IOSR Journal Of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 12, Issue 2 Ser. III (Mar. – Apr. 2020), PP 47-58
www.Iosrjournals.Org

Vertical Electrical Sounding (VES) Survey for Intrusive Rocks in Lokpaukwu, Leru Community, Umunneochi LGA, Abia State, Nigeria

Obodo Charles Oluchukwu[1], Prof. C. L. Eze[2], Dr. I. Tamunobereton-ari [3]
[1, 2, 3,] Department Of Physics, Rivers State University, 500001, Port Harcourt Nigeria
Corresponding Author: Obodo Charle Oluchukwus

Abstract: *The Vertical Electrical Survey (VES) survey of intrusive rocks in Lokpaukwu, Leru Community in Umunneochi Local Government Area of Abia State was carried out with a view to providing geology and geophysical information on the different sub-surface layers, depth, thickness, and to determine the viability of commercial mining of quarry rock materials within the study area. Eleven vertical electrical soundings were conducted using the Schlumberger array configuration covering the study area, with current electrode separation (AB/2) at 90m. The Electrical resistivity data were processed and interpreted by using IP12win software and the curve matching technique. Interpretations from the vertical electrical sounding (VES) data were used to generate Isopach and Isoresistivity contour maps in terms of thickness and resistivity of sub-surface layer using SURFER 10 software. The interpretation of the 11 VES locations suggested that only 4 of the locations could be considered to have appreciable presence of intrusive rock and the locations are VES 4, 5, 6 and 7. The overburden thickness of these VES locations is 15.8m, 10.8m, 3.42m and 15.3m respectively. From the analyses of the VES curves, it was revealed that the subsurface structure of 6 out of the 11 VES points were underlain by three layers while 4 were of five layer types and only 1 curve showed the presence of four layers in the sub-surface structure. The predominance of the three layer types as well as the low resistivity values obtained at most of the VES locations suggests the extent of fracturing in the study area. Quantitative analysis of data from the study area shows that the 'HK' type curves predominates in Lokpaukwu followed by 'A', 'H' and 'Q' type. 'A' type curves are obtained mostly in hard rock formations with conductive top soils. In this case, the resistivity of the layers will be continuously increasing ($\rho1<\rho2<\rho3$).*

Key Word*: Vertical Electrical Sounding; Intrusive Rocks; Overburden Thickness; Resistivity; Schlumberger array.*

Date of Submission: 06-04-2020 Date of Acceptance: 20-04-2020

I. Introduction

Intrusive rocks are formed within the Earth's crust from the crystallization of molten magma. Intrusions are one out of the two different ways igneous rock can be formed; the other form is extrusive rock, this is formed through a volcanic eruption from within the earth crust. Large bodies of molten magma that solidify underground before they reach the surface of the earth crust are called plutons. Plutonic rocks forms about 7% of the Earth's current land surface [1]. Coarse-grained abyssal rocks are formed within the earth while the hypabyssal rocks are formed near the surface of the earth. Intrusive rock formations are classified according to whether or not they are parallel to the bedding planes or foliation of the country rock: if the intrusion is parallel to the body, it is said to be concordant, otherwise it is discordant. Geophysical exploration techniques gives an insight into the nature of the earth's subsurface. These techniques include geoelectric, electromagnetic, seismic and geophysical borehole logging. The choice of a particular method is determined by the geology and cost considerations [2]. Vertical Electrical Soundings have been used by different authors to determine overburden thickness and geoelectric parameters of the subsurface. The sedimentary units in the area of study are generally Cretaceous in age, and have long been studied by several workers [3], [4], [5]. Several studies have been carried out in Lokpaukwu using different geophysical method to ascertain the presence of intrusive rocks. However, there are still some noticeable areas which are yet to be worked on and this project work is meant to cover these grey areas. Blind mining or trial excavation of the intrusive rock is practiced in this area and this has resulted in several abandoned pits [6]. These abandoned pits can be seen in places like Isiagu, Lokpaukwu, Lekwesi, Lokpanta and to Upper Benue trough areas.

This situation worsens, because many of the quarry operators fail to conduct geophysical and geological exploration of the intrusive body prior to excavation. Some of them are ignorant of the availability of modern and reliable geophysical exploration technique application to intrusive mapping. The purpose of this work is to investigate and determine the following hydrogeological parameters estimation of overburden thickness of the intrusive rocks in Lokpaukwu, develop an Iso-resistivity and Iso-pach maps of the study area and determine the viability of the commercial mining of quarry rock material within the study area using vertical electrical sounding (VES) technique.

