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Full Length Research Paper

Geoelectric investigation of treasured formation strata and groundwater potential in Ogume, Delta State, Nigeria

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Ogume in Delta State is a town of great geophysical interest because its formation strata are entirely different from those of the neighbouring towns and communities. It has formations of high economic and structural importance hence, it is now known as the "treasure land" of Delta state. It is therefore important that a geophysical study be made in Ogume to ascertain its formation strata, estimate their layer thicknesses and spread in relation to economic and structural viability and determine its existing groundwater distribution. Hence, ten randomly selected sites in Ogume were sounded using with a highly sensitive Terrameter SAS 1000 and applying Schlumberger array. The data obtained were analyzed and interpreted by curve matching and computer iteration techniques. The results show that formations in Ogume are predominantly AK and A curve types and that it possesses fine grain top soil underlain by sandy clay formation to a depth of about 6 m. This is followed by a very thick layer of commercially viable silt deposits to a depth of about 17 m. Static water level is at 18 m while viable aquifer is within 25 m and around the Ogbeagu Grammar School.

Key words: Geophysical, formation, groundwater, terrameter, Ogume, Delta.

INTRODUCTION

In recent time Ogume has been a source of wealth for many a people. The formation strata of Ogume are entirely different from those of the neighbouring towns and communities. While in Amai the numerous hand-dug wells are filled to the brim almost all the year round due to thick clay formation (Okolie et al., 2006), hand-dug wells are not too prominent features in Ogume and where they exist the water levels are low. Similarly, while Kwale has remarkably loose top large grain sandy soil, Ogume consists of fine grain sediments. With soil of high fertility for variety of crops and the presence of rich silty soil it is now known as the "treasure land" of Delta state. Silt is a solid mineral of economic importance if found in large quantity. It is also associated with the presence of quality groundwater because of its filtering property. It is therefore important that a geophysical study be carried out in Ogume to investigate the availability of silt for commercial and industrial purposes by estimating the layer thickness of silt and determine the effects of existing silt deposits on groundwater characteristics for effective siting of viable water wells in Ogume. Hence, fourteen randomly selected sites in Ogume were sounded using Schlumberger array with a highly sensitive ABEM Terrameter SAS 1000 a steady 12 Volt DC source. The data obtained were analyzed and interpreted by curve matching and computer iteration techniques (Ujuambi and Asokhia, 2000).

LOCATION AND GEOLOGY OF STUDY AREA

Ogume is located in Ndokwa West Local Government Area of Delta State, Nigeria. It is located within Latitude 6.48^{o}E and Longitude 5.40^{o}N (Figure 1). It consists of several small communities which coexist peacefully. It shares common boundary with Onitcha-Ukwani in the North, Abbi in the South, Amai in the West and Utagba-Ogbe (Kwale) in the East. All these neighbouring towns

