International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 12 No. 2 Dec. 2014, pp. 436-443

http://www.ijisr.issr-journals.org/

RESERVE ESTIMATION OF DOLERITE DEPOSIT IN OBIAGU LEKWESI, ABIA STATE SOUTHEASTERN PART OF NIGERIA USING GEOPHYSICAL APPROACH

M.O. Eyankware[1], P.N Nnabo[1], R.M. Akpolo[2], and P.N. Obasi[1]

[1]Department of Geology, Faculty of Sciences Ebonyi State University Abakaliki, P.M.B 053, Ebonyi State, Nigeria

[2]Geoprobe Company, Enugu State, Nigeria

ABSTRACT: The survey is aimed at evaluating the geological parameters and establishing the surface and downward trends of a suspected quarry rock material, through resistivity variation characteristics, prior to the location of a rock quarry as well as estimating the overburden thickness. Geological study revealed that the dolerite has density of 1,200kgm^3**.** A total of six (6) vertical electrical soundings (VES) and four (4) horizontal resistivity profiling (HRP) were carried out using Abem Terrameter SAS 1000 with Schlumberger array of electrode spacing of 200m and Wenner electrode array configuration were carried out with 10m respectively, field data were processed using different forward and inverse modeling computer Res2Div software. The VES results revealed that dolerite occurred at VES 5, VES 8 and VES 9 positions with thickness ranging from 12meters to 25meters but dolerite did not appear at; VES 2, VES 3 and VES 7. The results of the horizontal resistivity profiling HRP line trending north-east and south-west reveals that the intrusive rock occurs in boulders form scatter beneath the overburden in a very limited quantity while north-east direction indicates abortive. Results of the analysis show that the overburden thickness is not uniformly distributed, it decreases toward the natural hills (places of appreciable elevation and decreases as one approaches the low land areas (valley). The estimated volume of dolerite is 34, 92000.00 million tons.

KEYWORDS: Vertical Electrical Sounding, Overburden, Intrusive rock, Quarry and Dolerite.

1 INTRODUCTION

Dolerite is a volcanic rock. While similar to basalt, it contains crystals which can be seen with a hand lens. This indicates that it cooled a little more slowly than basalt. Geographically the study area is located between latitude 5^0 21'N and 5^0 28' N and Longitude 7^{0}10' E and 7^0 26' E. It is about few kilometers, off Enugu/ Okigwe/ Port Harcourt Express way and about 11km to Okigwe town. Geophysical exploration techniques are available which give an insight into the nature of subsurface. These include geoelectric, electromagnetic, seismic and geophysical borehole logging. The choice of a particular method is governed by the nature of the terrain and cost considerations (Emenike, 2001). But for this research geoelecteric method was used using schlumberger and wenner confriguation method. A number of factors determine whether a dolerite can be quarried for use. These include the volume that can be quarried, the ease with which it can be quarried; the wastage consequent upon quarrying; and the cost of transportation; as well as its appearance and physical properties (Yavuz, et al, 2005). Furthermore, the volume must sustain not less than good number of years of quarrying (Bell, F.G 2008). The aim of this is to carry out the geophysical assessment of the dolerite deposit within the area. This is done by the study of the resistivity variation characteristics of the subsurface in the area, to determine the overburden thickness (Ibe, et al 2013). This is complemented by the determination of the specific gravity and uniaxial compressive strength and eventually, reserve tonnage is estimated. This study reports abundant occurrence of dolerite deposits in Abia state of Nigeria. Geophysical Survey was employed to unravel most of the dolerite deposits which occur in the study area. The geophysical technique has made it possible to estimate the reserve in the area which is up to 34, 92000.00 million tones.

2 GEOLOGY OF STUDY AREA

The Geology of the area (Fig.1) is located within the Lower Benue Trough of Nigeria. The area is of Albian age and belongs to the Asu River Group.. The Albian sediment of southeastern Nigeria was first named by Reyment, (1965) from a river at Abakaliki called Asu. Therefore the Asu River at Abakaliki, Obiagu, Lekwesi Community is a type locality of the Albian sediment of southeastern Nigeria. Faulting and folding and magmatic activity which occurred in southeastern Nigeria during the Santonian to early Campanian only affected the Albian sediment. That is the reason for Ore deposit, igneous and pyroclastic rock in southeastern Nigeria and is only found in the Albian sediment. Umunneochi local government area are vintage accumulation of lead, zinc and copper (John et al 2009). The sediment of the Asu-River is also associated with Lead zinc pyroclastic sediment, pyroclastic rocks, igneous rock and ore metallic deposit in southeastern Nigeria were all found in Albian sediment.