II. Location And Geology Of The Study Area

The study area is located in Lokpaukwu, Leru community in Umunneochi L.G.A of Abia state, Nigeria. Lokpaukwu is located at about 2.5km south of the Leru-Awgu Highway or at about 3km southeast of Lokpanta junction. The community occupies an area of 18.92 hectares of land. The community has a population of 163,928, according to the 2006 Nigeria National Census. The area has a humid tropical climate, having a mean annual rainfall of 2250mm and a mean annual temperature range of 27 – 28 degrees Celcius. The type of rain fall prevalent in this area is Orographic rainfall. The intrusive area is characterized by thick and dense vegetation typical of the tropical rainforest. The fine-grained soil, mostly clay, shale, silts and mixture of these and sands support luxuriant plant growth [7]. The vegetation however is denser in the parts directly overlaid by the Asu-River Group [8].

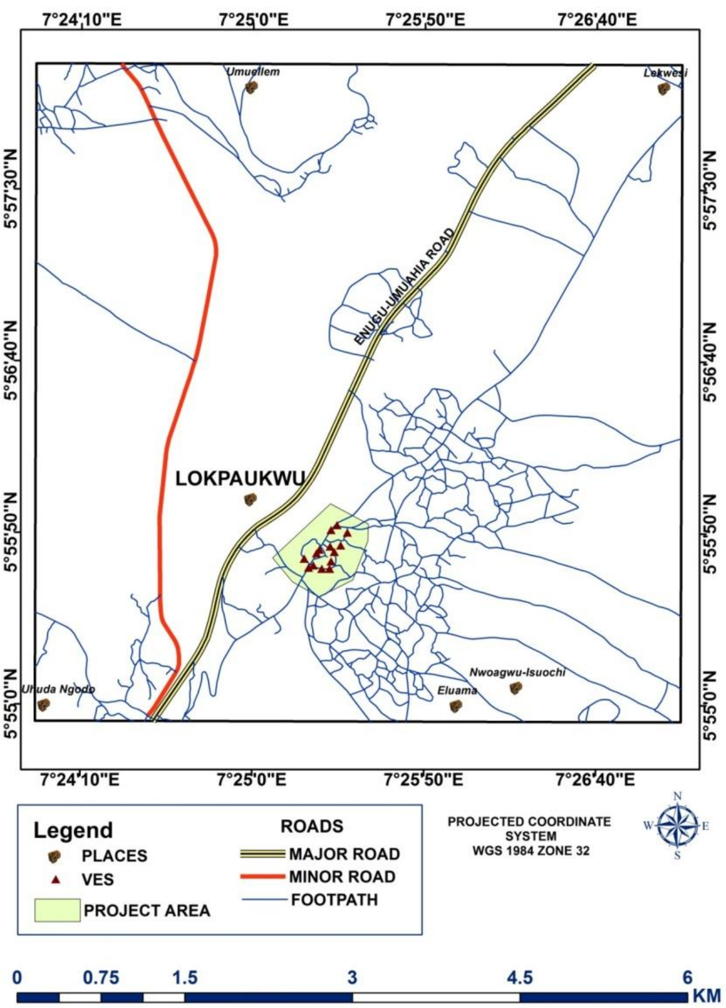


Figure 1: Showing map of study area

III. Material And Methods

Data Acquisition: A four day survey was carried out using the electrical resistivity method. The survey was conducted with ABEM Terrameter SAS 300B. A total of 11 Vertical Electrical Sounding (VES) stations were occupied randomly to cover the area of study. The Schlumberger array with maximum electrode spacing (AB/2) = 90m was used for the field resistance measurements.

These steps were followed to acquire electrical resistivity data;

1. Determine locations of resistivity sounding points.

2. Select line of measurement and place four electrodes on the ground surface along the straight line. Connect electrodes to the resistivity meter SAS 300B via electric cables.
3. Start the measurement and read the resistance value of R.
4. Increase spacing between current electrodes and repeat step (3).
5. Repeat steps (3) and (4) until maximum AB value required for that location is reached.
6. Record name of sounding point and location of sounding point by GPS in a data sheet.
7. Move to next sounding point and repeat steps (2), (3), (4), (5) and (6).
8. All together 11 sounding stations were measured within the study area.
9. In order to obtain the apparent resistivity as the function of depth, the measurements for each position, is performed with several different distances between current electrodes. The apparent resistivity is calculated as

$$\rho_k = k\frac{U_{MN}}{I_{AB}} \tag{1}$$

10. Here, *k* is a geometric factor, — voltage between electrodes M and N, — current in the line AB. The geometric factor is defined by

$$K = \frac{2\pi}{\frac{1}{r_{AM}} - \frac{1}{r_{BM}} - \frac{1}{r_{AN}} + \frac{1}{r_{BN}}} \tag{2}$$

11. Where *r* is the distance between electrodes.

Data Processing: Electrical resistivity data were processed and interpreted by using IP12win software and the curve matching technique. The procedures are as follows:

1. Input observed resistivity data and their corresponding AB/2 current electrode spacing of a sounding point into the IP12win software.
2. Display resistivity curve of apparent resistivity versus AB/2 current electrode spacing in log-log graph. This procedure will allow us to guess an initial resistivity model of the ground, e.g. number of ground layer, resistivity and thickness of each ground layer.
3. Input this initial resistivity model into the IP12win software program and let the program compute a calculated resistivity curve.
4. Compare this calculated resistivity curve with the observed resistivity curve. If they are mismatched, modify the resistivity model until they are matched to each other. The final resistivity model which gives a good match between the calculated and the observed resistivity curves will represent the ground structure at that sounding point.