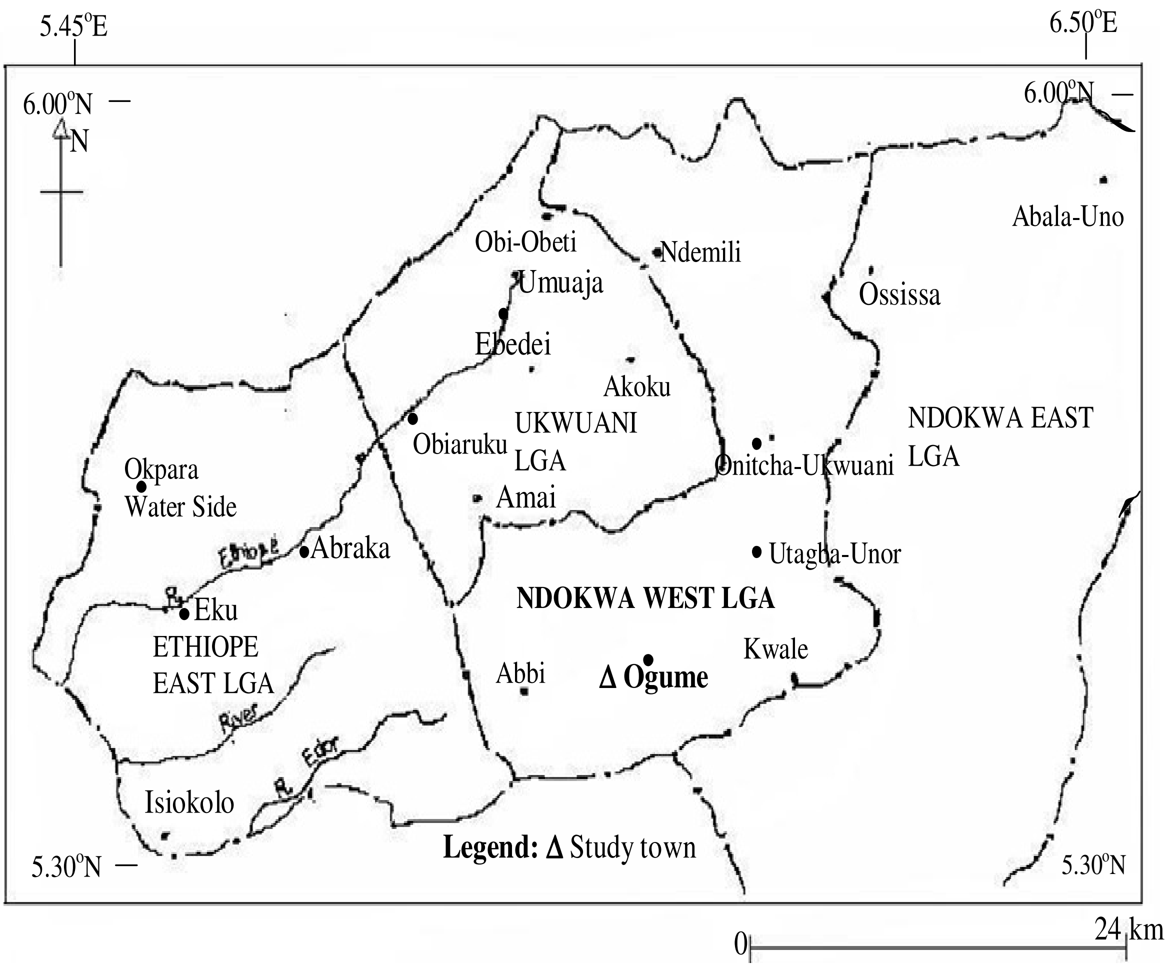

Figure 1. Map showing study area.

and communities are marked with appreciable annual rainfall and thick vegetations and hand dug wells which are almost fill to the brim. Ogume on the other hand, experiences heavy rainfall for over six months of the year but is typically grassland with parches of shrubs despite the existence of some swampy zones in the rainy season. Ogume is in a typical Niger Delta region characterized by the Benin, Agbada and Akata formations (Zohdy, 1974). It is basically a low land sedimentary region with flat topography in a continental fluid-tide environment characterized by fine whitish top soil underlain by silty formations. The major traditional potential sources of water have been from nearby ponds, slow running streams and a few inadequate deep hand dug wells.

MATERIALS AND METHOD

Four electrodes capable of making good electrical contact with the earth were carefully connected to the terminals of a sensitive ABEM terrameter SAS 1000. Vertical electrical soundings (VES) were made by sending current into the earth through one of the current electrodes and back to the terrameter through the other current electrode while the potential difference between the two inner electrodes was also measured (Reinhard, 1974). The SAS 1000 terrameter was able to resolve the measured current and potential values of the subsurface under investigation, compute the resistance, *R* and stack the resistance value with the geometric factor, *k* using (*k x R*) to obtain and display the apparent resistivity of the specific formation under investigation (Table 1). The Schlumberger configuration is a special array of vertical electrical sounding in the study of subsurface structures within the earth. It requires that the two outer current electrodes spacing is much greater that the potential electrodes (Okolie et al., 2007). Thus, the current and potential pairs of electrodes have a common midpoint O, but distance between adjacent electrodes differs (Mamah and Ekine, 1989) (Figure 2). Hence, the electrode spacings are expanded by increasing the distance between current electrodes on a logarithmic scale in the course of measurements in the field (Dobrin and King, 1965) and the potential adjusted accordingly so that AB/2 > 5 MN/2. The Schlumberger is a choice in this work because of its deep penetration into the earth subsurface (Okwueze et al., 1994) and logistics of reduced manpower need since the potential electrodes are not frequently moved as in the other arrays (Okolie et al., 2010). Ten sites were sounded and seventeen to eighteen soundings were made in each site in Ogume with a maximum current electrode spread of 928 to 1362 m. An

Table 1. Sample field data.