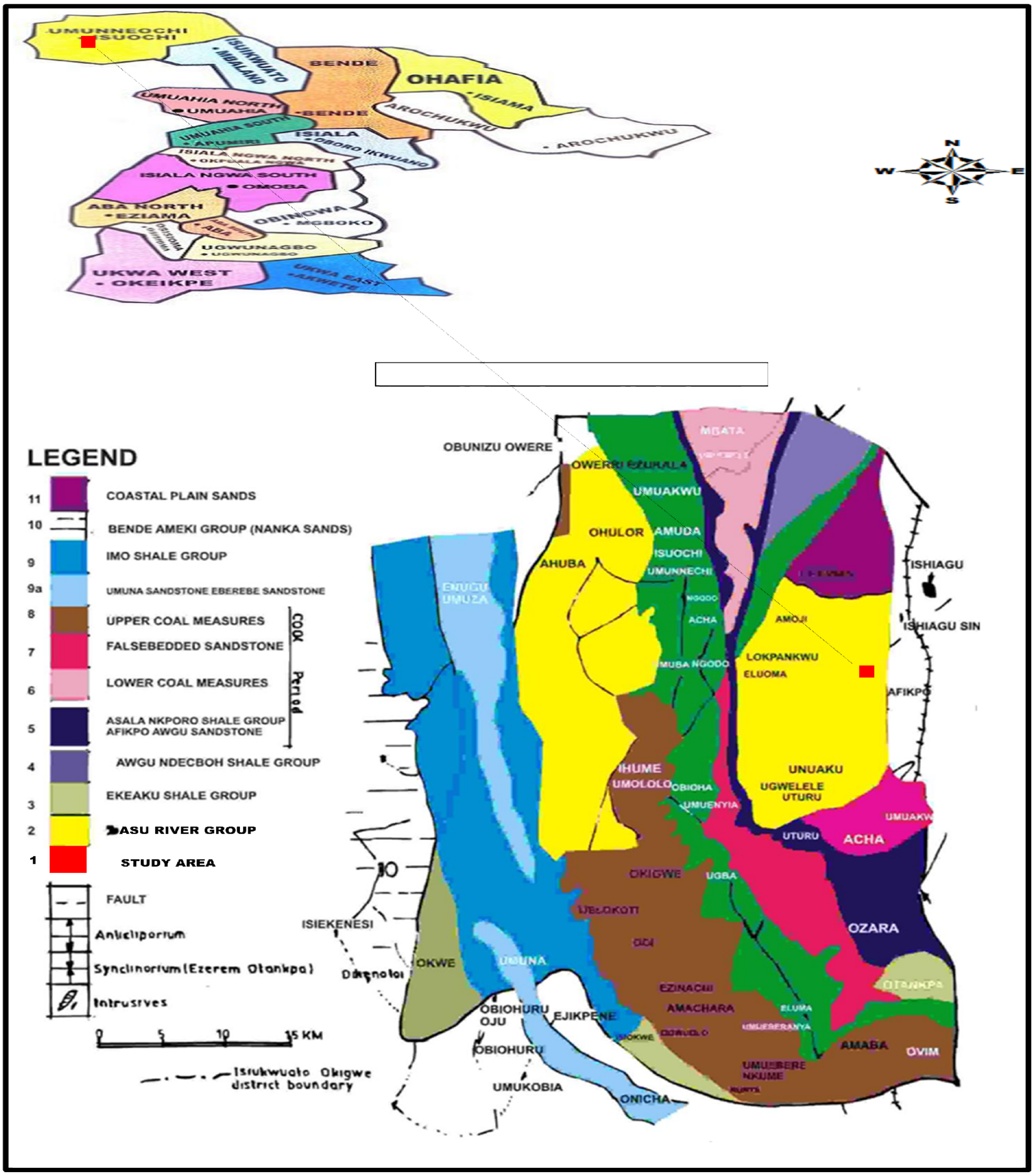


Fig.1 Geological Map of the study Area. Source: Igbokwe et al (2010)

3 Methodology

3.1 Geoelectrical Study

The geophysical investigation was carried out using the ABEM SAS 1000 Terrameter. This equipment is equipped with an in-built digital display and recording system. The geophysical investigation was carried out using the ABEM SAS 1000 Terrameter and employing the Vertical Electrical Sounding (VES) and Horizontal Resistivity Profiling (HRP) techniques. The VES and HRP traverses were made in a more or less NE-SW direction in both areas. The HRP was carried out using Wenner electrode array with a constant station interval of 10m.

This equipment is equipped with an in-built digital display and recording system. Rechargeable 12-volt batteries coupled to the equipment provide the energy for the equipment operation. Schlumberger and Wenner array method was used for the VES data acquisition and is capable of isolating successive geoelectric layers beneath the surface and a maximum electrode spacing (AB/2) of 200m was used throughout the study. The instrument displays the resistance of the area and the result was multiplied by its geometric Factor to calculate the apparent resistivity of each point. The values obtained were then plotted on a log-log paper as points with the apparent resistivity values being on the vertical axis and the electrode spacing (AB/2) on the horizontal axis. The field curves were manually interpreted (Koefoed, O., 1979), using master curves (Orellana,et al 1966) and auxiliary point charts (Keller, et al 1966). Geoelectric parameters obtained from manual interpretation were then used as an in-put model for computer- aided iteration of Res2Div Program for the interpretation (Vander Velpen, B.P.A. 1988) until it finds a final geoelectric model that is satisfactorily best of fits for the data. Six (6) VES surveys were conducted around the study area to determine the overburden thickness and these was carried out. The configuration used is shown in Fig 2.