IV. Result And Discussion

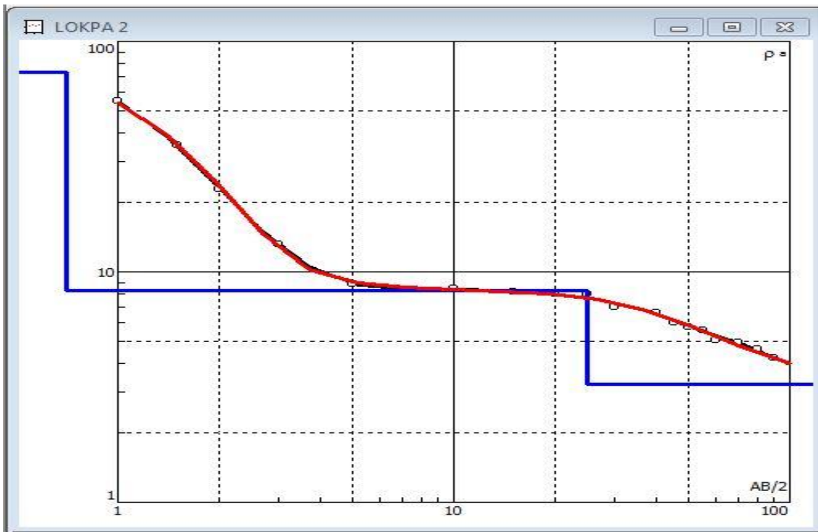
VES Location 1: The apparent resistivity curve for VES location 1 shows a five-layer subsurface structure with resistivity value varying between 39.9 Ωm and 956 Ωm as shown in Figure 2. The topsoil had a thickness of 0.706 m and a resistivity of 466 Ωm whereas the thickness of the second layer is 0.916 m with a resistivity of 39.9 Ωm. The resistivity of the third layer is 93 Ωm and it has a thickness of 13.1m. The fourth layer has a resistivity of 6.79 Ωm and a layer thickness of 36.5m. The resistivity of the fifth layer is 956 Ωm. Deductions from the results suggest a very remote possibility of finding intrusive rock in this location due to the low resistivity values of the layers.

RMS=3.07%

N	1	2	3	4	5
ρ	466	39.9	93	6.79	956
h	0.706	0.916	13.1	36.5	
d	0.706	1.62	14.7	51.2	
Alt	-0.706	-1.622	-14.72	-51.22	

Figure 2: Showing curves generated for VES location 1

VES Location 2: The curve for VES location 2, suggests that the subsurface is made up of three layers as shown in Figure 3 with apparent resistivity values ranging between 3.25 Ωm to 73.8 Ωm. The topmost layer with an apparent resistivity of 73.8 Ωm has a thickness of 0.705 m and beneath is a second layer of resistivity, 8.32 Ωm and thickness, 24.2 m. The third layer, has an apparent resistivity value of 3.25 Ωm. It can be deduced from these results that this location might not have any potential for the presence of intrusive rock.



RMS=1.95%

N	1	2	3
ρ	73.8	8.32	3.25
h	0.705	24.2	
d	0.705	24.9	
Alt	-0.7053	-24.91	

Figure 3: Showing curves generated for VES location 2

VES Location 3: VES location 3 curve has a subsurface that consists of three layers as shown in Figure 4. The apparent resistivity value is within the range of 3.27 Ωm to 38236 Ωm. The apparent resistivity of the first layer is 3.27 Ωm and thickness is 0.533 m. The second layer is 0.667 m thick and has a resistivity of 20.8 Ωm. The third layer however has the highest apparent resistivity of 38236 Ωm. The very high resistivity of the deepest layer suggests that the layer could be a potential zone for intrusive rock mining.

