

VERTICAL ELECTRICAL SOUNDING SURVEY FOR GROUNDWATER
EXPLORATION IN PARTS OF ANYIGBA AND ITS ENVIRONS, IN THE
ANAMBRA BASIN OF NIGERIA

ABSTRACT

Vertical electrical sounding surveys using Schlumberger electrode array were carried out in Anyigba and its Environs in the Anambra basin with the objective of delineating the subsurface geologic layers in the basin and evaluating the aquifer potential.

Computer aided interpretation of the resistivity sounding data alongside lithologic logs from drilled holes reveals the presence of four to six geologic layers within the study area. The geologic layers and the mean thickness of the layers are i. Lateritic top soil (1.022m), ii. Lateritic sandy layer (5.285m), iii. unsaturated loosely compacted sandstone layer (9.843m), iv. unsaturated compact sandstone layer (45.8m), v. partly saturated sandstone layer (26.9), and vi. a fully saturated sandstone layer.

The partly saturated sandstone and the fully saturated sandstone layers constitute the main aquifer units in the sub-basin.

KEYWORDS: Aquifer, Sandstone, Geoelectric, Layer and Resistivity.

INTRODUCTION

Anyigba and its environs in Kogi state, central Nigeria, lie within the Anambra sedimentary basin. The area has witnessed a large influx of people following the creation of Kogi state and this has led to an increase in demand for water supply. The principal stores of groundwater in Africa are concentrated in the earth to a depth of 400metres (Rybkina, 1978). Groundwater is widely known to be more hygienic than surface water, thus the possibility of utilizing it as a source of water supply for public use is always attractive (Abdullahi *et al.*, 2005). The Vertical Electrical Sounding survey method of geophysical exploration is very useful in groundwater exploration (Williams, 1997). Olorunfemi and Fasuyi (1993) identified aquifer types/hydrogeologic characteristics of part of the central basement terrain of Nigeria using the vertical electrical sounding

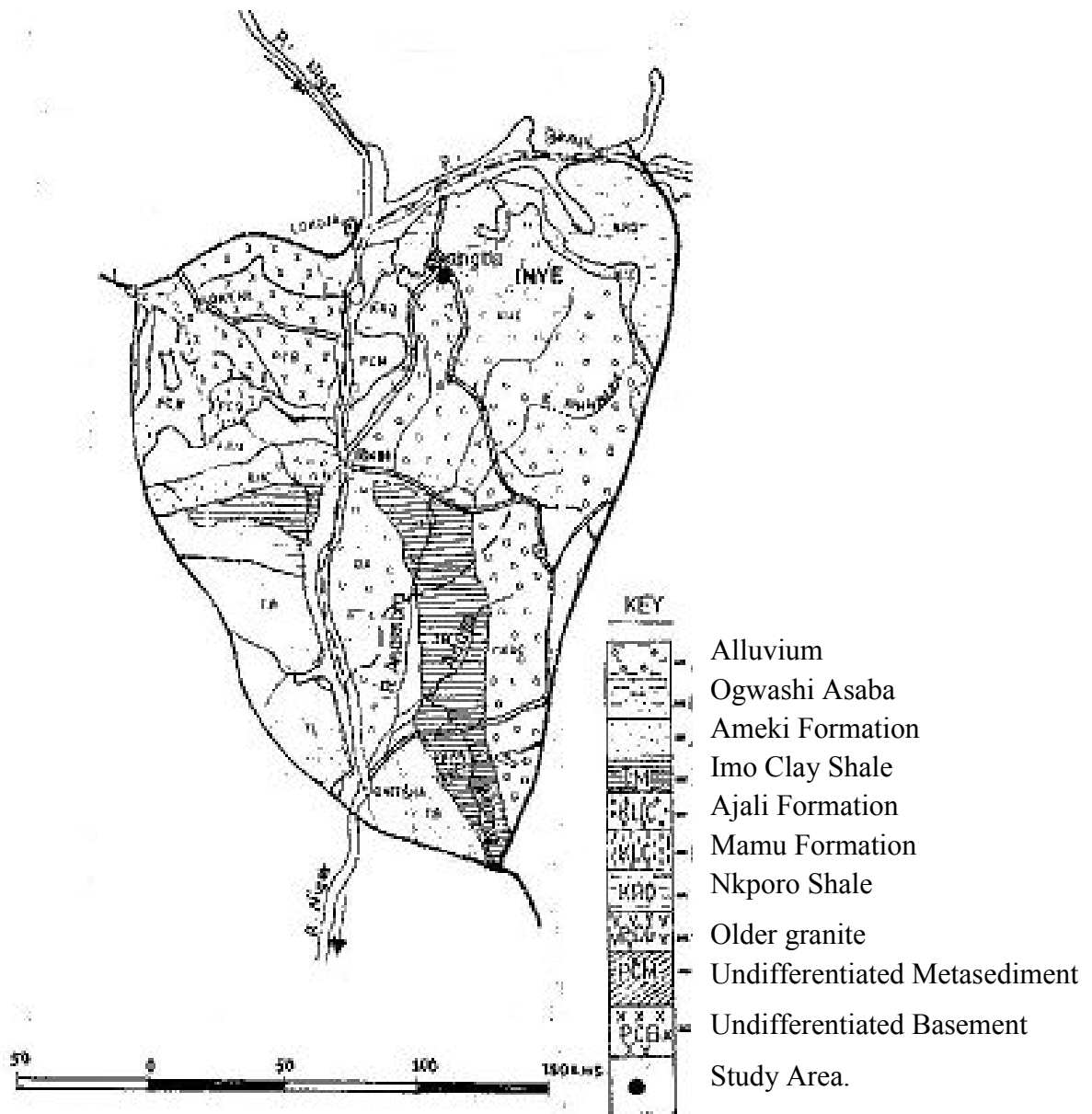
method. Olayinka (1990) used the resistivity sounding method in groundwater investigation in the basement complex terrain of Egbeda- Kabba in Kogi state, Nigeria. This study is aimed at delineating the geological sequence and identifying the aquifer units in Anyigba and environs using the vertical electrical sounding method of geophysical surveying.