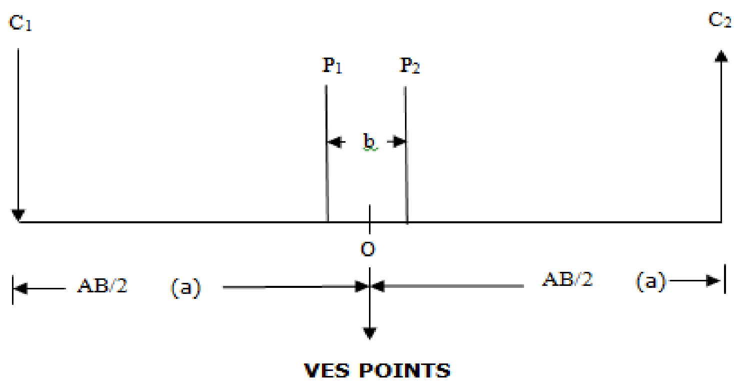


Fig 2: Schlumberger Electrode Configuration

The instrument displays the resistance of the area and the result was multiplied by its Geometric Factor to calculate the apparent resistivity of each point using the relation:

ℓa= (a2/b – b/4) R where
ℓa=apparent resistivity in Ohm-m
a=AB/2, the Half Current Electrode Separation in metres
b=Potential electrode separation in metres
R=Meter Reading in Ohms.

The values obtained were then plotted on a log-log paper as points with the apparent resistivity values being on the vertical axis and the electrode spacing (AB/2) on the horizontal axis. The field curves were manually interpreted (Koefoed, 1979), using master curves (Orellana, et al, 1966) and auxiliary point charts (Zohdy, 1976 and Keller et al, 1966).

Calculation of Reserve

- The volume of the reserve was calculated using the formula:
- Reserve Volume (m3) = Σ (area grid (m2) x average thickness of grid (m)
- The reserve tonnage is therefore calculated by:
- Reserve Tonnage (tons) = Σ (volume grid (m3) x specific gravity of the rock).
- Volume of Reserve = Area x Thickness x Density.

The average thickness of the overburden over the study area is 10m; this is of course rather high overburden thickness especially when the cost of removing it is put into consideration for profitable quarrying. Therefore, there is the need for selection and consideration of parts of the study area that are economically viable for exploitation. The criterion employed for area selection for the reserve estimation is such that the minimum ratio of overburden thickness to rock thickness is ratio 1:1.

4 Discussion

4.1 Geophysical Interpretation

Resistivity measurements were made in the field using the vertical electrical sounding VES and horizontal resistivity profiling HRP. The field measurements were analyzed using Res2D. The values of AB/2 and MN/2 were manually keyed into the progamme and subjected to iterative computer modeling and result are shown (Fig. 4-13. Respectively). There is a correlation in the resistivities values within the subsurface layers. Low resistivity values indicate area with clay moderately high values indicate clay shale with possible saturation of groundwater while areas of moderately high resistivity represent dolerite. While high resistivity values indicate intrusive rocks.

For VES. 2, has three (3) layers with resistivity values ranging from 105.81-10.00 (Ohms) and its depth ranges from 0.723-4.34m respectively. Layer with low resistivity indicate present of clay as shown in Fig.4. VES 3. Has five (5) layers with resistivity values ranging from 55.170-351.79 Ohms and its depth ranges from 1.04-62.27m respectively as shown in Fig.5. VES. 5 has five layers with resistivity values ranging from 7.08-1882.1 Ohms and its depth ranges from 0.56-9.7133m respectively as shown in Fig.6. VES 7. has a four(4) layers with resistivity value ranging from 4.44-347.15 Ohms and its depth ranging from 2.37-31.65m respectively shown in Fig.7. VES. 8 has three layers with resistivity value ranging from 0.51-0.251Ohms and its depth ranging from 0.22-3.00m respectively. VES 9 has five layers with resistivity value ranging from 144.69-10.00Ohms and its depth ranging from 0.99-19.52m respectively as shown in Fig. 3 and 9.

The results of the horizontal resistivity profiling HRP line trending north-east and south-west reveals that the intrusive rock occurs in boulders form scatter beneath the overburden in a very limited quantity while north-east direction indicate abortive as shown in (Fig.10-13). VES 3 and 7 shows no presence of dolerite as shown in Fig. 5 and 7, respectively. While for VES 5, 8 and 9 shows occurrence of dolerite based of their resistivity value as shown in Fig 3. Also the result from Wenner shows that line 1 has no evidence of intrusive rock (dolerite) as shown in (Fig.11) based on the resistivity using colour differentiation representing resistivity of the rock (lateritic material to hard shale). Line 2, 3 and 4 showed evidence of occurrence of dolerite with resistivity values from 1182-5252ohmm and depth ranges from 8.32-18.4m as shown in (Fig. 12-14).

4.2 Resource Potential

Limited quantities of intrusive rock occurring in form of boulders abound in the study area covered with non uniform overburden thickness.