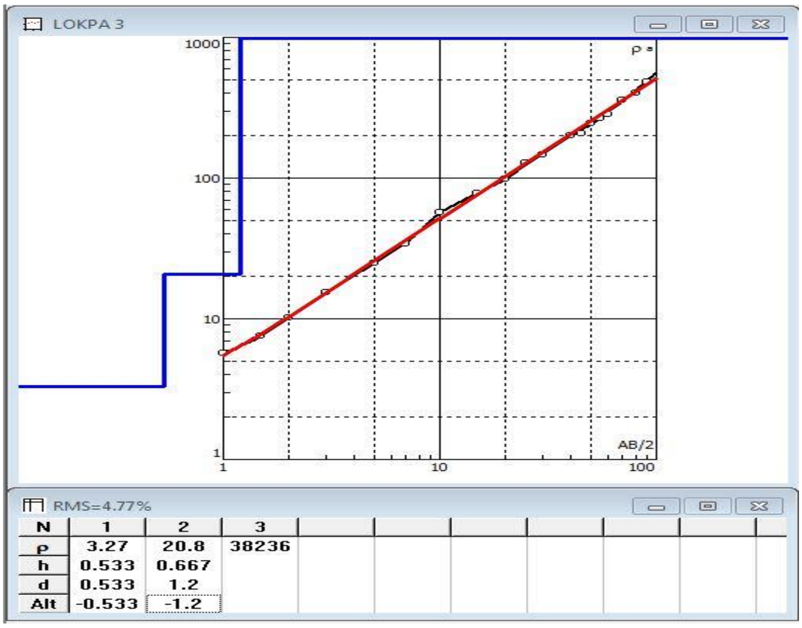


Figure 4: Showing curves generated for VES location 3

VES Location 4: The subsurface structure at VES location 4 is made up of three layers of apparent resistivities ranging between 164 Ωm and 6139 Ωm as shown in Figure 5. The result shows that the topmost layer has an apparent resistivity value of 164 Ωm and is 4.15 m thick. The second layer with a thickness of 11.6 m has an apparent resistivity of 506 Ωm and is underlain by a third layer of resistivity 6139 Ωm. It can be inferred from these results that the third layer could be a very good zone for intrusive rock accumulation.

Figure 5: Showing curves generated for VES location 4

VES Location 5: The geological section at VES location 5 shows that the subsurface structure consists of three layers with apparent resistivity values ranging between 143 Ωm to 10493 Ωm as shown in Figure 6. The upper layer has thickness and apparent resistivity values of 0.554 m and 457 Ωm respectively whilst the second layer has a thickness of 10.2 m and a resistivity of 143 Ωm. The third layer which is the deepest layer has an apparent resistivity of 10493m. Analysis of these results reveals that the third layer which is the deepest layer and has a high apparent resistivity value could contain reasonable deposit of intrusive rock. Hence, it's considered to be a good intrusive rock mining location.

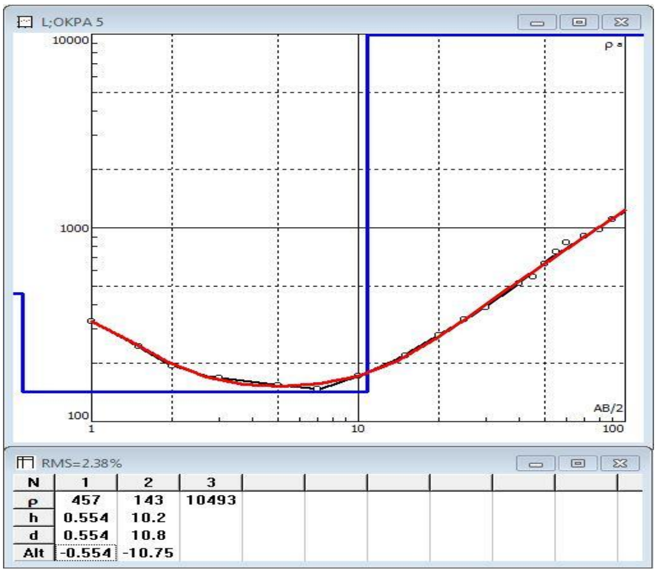


Figure 6: Showing curves generated for VES location 5

VES Location 6: From the VES curve at location 6, it is observed that three subsurface layers exist as shown in Figure 7. Apparent resistivity values generally range from 81.7 Ωm to 11716 Ωm. The top layer has apparent resistivity of 98.1 Ωm and thickness of 1.31 m. Just below this, is the second layer with apparent resistivity and thickness of 81.7 Ωm and 2.11 m and a third layer of resistivity 11716 Ωm. The third layer may probably host appreciable amount of intrusive rock deposit.