GEOLOGIC AND HYDROGEOLOGIC SETTING

The study area is part of the Anambra sedimentary basin and lies within latitude $6^{\circ} 52' 30''\text{N}$ to $7^{\circ} 52' 30''\text{N}$ and longitudes $6^{\circ} 45'$ to $7^{\circ} 52'\text{E}$. The Anambra basin is a nearly triangular shaped embayment covering an area of about 300, 0000 sq. km. It stretches from the area just south of the confluence of the rivers Niger and Benue to as far as Awka, east of the river Niger (Fig.1). The lithostratigraphic units underlying the study area are:

- (i) The basal Nkporo Group which is of Campanian age and consists of dark shales and mudstones with occasional thin beds of sandy shale and sandstone.
- (ii) The Mamu Formation, which overlies the Nkporo Formation is Lower Maestrichtian in age and consists of distinct assemblages of mudstones, sandstone, siltstone, sandy - silty shale, grey shales, carbonaceous shales and coal seams (Obaje, 2009). The Mamu Formation serves as a confining Formation for the overlying Ajali Formation.
- (iii) The Ajali Formation (Upper maestrichtian) is the main aquiferous Formation within the Anambra basin. The Formation has an average thickness of about 300 meters. The Ajali Formation consists essentially of stratified sandstone units with planar cross bedding and coarse to fine grained texture. The Formation is capped by a considerable thickness of red earth at the top resulting probably from weathering and ferruginisation. The Formation is readily recharged in its outcrop belt around the Idah-Nsukka-Enugu escarpement.
- (iv) The marine shales of the Imo and Nsukka Formation which were deposited in the Paleocene overlie the Ajali Formation.
- (v) The continental Nanka and Ameki sandstones of Eocene age overlie the Imo and Nsukka Formation (Fig.2)

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67 Fig.1: Geologic Map of the Anambra basin showing the study area