Current electrode spacing AB/2	Potential electrode spacing MN/2	Smoothed apparent resistivity (Ωm) for VES I	Smoothed apparent resistivity (Ωm) for VES 2	Smoothed apparent resistivity (Ωm) for VES 3	Smoothed apparent resistivity (Ωm) for VES 4	Smoothed apparent resistivity (Ωm) for VES 5
1.00	0.5	200	124	58	104	66
1.47	0.5	209	76	65	117	74
2.15	0.5	219	105	82	127	89
3.16	0.5	230	121	125	136	108
4.64	0.5	240	135	130	145	128
6.81	1.0	330	174	195	156	147
10.00	1.0	430	150	219	178	164
14.70	1.0	560	131	230	208	178
21.50	1.0	725	285	326	253	193
31.60	2.0	981	312	378	303	212
46.40	2.0	1485	370	425	340	233
68.10	5.0	1960	533	482	375	255
100.00	10.0	2513	678	523	394	272
147.0	10.0	3005	438	466	345	284
215.0	20.0	2654	339	423	307	291
316.00	20.0	2283	260	320	277	295
464.00	50.0	1641	226	234	236	298
681.00	50.0	707		195	150	

approximate measurement time of two and half hours per site was used. The smoothed resistivities were plotted against half current electrode spacings on a 3- decade bi-log graph (Figures 3 to 7) from which qualitative interpretations of the formations of the study sites were made by considering their curve types and estimated site layers. Furthermore, the apparent resistivities and layer thicknesses of each site were determined quantitatively by partial curve matching with Schlumberger master and auxiliary curves and computer iterations (Ako and Osondu, 1986).

Theoretically, the potential at electrode P_1 from C_1 (Figure 2) will be;

$$V_{P1} = \frac{\varrho I}{2\pi}\left\{\frac{1}{a - b/2} - \frac{1}{a + b/2}\right\} \qquad (1)$$

and the potential at P_2 from C_1 is

$$V_{P_2} = \varrho\frac{I}{2\pi}\left\{\frac{1}{a + b/2} - \frac{1}{a - b/2}\right\} \qquad (2)$$

Where a>>b as in Schlumberger array. Thus, the potential difference between the two potential electrodes is

$$dV = \frac{\varrho I}{2\pi}\left(\frac{8b}{4a^2 - b^2}\right) \qquad (3)$$

$$= \frac{\varrho I b}{\pi a^2} \qquad (4)$$

$$\text{and } \varrho_{as} = \frac{\pi a^2}{b}\frac{dV}{I} = \frac{\pi a^2}{b}R \qquad (5)$$

Where ϱ_{as} apparent resisitivity for Schlumberger array and the geometric factor, is given as:

$$K_S = \frac{2\pi}{8b}\left(4a^2 - b\right) \qquad (6)$$

Hence, for AB >> 5 MN

$$K_S = \frac{\pi a^2}{b} \qquad (7)$$

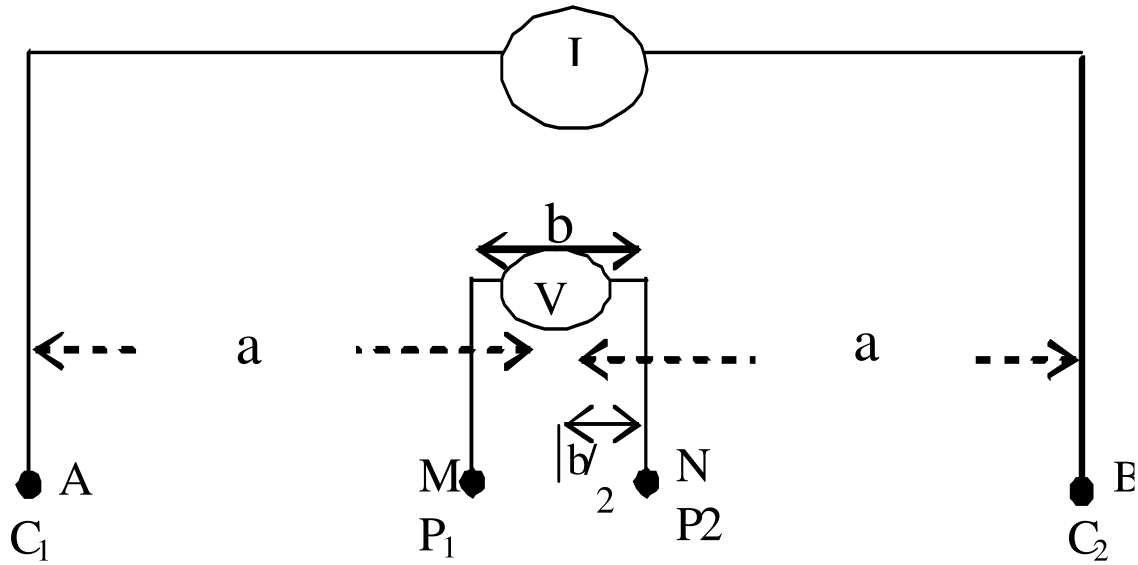

Figure 2. Schlumberger field electrode configuration.

