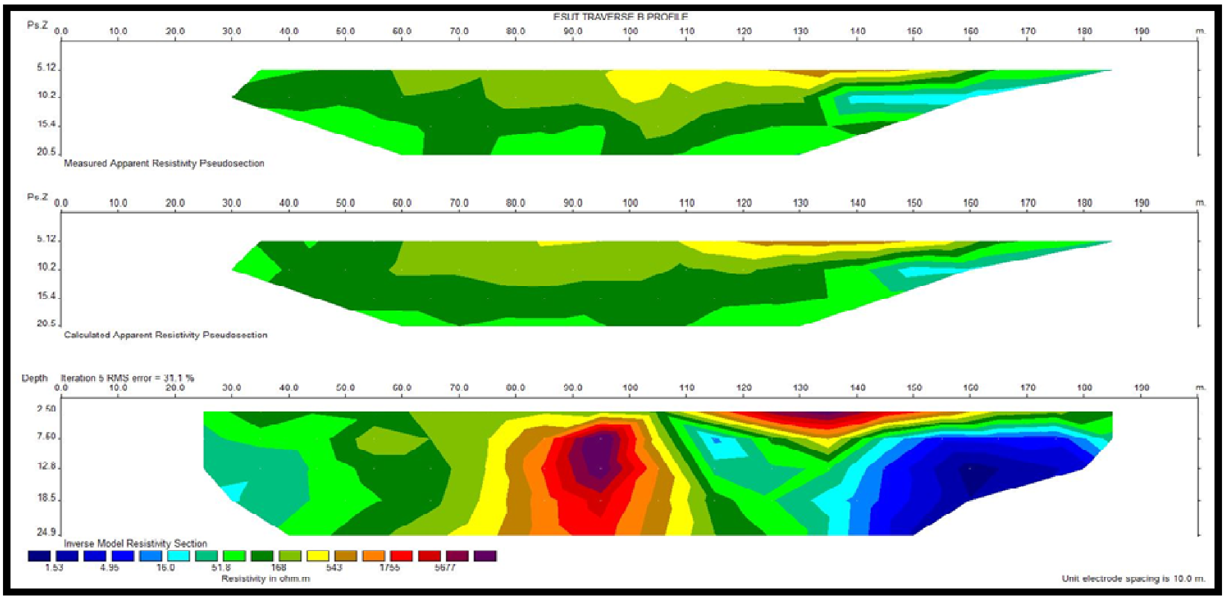

Figure 15: Apparent resistivity pseudo section for traverse B.

Least squares inversion was carried out on the Resistivity data to generate the Resistivity Pseudosections. The SP anomaly variations are both positive and negative. In resistivity profiles, a marked differentiation was observed in the level of resistivity anomalies. Electrical resistivity was employed in other to investigate the possible rock types and its lateral variations, while the SP method investigates the mineralization potentials. The resistivity of rocks and minerals (Parasnis, 1986, Osemeikhan and Asokhia, 1994) suggests that the subsurface formations are predominantly sandstone and clay/shale. Three rock types were differentiated (Figure 14 and 15). There is a facie change up slope from shale to shaly-sandstone/sandyshale to sandstone. The shales and shaly-sandstones were obviously found at the valley sections (low land areas), while the sandstone occupies the cliff areas (high land areas). They are 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 ore bodies were mainly those that contain pyrite (FeS_2) and pyrrhotites (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 (-100mV to -500mV) leads credence to the fact that the possible suspected sulphide ore is Pyrite (FeS_2). Pyrite is a good lead to galena and sphalerite enrichment. The geology of this area supports this prediction. At the outcrop locations of Agbani Sandstone there are strong presence of ferroginizations (the weathering of ironstones). This is as a result of the oxidation process, the ferrous ions (Fe^{2+}) which gives rise to the reddish colourations observed (Chukwu,2013). Comparative profile plots Figure 6-13 shows that areas with high negative SP anomaly corresponds to the flanks of the sandstone ridges with zones of weakness (possibly fracture/ joints). The zone of weakness is evident on the 2D resistivity (Figure 14) pseudosection. These fracture/ joint zones are possible sulphide ore enrichment zones based on gravity flow (Figure16).

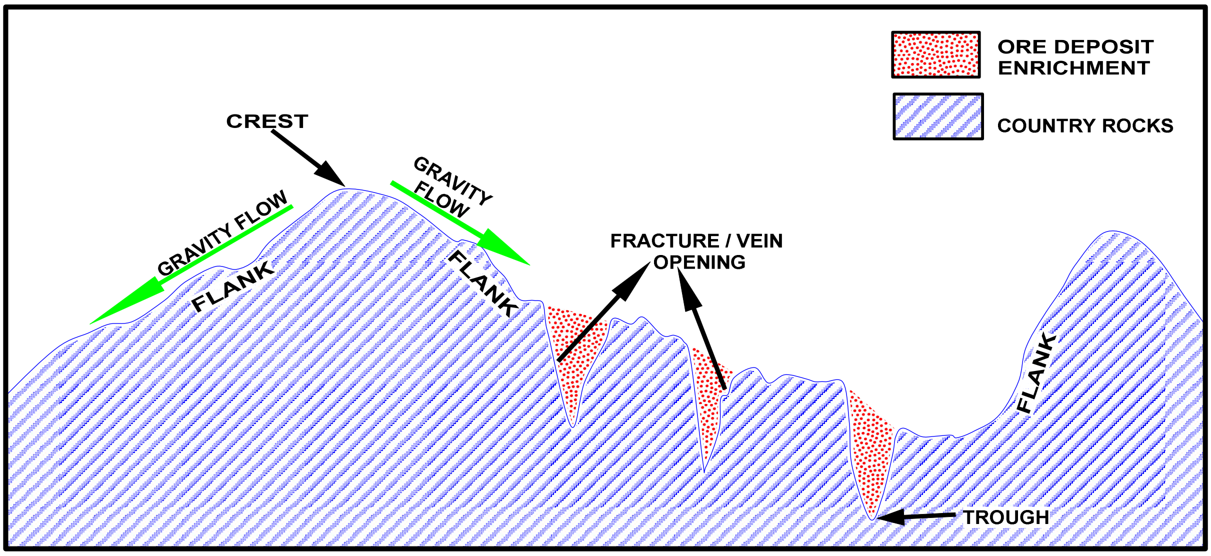

Figure 16: A conceptual gravity flow model showing possible ore enrichment pattern of study area.

5.0 CONCLUSION

The use of 2D electrical resistivity (ER) imaging technique in this study has shown a better understanding of the subsurface structure of the study area. The presence of fractures and joints are evident on the ER data imaging. These are possible structures for ore emplacement/enrichment zones. The high negative sp anomalies are indication of sulphide ore bodies, possibly Pyrite. Stream sediments analysis and rock geochemistry are recommended in other to check the percentage concentration of the pyrite ore and its accessory sulphide ores.

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