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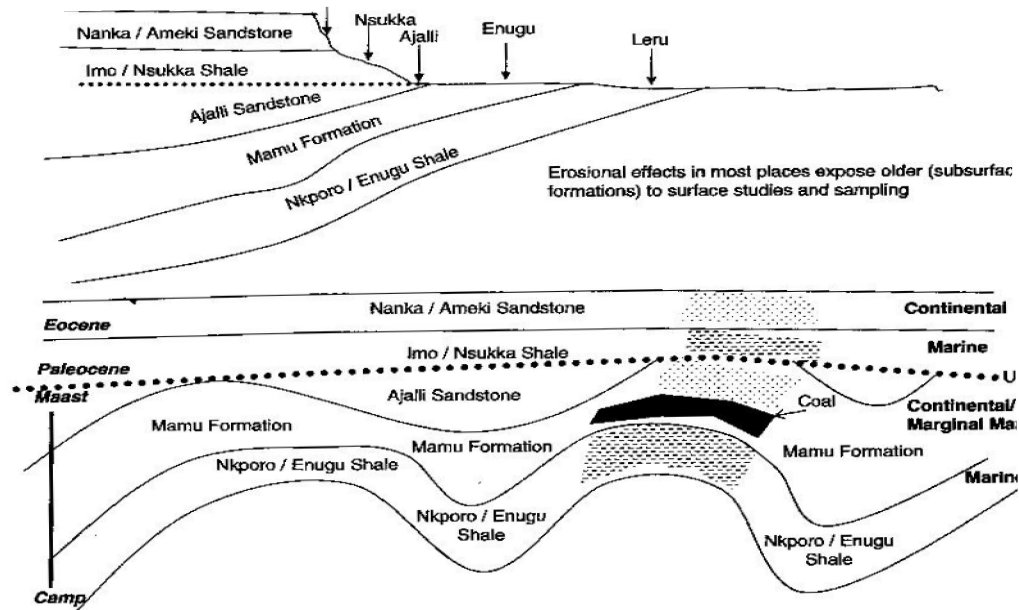


Fig. 2: Stratigraphic successions in the Anambra basin (After Obaje, 2009)

3.0 METHODOLOGY

A total of 10 VES sounding surveys were carried out in the study area as shown in Fig 3.

The VES survey was carried out using the Schlumberger array. Current Electrode spacing (AB/2) was varied from 1 to 600m with a maximum spread length of 1200m. The VES data were acquired using an ABEM (SAS 1000) terrameter.

The Apparent resistance value, (R_a), as displayed by the terrameter was multiplied by the “geometric factor” for the Schlumberger array to obtain the apparent resistivity (ρ_a) of the spread concerned. The apparent resistivity values for the corresponding current and potential electrode separation was plotted against half of the current electrode separation (AB/2) on a log-log graph paper using the IP2WIN software. The software iteratively adjusts the field curve until it matches the theoretical curve within a tolerance of 5.0% Root Mean Square (RMS).