- These rock boulders are seen scatterd at the surface at some places within the proposed quarry site.
- The overburden thickness is not uniform within the study area and varies from 9.1m at VES 9

Generally, subsurface geophysical data agreed with the geology of the Area.

- The static water level within the study area is between 13.m and 27m and the average overburden thickness is 15.9 meters indicating that intrusive rock is within the zone of underground water hence effects of flooding in mining pits will be maximum.

4.3 Reserve Of Estimation

Approximate area with intrusive rock = 0.12km^2.
Average thickness of intrusive rock = 10.00m.
Total volume of intrusive rock is Approximate area with intrusive rock (0.12km^2) by thickness of the intrusive rock (10m) = 1,200m^3
Density of the dolerite= 2.91kg/m^3
Therefore the quantity of dolerite is volume (1,200.00m^3) by Density of the rock (2.91kg/m^3) = 34, 92000.00 million tons.

5 CONCLUSION

Average overburden thickness is 15.9meters and average tonnage is 35 millions but mining pits may not exceeds 20metres due to problem of both surface and underground water as the study area is liable to flooding.

6 RECOMMENDATIONS

From the geophysical survey Study, the under listed points are highly recommended:

- Limited and localized quantity of dolerite occurring inform of boulders abound in the study area but are not laterally extensive.
- The study area is feasible for mining of the rock only for a very limited time due to the boulders nature, occurrence of the rock and also part of the site has been mined.
- Large Market demand abounds for the product to be mined hence further effort should be made to search for other suitable site as this present site may not last for a long time.
- Also other prospecting measure by way of core drilling is recommended for additional information/ confirmation of this geophysical report.
- Physically, visual look of the sample collected at site but further test for physical and chemical properties of rock is highly recommended.

ACKNOWLEDGMENT

The first author wishes to acknowledge Dr. P. N Nnabo the Head of Department of Geology Ebonyi State University for his assistance and Richard Akpolo of Geoprobe for assistance in acquiring data from the field.

REFERENCES

[1] Bell, F.G. (2008): Engineering Geology, 2nd Edition, *Elsevier*, 581p.
[2] Emenike E. A (2001). Geophysical Exploration for Ground water in a sedimentary environment. *Global J. pure and applied sci*, Vol.7: 1, pp
[3] Ibe Kalu K., Ibeneme Sabinus I., Selemo Alex O., Nwagbara Johnbosco O., Ikoro Diugo O., Obioha Young E.(2013). Geological And Geoelectrical Characterization of the Ukomi Diorite Deposit Lokpaukwu, Umuchieze Area, South Eastern Nigeria: Implications For Establishing A Quarry Site. *Scientific Research Journal* (SCIRJ), Vol. I, Issue IV,pp 1-11.
[4] Ubechu Bridget O., Chinemelu Ekeoma S. and Onwuka Chibuike O.(2013). Geological And Geoelectrical Characterization of the Ukomi Diorite Deposit Lokpaukwu, Umuchieze Area, South Eastern Nigeria: Implications for Establishing A Quarry Site. *Scientific Research Journal* (SCIRJ), Vol. I, Issue IV. Pp.1-11.
[5] Igboekwe. M. U and Akpan, C. B. (2010*).* Determination of aquifer potentials of Abia State University, Uturu (ABSU) and its environs using vertical electrical sounding (VES). *Journal of Geology and Mining Research* Vol. 3(10), pp. 251-264.
[6] John-Onwualu, J. N. and V.U. Ukaegbu. (2009). Petrogenetic and Geotectonic Implications of Lokpa-Ukwu Pyroclastics in Southern Benue Trough, Nigeria". *Pacific Journal of Science and Technology*. Vol.10(1):pp 487-500.
[7] Keller, G. V. and Frischknecht, F.C. (1966): Electrical Methods in Geophysical Prospecting. Pergamon Press. London. 519Pp.
[8] Koefoed, O., (1979): Geosounding Principle-1, *Elsevier,* Amsterda, 276 pp,
[9] Orellana, E. and Mooney, H. M. (1966): Tables and Master Curves for Vertical Electrical Sounding. Interciencia, Madrid, 160pp.
[10] Reyment, R.A. (1965). Aspects of the geology of Nigeria .University of Ibadan, Nigeria. P. 145.
[11] Yavuz, A.B, Turk, N. and Koca, M.Y. (2005): Geological parameters affecting the Marble production in the quarries along the southern the Flank of Menderes Massif, in SW Turkey. Engineering Geology, 80, 214-241.
[12] Zohdy, A.A.R., (1976). Application of surface geophysics (Electrical methods to groundwater investigations) in: Techniques for water resources investigations in the United States. Section D, book 2, pp. 5 - 55.