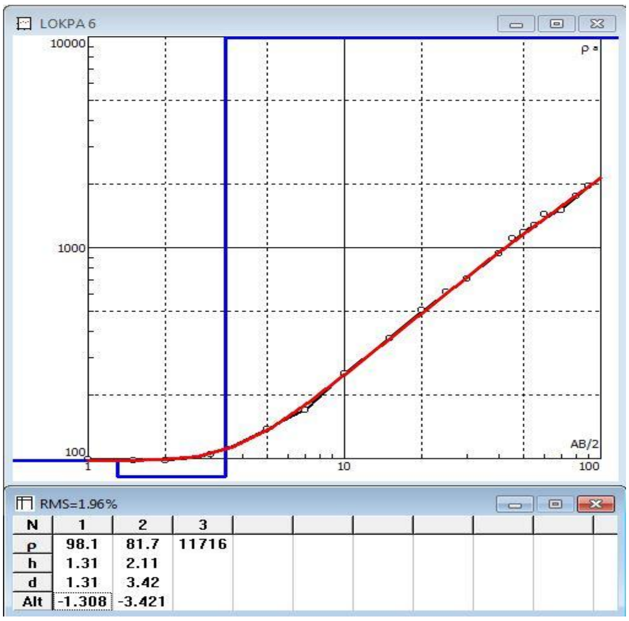


Figure 7: Showing curves generated for VES location 6

VES Location 7: As shown in Figure 8, it is simple to see that the subsurface structure at VES location 7 consists of three layers with apparent resistivity values ranging between 9.1 Ωm and 4303 Ωm. The topsoil, which is 1.51 m thickness has an apparent resistivity value of 187 Ωm whereas the second layer has thickness and resistivity values of 13.8 m and 9.1 Ωm respectively. The third layer has apparent resistivity of 4303 Ωm. These results depict that the third layer could possibly host considerable quantity of intrusive rock deposit and hence, might be a reliable location for mining of rock.

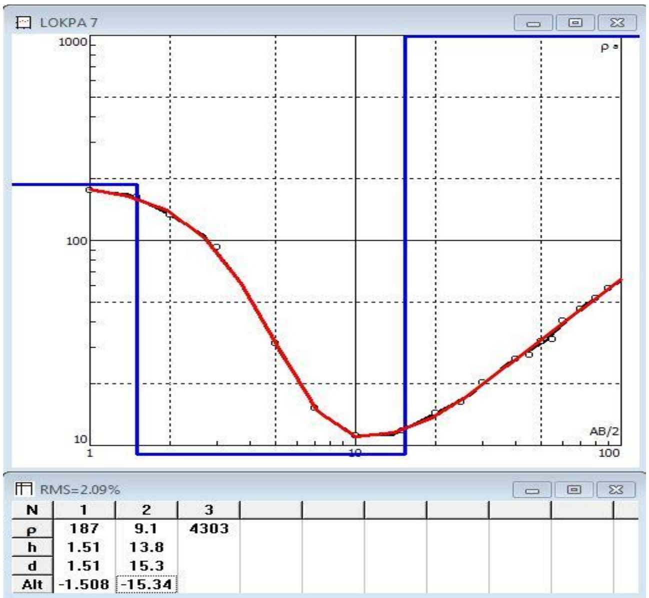


Figure 8: Showing curves generated for VES location 7

VES Location 8: The VES curve of location 8 as shown in Figure 9 reveals five layers in the subsurface with the top layer having an apparent resistivity of 250 Ωm and a thickness of 0.5 m. The second layer, which is 0.808 m thick has an apparent resistivity value of 107 Ωm and is underlain by a third layer of resistivity 10.5 Ωm. The fourth layer has an apparent resistivity of 18.2 Ωm and a thickness of 14.5 m, while the deepest layer which is the fifth layer has an apparent resistivity of 1.7 Ωm. Deductions made from these results suggests that none of these layers will be a good to find intrusive rock due to the very low apparent resistivity values of the layers.