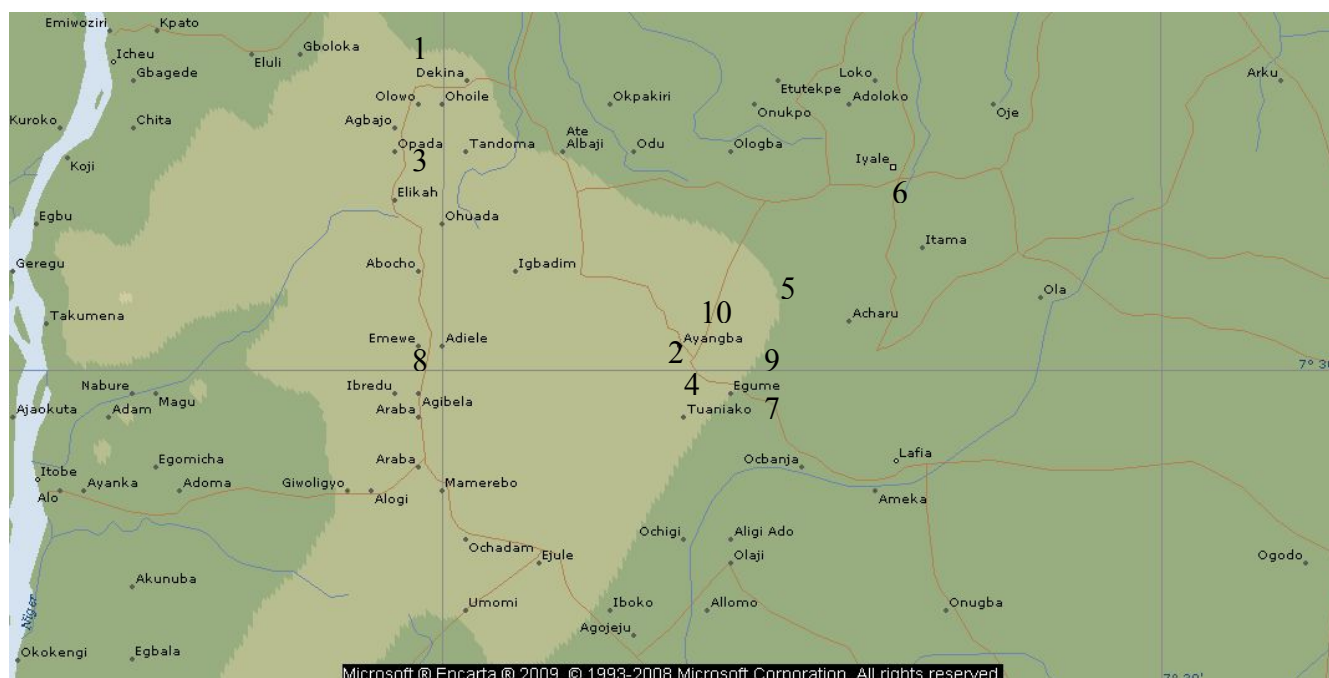


Fig. 3. Map of Anyigba And its Environs showing the VES points

4.0 RESULTS AND DISCUSSIONS

The Apparent Resistivity values for the different electrode spacing for the VES locations are presented below (Table 1). Plots of Apparent Resistivity Versus Current Electrode Separation ($AB/2$) were generated. The VES curves showing the field resistivity, calculated resistivity and thickness of the subsurface layers in the area are presented below (Figs. 4-13).

The Root mean Square errors for the analysis were found to be very low with an average of 3.90 (Table 2). This underscores the reliability of the analysis tool for this type of work.