APPENDIX

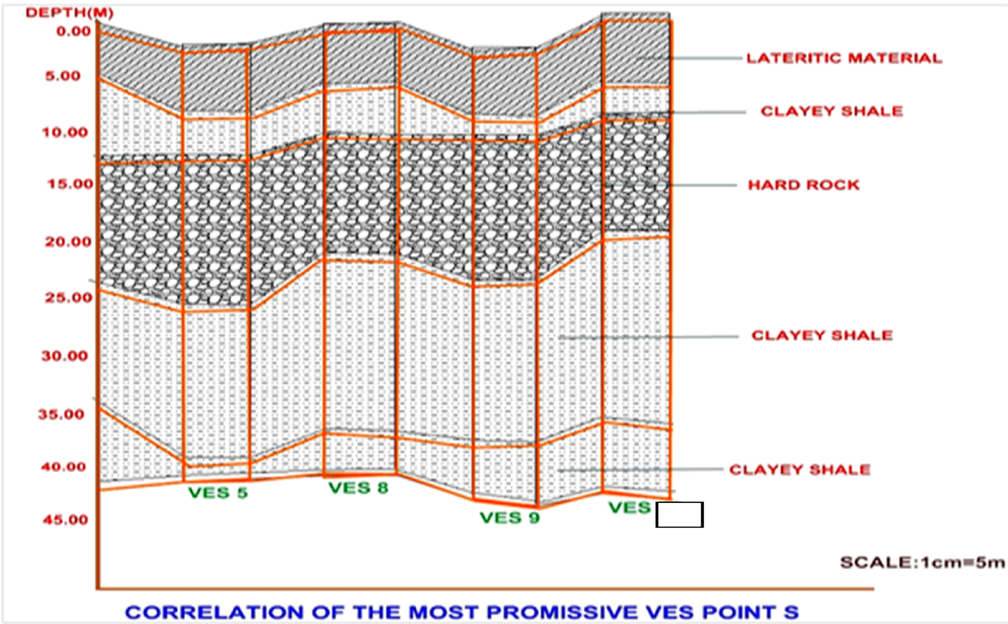
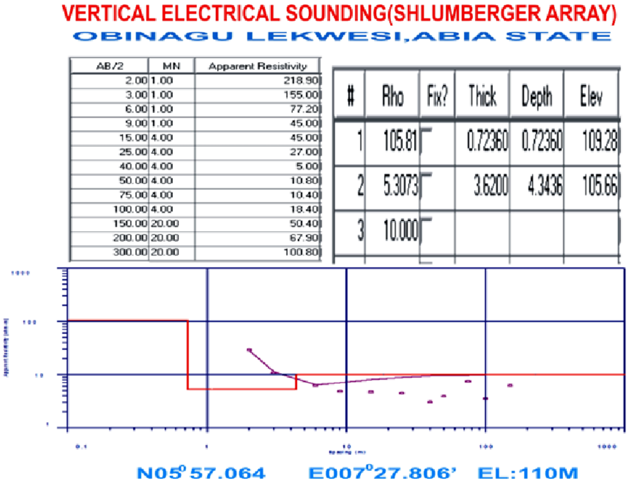


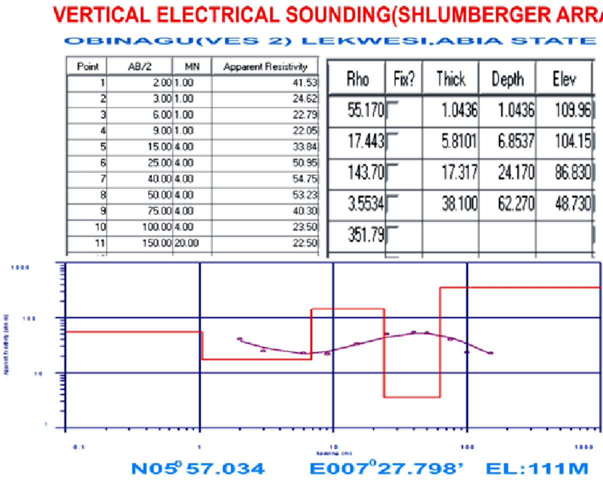
Fig.3.Correlation of the most promissive VES points



AB/2	MN	Apparent Resistivity
2.00	1.00	218.90
3.00	1.00	155.00
6.00	1.00	77.20
9.00	1.00	45.00
15.00	4.00	45.00
25.00	4.00	27.00
40.00	4.00	5.00
50.00	4.00	10.80
75.00	4.00	10.40
100.00	4.00	18.40
150.00	20.00	50.40
200.00	20.00	67.90
300.00	20.00	100.80

#	Rho	Fix?	Thick	Depth	Elev
1	105.81		0.72360	0.72360	109.28
2	5.3073		3.6200	4.3436	105.66
3	10.000				

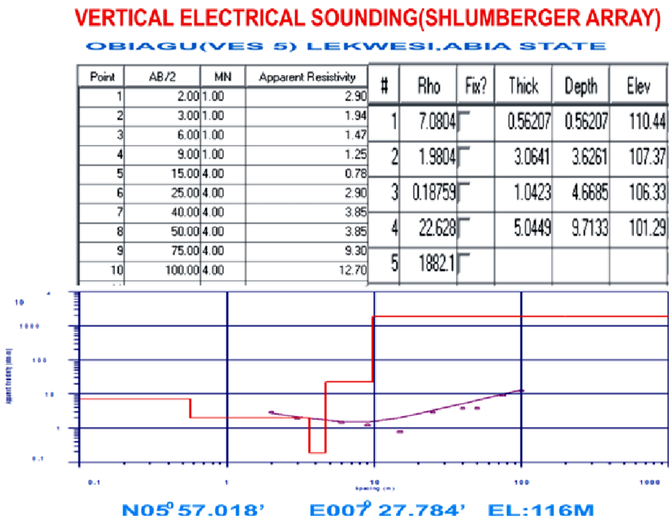
Fig.4 Vertical Electrical Sounding Interpretation (VES 2)