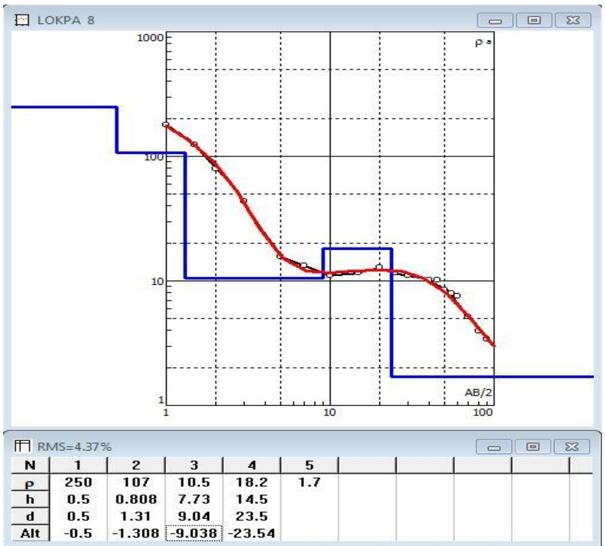


Figure 9: Showing curves generated for VES location 8

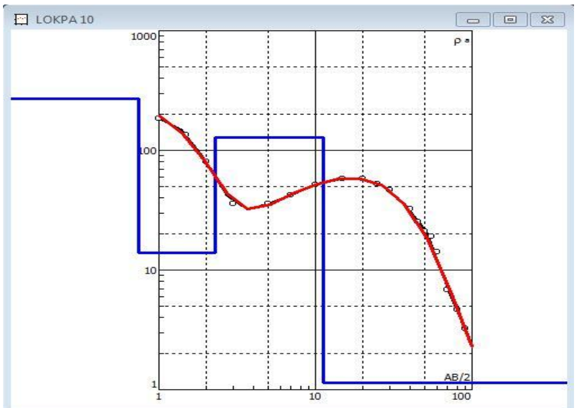
VES Location 9: VES curve analysis at location 9 revealed a five layered structure as shown in Figure 10. The apparent resistivity values range between 11.2 Ωm and 861 Ωm. The upper layer, indicative of a moderately weathered formation has an apparent resistivity value of 861 Ωm and is 0.908 m thick. Underlying this is a low resistivity second layer with apparent resistivity of 50.8 Ωm and a thickness of 1.33 m whilst the third layer has an apparent resistivity of 240 Ωm and a thickness of 4.48 m. The fourth layer has a resistivity value of 24.6 Ωm and a thickness of 32.2 m and this is underlain by a highly weathered fifth layer with resistivity of 11.2 Ωm. The very low values of apparent resistivity indicate that none of the layers will have reasonable deposit of intrusive rock.

RMS=2.64%

N	1	2	3	4	5
ρ	861	50.8	240	24.6	11.2
h	0.908	1.33	4.48	32.2	
d	0.908	2.24	6.72	38.9	
Alt	-0.908	-2.238	-6.718	-38.92	

Figure 10: Showing curves generated for VES location 9

VES Location 10: As shown in the VES graph (Figure 11), four layers exist in the subsurface of location 10. Apparent resistivities were in the range of 1.15 Ωm to 268 Ωm with the first layer having a resistivity and thickness of 268 Ωm and 0.741 m. The second layer resistivity and thickness was 14 Ωm and 1.54 m whilst the third layer had an apparent resistivity value of 129 Ωm and thickness of 8.97 m. Underlying the third layer is a highly weathered fourth layer with a low resistivity value of 1.15 Ωm. Analysis of these results indicate that almost all the layers are highly weathered and will not contain sufficient amount of intrusive rock.

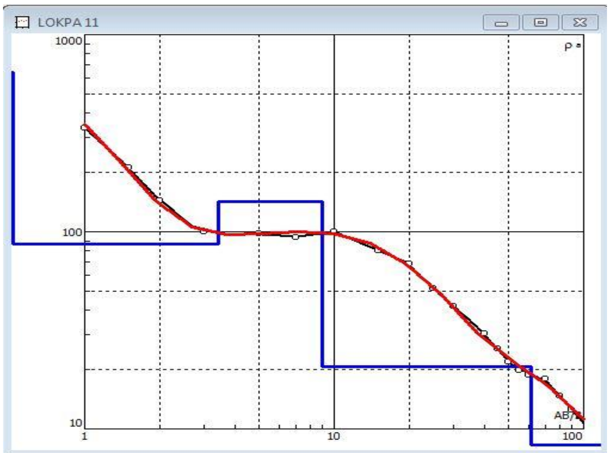


RMS=4.55%

N	1	2	3	4
ρ	268	14	129	1.15
h	0.741	1.54	8.97	
d	0.741	2.28	11.3	
Alt	-0.741	-2.281	-11.25	

Figure 11: Showing curves generated for VES location 10

VES Location 11: VES curve analysis at location 11 (Figure 12) indicated five subsurface layers. Apparent resistivities varied between 643 Ωm at the upper layer with 0.5 m thickness to 0.37 Ωm at the fifth and deepest layer. The second layer is 2.95 m thick and has a resistivity of 86.2 Ωm. The third layer has a resistivity value of 142 Ωm and thickness of 5.53 m while the fourth layer resistivity and thickness is 20.7 Ωm and 50.3 m respectively. From the results of the sounding at this location, it is inferred that none of the layers will be a good zone for adequate intrusive rock accumulation.



N	1	2	3	4	5
ρ	643	86.2	142	20.7	0.37
h	0.5	2.95	5.53	52.3	
d	0.5	3.45	8.98	61.3	
Alt	-0.5	-3.45	-8.98	-61.28	

Figure 12: Showing curves generated for VES location 11

Contour maps of apparent resistivity at half current electrode spacing of 10, 20, 50, and 90m was developed in order to monitor horizontal and vertical changes in apparent resistivity with depth. The Iso-resistivity maps revealed a progressive increase in resistivity with depth and the highest resistivity value of 6500 Ωm was recorded at AB/2 = 90m. Also the Iso-resistivity maps clearly shows three distint parts, the green coloured parts are areas with high resistivity indicating the presence of intrusive rocks, while the brown coloured parts indicates areas of low resistivity. For the Iso-pach map as shown in Figure 17, the intrusive rock potential zones are colored green and they are areas that corresponds to the highest layer thickness with values of 44m and above.