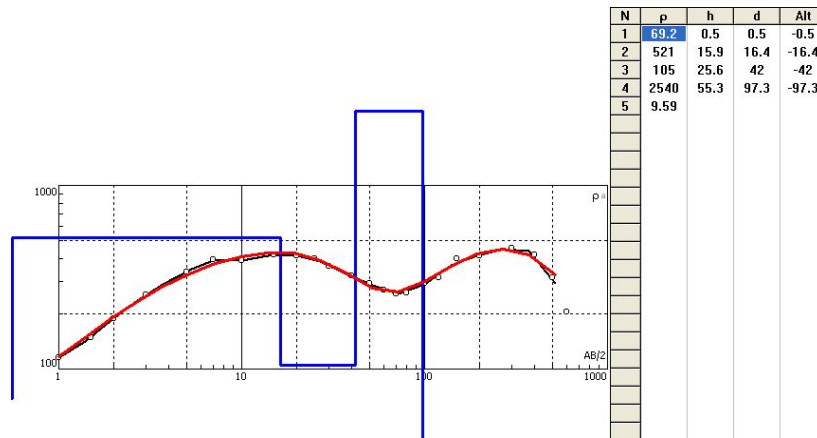


Fig.4: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 1

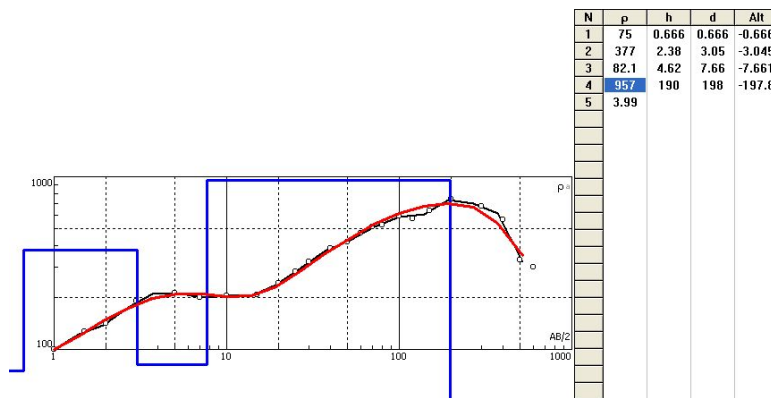


Fig.5: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 2

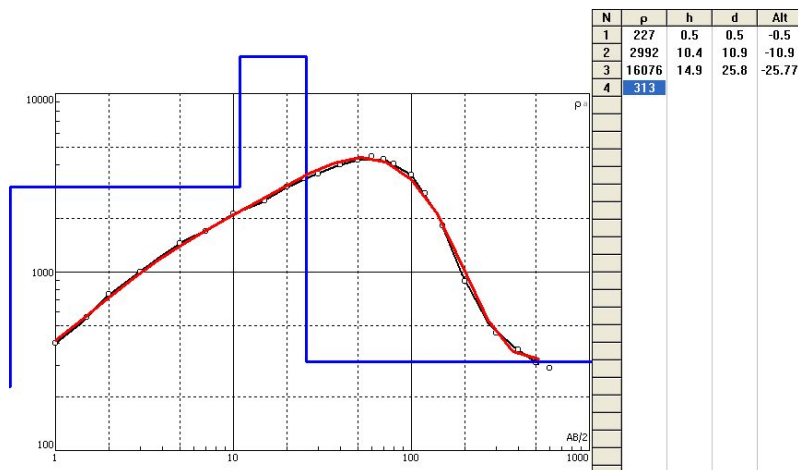


Fig.6: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 3

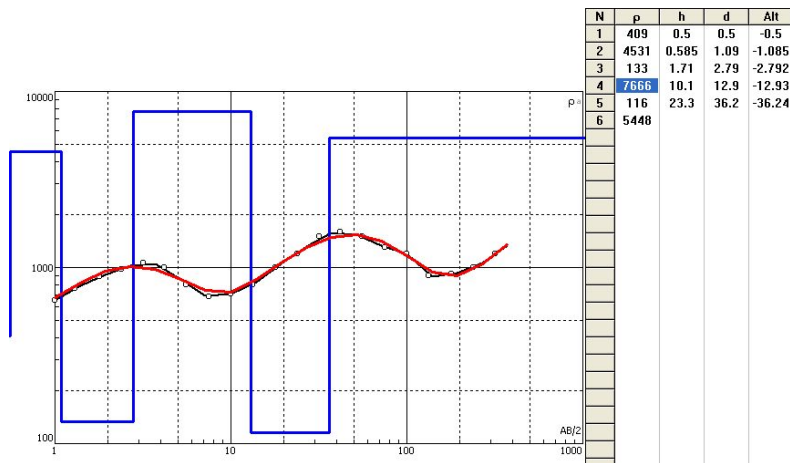


Fig.7: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 4

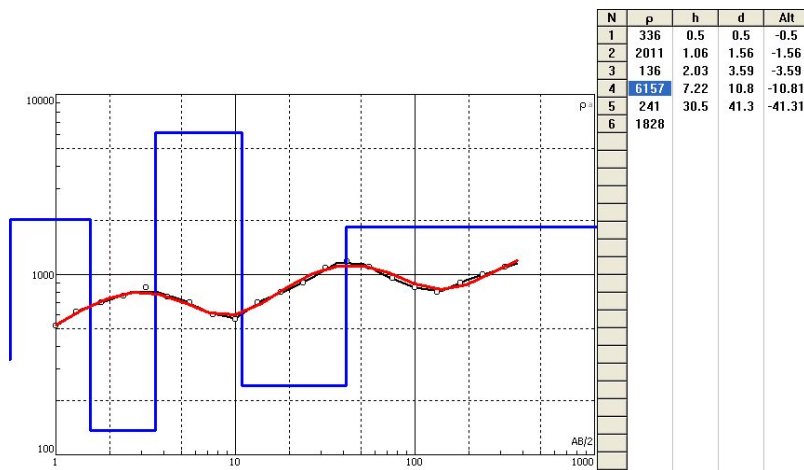