Point	AB/2	MN	Apparent Resistivity
1	2.00	1.00	41.53
2	3.00	1.00	24.62
3	6.00	1.00	22.79
4	9.00	1.00	22.05
5	15.00	4.00	33.84
6	25.00	4.00	50.95
7	40.00	4.00	54.75
8	50.00	4.00	53.23
9	75.00	4.00	40.30
10	100.00	4.00	23.50
11	150.00	20.00	22.50

Rho	Fix?	Thick	Depth	Elev
55.170		1.0436	1.0436	109.96
17.443		5.8101	6.8537	104.15
143.70		17.317	24.170	86.830
3.5534		38.100	62.270	48.730
351.79				

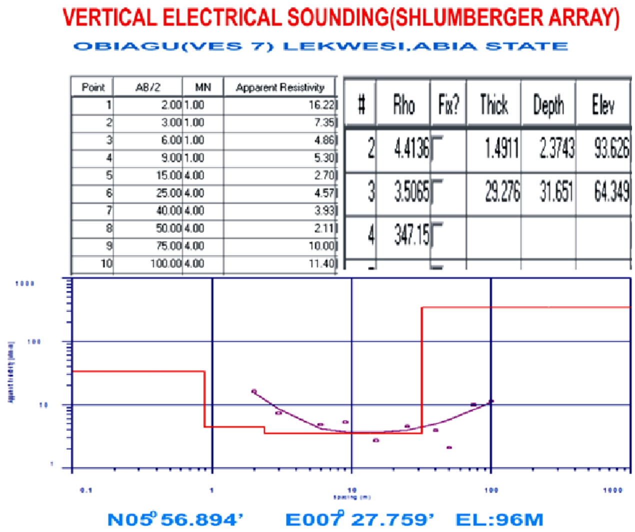
Fig. 5. Vertical Electrical Sounding Interpretation(VES 3)



Point	AB/2	MN	Apparent Resistivity
1	2.00	1.00	2.90
2	3.00	1.00	1.94
3	6.00	1.00	1.47
4	9.00	1.00	1.25
5	15.00	4.00	0.78
6	25.00	4.00	2.90
7	40.00	4.00	3.85
8	50.00	4.00	3.85
9	75.00	4.00	9.30
10	100.00	4.00	12.70

#	Rho	Fix?	Thick	Depth	Elev
1	7.0804		0.56207	0.56207	110.44
2	1.9804		3.0641	3.6261	107.37
3	0.18759		1.0423	4.6685	106.33
4	22.628		5.0449	9.7133	101.29
5	1882.1				

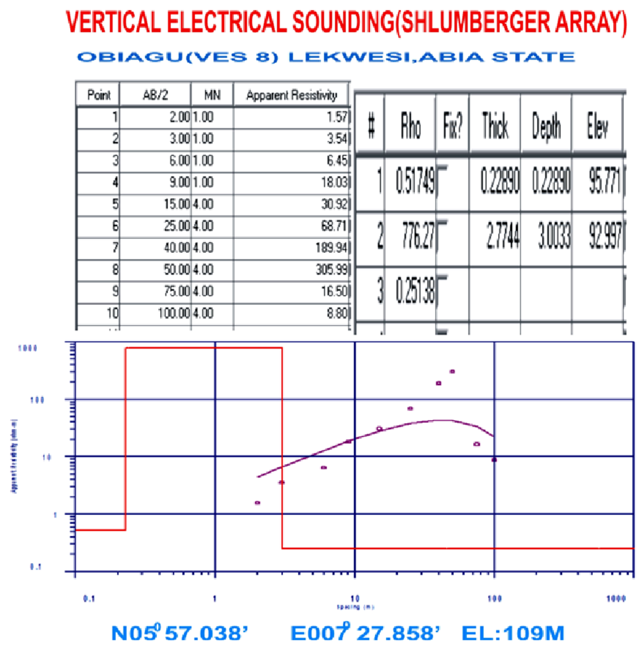
Fig.6. Vertical Electrical Sounding Interpretation (VES 5).