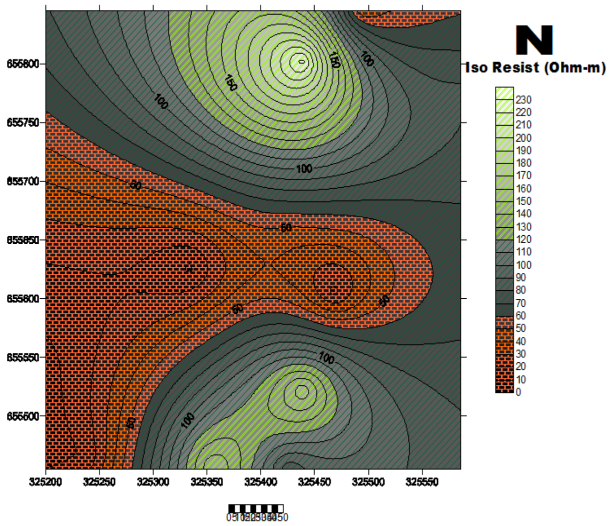


Figure 13: Iso-resistivity map at AB/2 = 10m

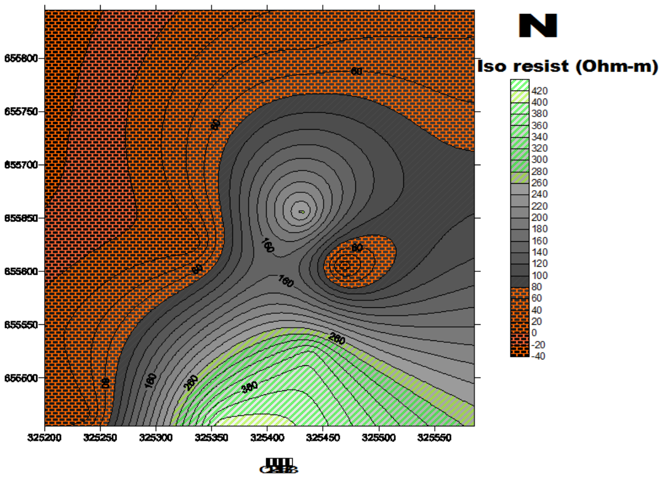


Figure 14: Iso-resistivity map at AB/2 = 10m

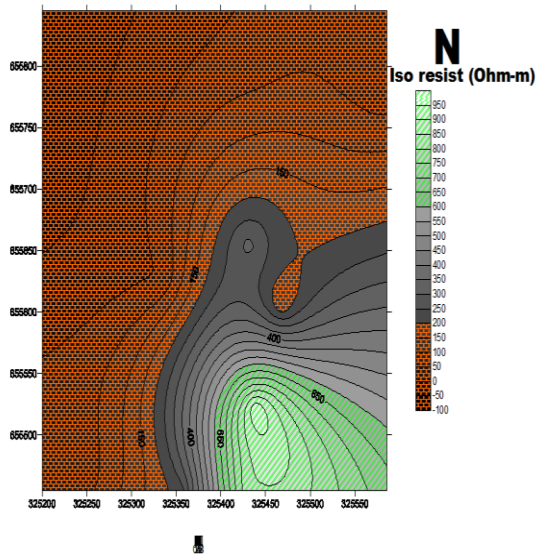


Figure 15: Iso-resistivity map at AB/2 = 50m

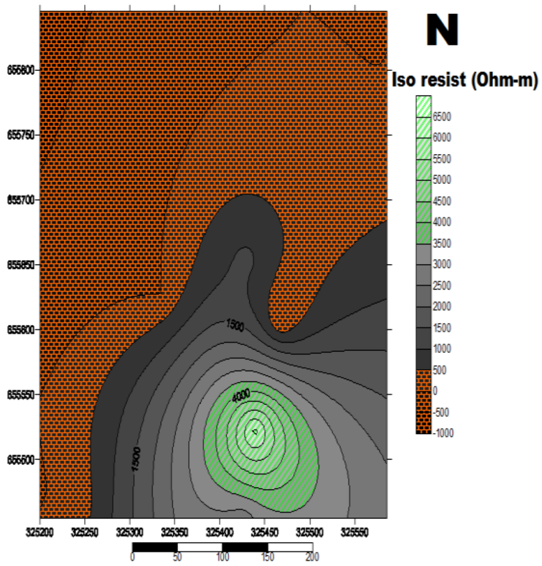


Figure 16: Iso-resistivity map at AB/2 = 90m

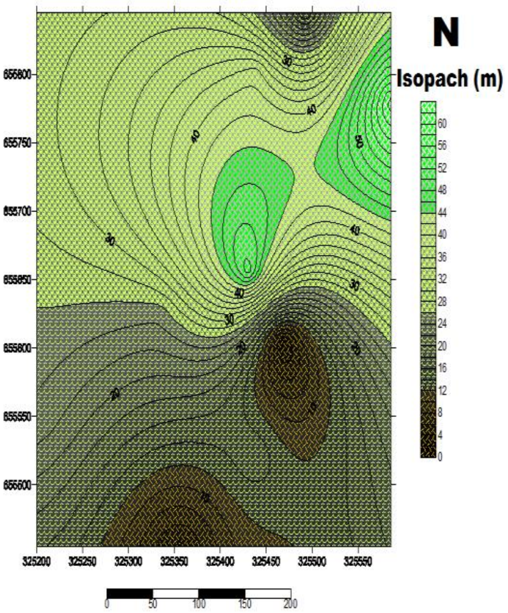


Figure 17: Isopach map of the study area

V. Conclusion

As a conclusion for this research project, the geophysical analysis using Vertical Electrical Sounding (VES) resistivity method has successfully reached it objectives of establishing potential zones for the presence of intrusive rocks within the study area, Iso-resistivity and Iso-pach contour maps of the study area was also generated. Out of the 11 location surveyed, the interpretation of the VES curves suggested that only 4 of the locations could be considered to have appreciable presence of intrusive rock and the locations are VES 4, 5, 6 and 7. The overburden thickness of these VES locations is 15.8m, 10.8m, 3.42m and 15.3m respectively. From the analyses of the VES curves, it was revealed that the subsurface structure of 6 out of the 11 VES points were underlain by three layers while 4 were of five layer types and only 1 curve has four layers. The predominance of the three layer types as well as the low resistivity values obtained at most of the VES points suggests the extent of fracturing in the study area. Conclusions drawn from the interpretation of the VES data obtained in this study shows that the third layer of location 4, 5, 6 and 7 are very good potential intrusive rock zones and the layers are characterized by high resistivity values ranging from 4303 Ωm to 38236 Ωm. However, these locations are a very small percentage of the total area and will not yield rocks in a commercial quantity to make it attractive for investment. Quantitative analysis of data from the study area shows that the 'HK' type curves predominates in Lokpaukwu followed by 'A', 'H' and 'Q' type. 'A' type curves are obtained mostly in hard rock formations with conductive topsoils. In this case, the resistivity of the layers will be continuously increasing ($\rho1<\rho2<\rho3$). For the VES survey conducted in Lokpaukwu, VES locations 3, 4 and 6 which produced 'A' type resistivity curve clearly signifies the presence of intrusive igneous rock in those locations. The 'A' type curve has a lower layer with high resistivity value and this is normally found in hard rock formations.

Acknowledgement