Fig.8: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 5

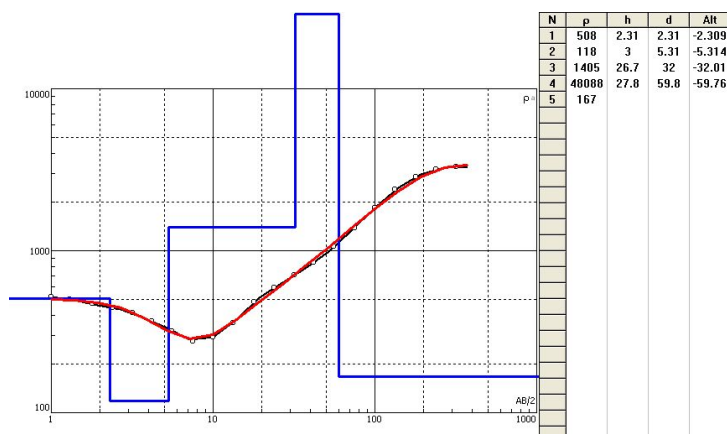


Fig.9: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 6

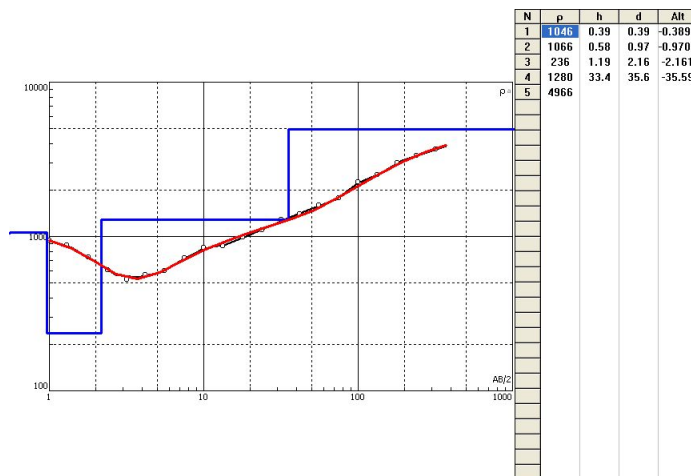


Fig.10: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 7

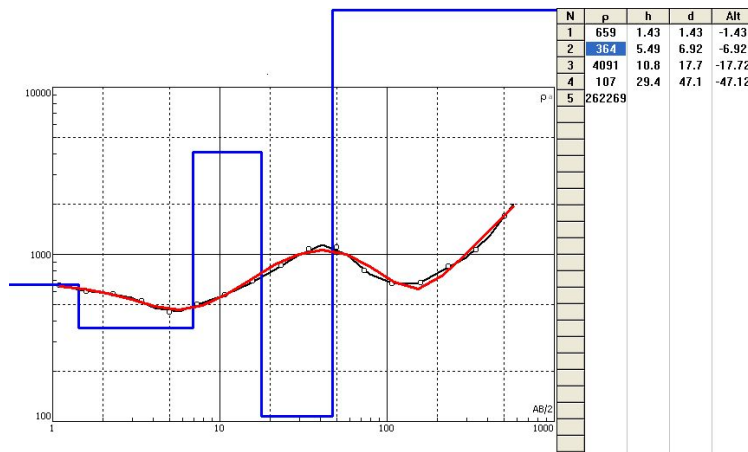


Fig.11 Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 8

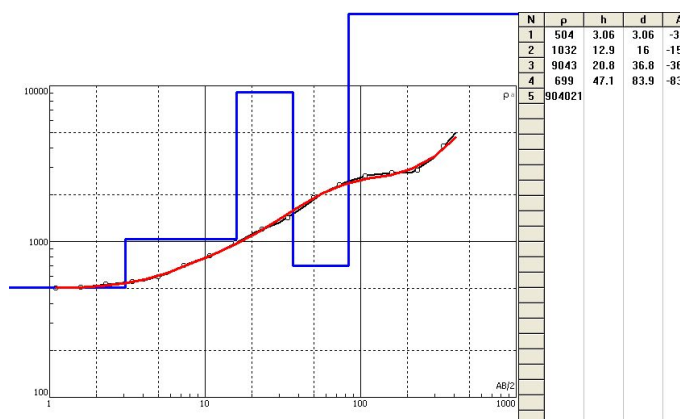
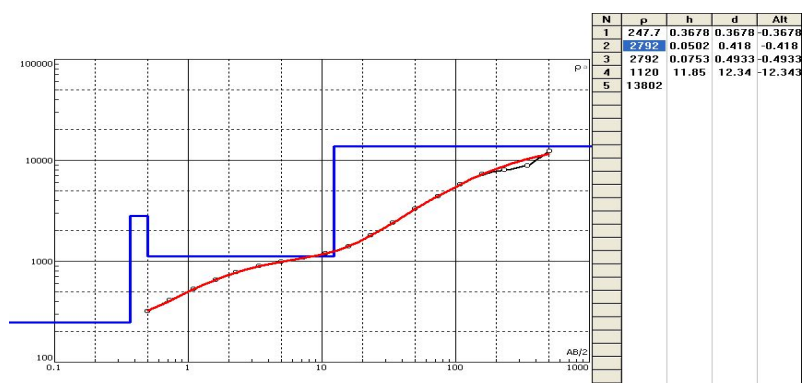