Point	AB/2	MN	Apparent Resistivity
1	2.00	1.00	16.22
2	3.00	1.00	7.35
3	6.00	1.00	4.86
4	9.00	1.00	5.30
5	15.00	4.00	2.70
6	25.00	4.00	4.57
7	40.00	4.00	3.93
8	50.00	4.00	2.11
9	75.00	4.00	10.00
10	100.00	4.00	11.40

#	Rho	Fix?	Thick	Depth	Elev
2	4.4136		1.4911	2.3743	93.626
3	3.5065		29.276	31.651	64.349
4	347.15				

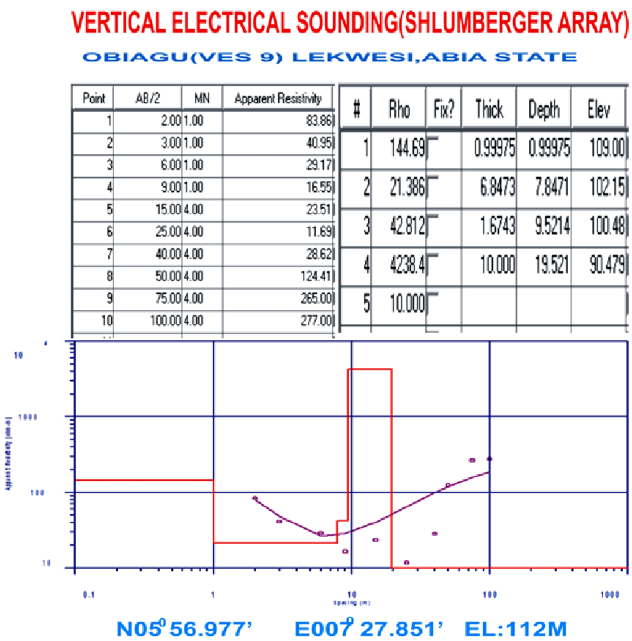
Fig.7 Vertical Electrical Sounding Interpretation (VES 7).



Point	AB/2	MN	Apparent Resistivity
1	2.00	1.00	1.57
2	3.00	1.00	3.54
3	6.00	1.00	6.45
4	9.00	1.00	18.03
5	15.00	4.00	30.92
6	25.00	4.00	68.71
7	40.00	4.00	189.94
8	50.00	4.00	305.99
9	75.00	4.00	16.50
10	100.00	4.00	8.80

#	Rho	Fix?	Thick	Depth	Elev
1	0.51749		0.22890	0.22890	95.771
2	776.27		2.7744	3.0033	92.997
3	0.25138				

Fig.8. Vertical Electrical Sounding Interpretation (VES 8)



Point	AB/2	MN	Apparent Resistivity
1	2.00	1.00	83.86
2	3.00	1.00	40.95
3	6.00	1.00	29.17
4	9.00	1.00	16.55
5	15.00	4.00	23.51
6	25.00	4.00	11.69
7	40.00	4.00	28.62
8	50.00	4.00	124.41
9	75.00	4.00	265.00
10	100.00	4.00	277.00

#	Rho	Fix?	Thick	Depth	Elev
1	144.69		0.99975	0.99975	109.00
2	21.386		6.8473	7.8471	102.15
3	42.812		1.6743	9.5214	100.48
4	4238.4		10.000	19.521	90.479
5	10.000				

Fig.9. Vertical Electrical Sounding Interpretation (VES 9).