As To God Almighty, I return all the Glory, I will always be grateful for His inspiration, mercy, grace, guidance and protection during the process of execution of this challenging assignment. Definitely, this piece of task wouldn't have been possible without the collective help, support, contributions, suggestions and criticisms from many of us. These individuals I will continually be in their debt for their enormous contribution towards making this project a success. I am extremely grateful to Prof. C. L. Eze for his invaluable contribution and devotions towards the completion of this project. For his tolerance, fatherly recommendation, constructive criticisms and suggestions, I stay deeply grateful. My heartfelt gratitude also goes to Dr. I. Tamunobereton-ari of Physics Department for his support and guidance towards the success of this task. My special appreciation goes to everyone who has either directly or indirectly assisted in carrying out this project. I may not mention names but I am sincerely grateful for all your support and encouragement. God will greatly reward you all.

References

[1]. Wilkinson, B. H., McElroy, B. J., Kesler, S. E., Peters, S. E., & Rothman, E. D. (2008). "Global geologic maps are tectonic speedometers—Rates of rock cycling from area-age frequencies". *Geolog*ical Society of America Bulletin, 121 (5–6), 760–779.

[2]. Emenike, E.A (2001).Geophysical exploration for groundwater in a sedimentary environment. A case study from Nanka over Nanka formation in Anambra basin south east, Nigeria. Global 1.*Pure and Applied Science*,.97-110.

[3]. Reyment, R.A. (1965). *Aspect of the geology of Nigeria; Ibadan University Press*.

[4]. Kogbe, C. A. (1975).*The Geology of Nigeria, University of Ife Press*.

[5]. Adegoke, C.J. (1969). *Mem. Geol. Minieres*, 69: 23-40.

[6]. Webmaster (2012). Risk Assessment of Abandoned or Inactive Mine Posted in El Piedra; Mines and Geosciences Bureau Region IX

[7]. Etuk, E. E, Ukpabi, U, Ukaegbu, V. U.&Akpabio I. O. (2008). Structural Evolution, Magmatism, and Effects of Hydrocarbon Maturation in Lower Benue Trough, Nigeria: A Case Study of Lokpaukwu, Uturu, and Ishiagu; *Pacific Journal of Science Technology*, 9(2), 526-532

[8]. Whiteman, A.J. (1982). Nigeria. Its Petroleum Geology, Resources and Potential. Graham and Trotman, London. *AAPG Bulletin*. 77, 1405-1434.

Obodo Charles Oluchukwu,etal. "Vertical Electrical Sounding (VES) Survey for Intrusive Rocks in Lokpaukwu, Leru Community, Umunneochi LGA, Abia State, Nigeria." *IOSR Journal of Applied Physics (IOSR-JAP)*, 12(2), 2020, pp. 47-58.