Fig.12: Typical depth sounding curve showing synthetic curve (Red) at Anyigba Post office VES 9

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144 Fig.13: Typical depth sounding curve showing synthetic curve (Red) Anyigba VES 10

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154 Table 2: Geoelectric layer Resistivities and Thicknesses obtained in the VES locations
 155 in the survey area.

Community	VES Location	RMS Errors	Geoelectric Layer Resistivity						Geoelectric Layer Thickness				
			1	2	3	4	5	6	1	2	3	4	5
Anyigba	1	3.93	69.2	521	105	2540	9.59		0.5	15.9	25.6	55.3	
	2	5.23	75	377	821	957	3.99		0.66	2.38	4.62	190	
	3	4.54	227	2992	16076	313			0.5	10.4	4.9		
	4	4.11	409	4531	133	7666	116	5448	0.5	0.59	1.71	10.1	23.3
	5	3.27	336	2011	136	6157	241	1828	0.5	1.06	2.03	7.22	30.5
	6	3.24	508	118	1405	48088	167		2.31	3	26.7	27.8	
	7	2.33	104	1066	1236	1280	4966		0.39	0.58	1.19	33.4	
	8	5.15	659	4091	107	262269			1.43	5.49	10.8	29.4	
Mean	9	2.98	504	1032	9043	699	904021		3.06	12.9	20.8	47.1	
	10	4.26	248	2792	2792	1120	13802		0.37	0.55	0.08	11.85	
		3.904	313.92	1953.1	3185.4	33108.9	115415.82	3638	1.022	5.285	9.843	45.796667	26.9

158 The mean thickness and resistivity of the geoelectric layers for all the sounding locations
159 have been calculated and are presented in Table 3.

160 The study reveals the presence of six geoelectric layers within the study area. These
161 geoelectric layers have been identified with lithologic type using lithology logs obtained
162 from boreholes drilled in the study area and standard rock resistivity charts.

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164 Table 3: Geoelectric layer Parameters and the interpreted lithologic types

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Number of Geoelectric Layers	Mean thickness of Geoelectric Layers (m)	Mean depth of Geoelectric Layers (m)	Mean resistivity of Geoelectric Layers (Ω m)	Lithologic type
1	1.022	1.022	313.92	Lateritic top soil
2	5.285	6.307	1953.1	Lateritic sand
3	9.843	16.250	3185.4	Unsaturated sandstone
4	45.8	62.05	33108.9	Unsaturated sandstone
5	26.9	88.95	115415.82	Partly saturated sandstone
6			3638	Saturated sandstone unit

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167 The fifth and sixth geoelectric layers constitute the main aquifer units within the study
168 area.

169 **GROUNDWATER POTENTIAL EVALUATION**

170 **6.0 CONCLUSION**

171 The aquifer units in Anyigba and environs of the Anambra basin have been delineated
172 using the Vertical Electrical Sounding survey technique.

173 The aquifer units in the study area consist of the partly saturated sandstone and fully
174 saturated sandstone units corresponding to the fifth and sixth geoelectric layers of the
175 VES curves respectively. These layers occur at mean depths of 88.95m and beyond. It is
176 therefore recommended that the minimum depth for successful borehole yields in the
177 study area should be about 120m.

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