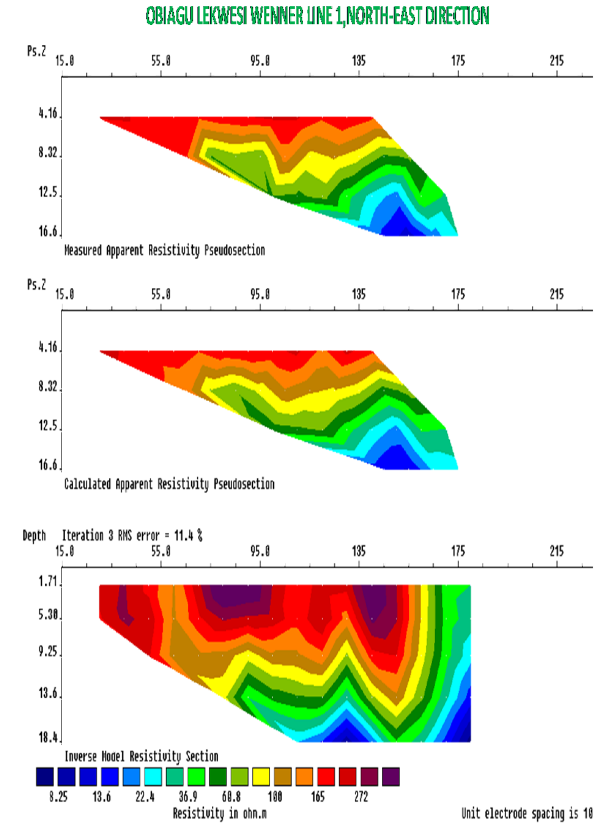


Fig. 10: Wenner North East direction Line 1

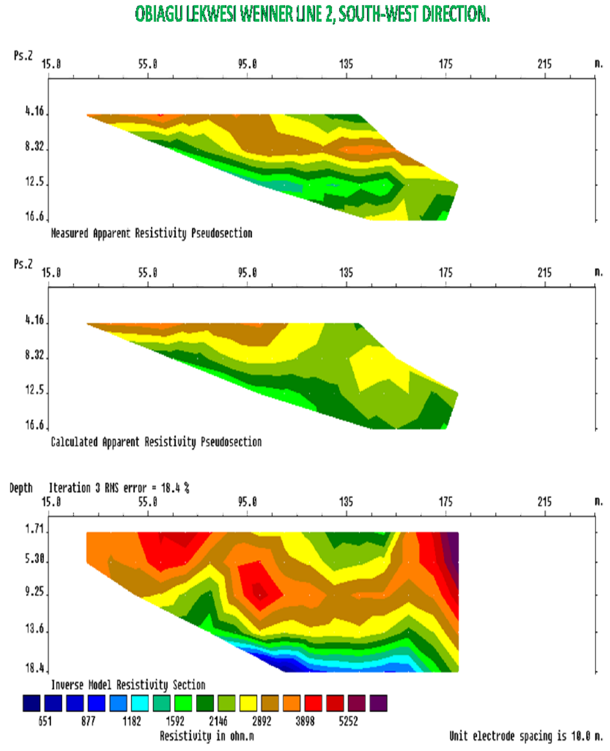


Fig.11: Wenner Line South west direction. Line 2

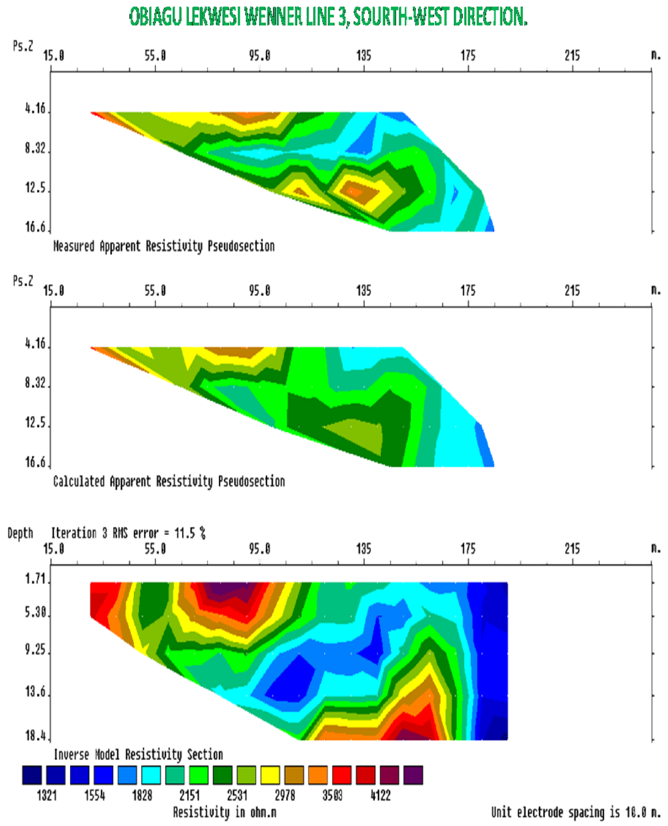


Fig.12: Wenner Line South West direction. Line 3

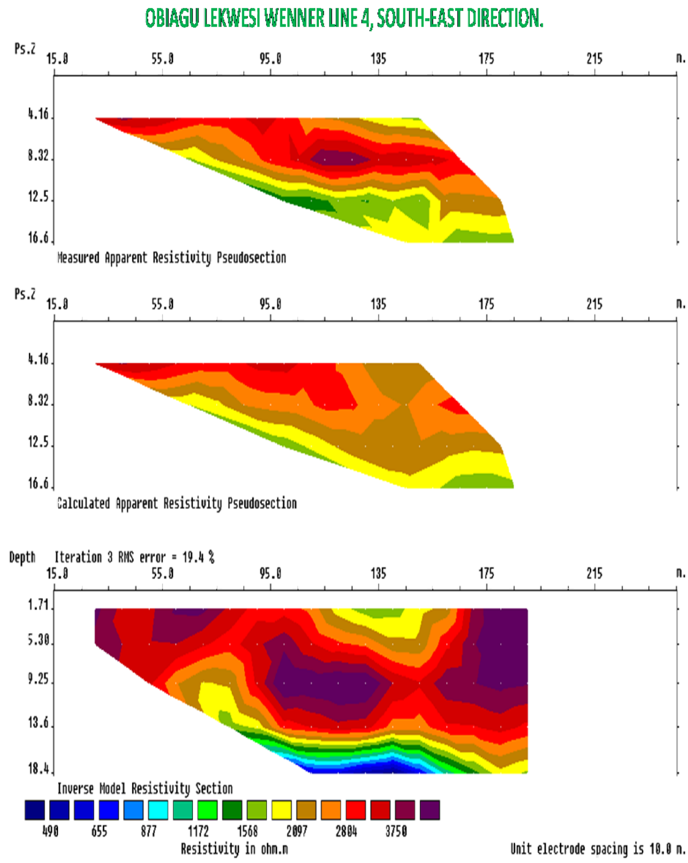


Fig.13: Wenner Line South-East direction. Line 4