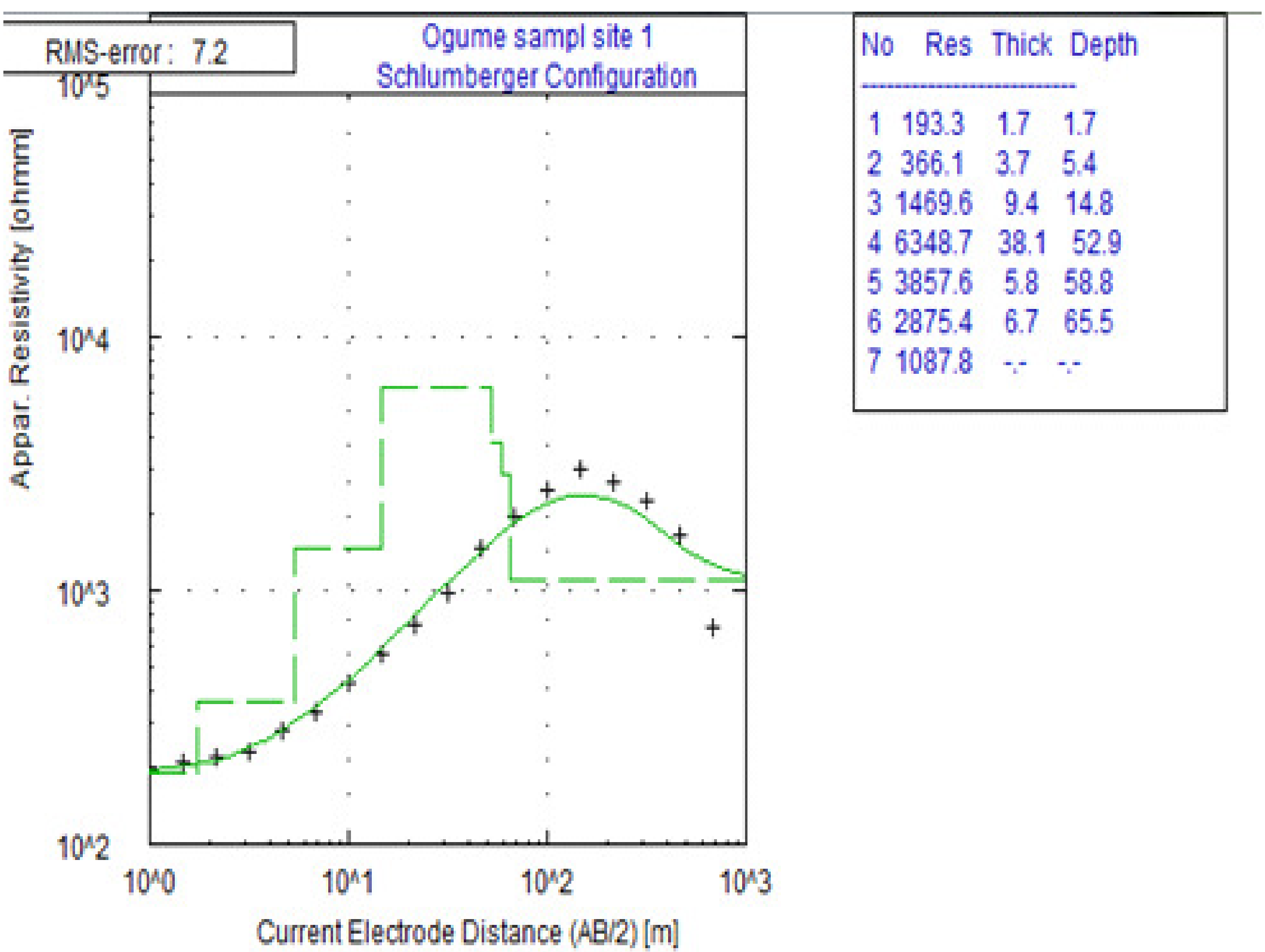

Figure 3. Sample resist graph for site 1 in Ogume.

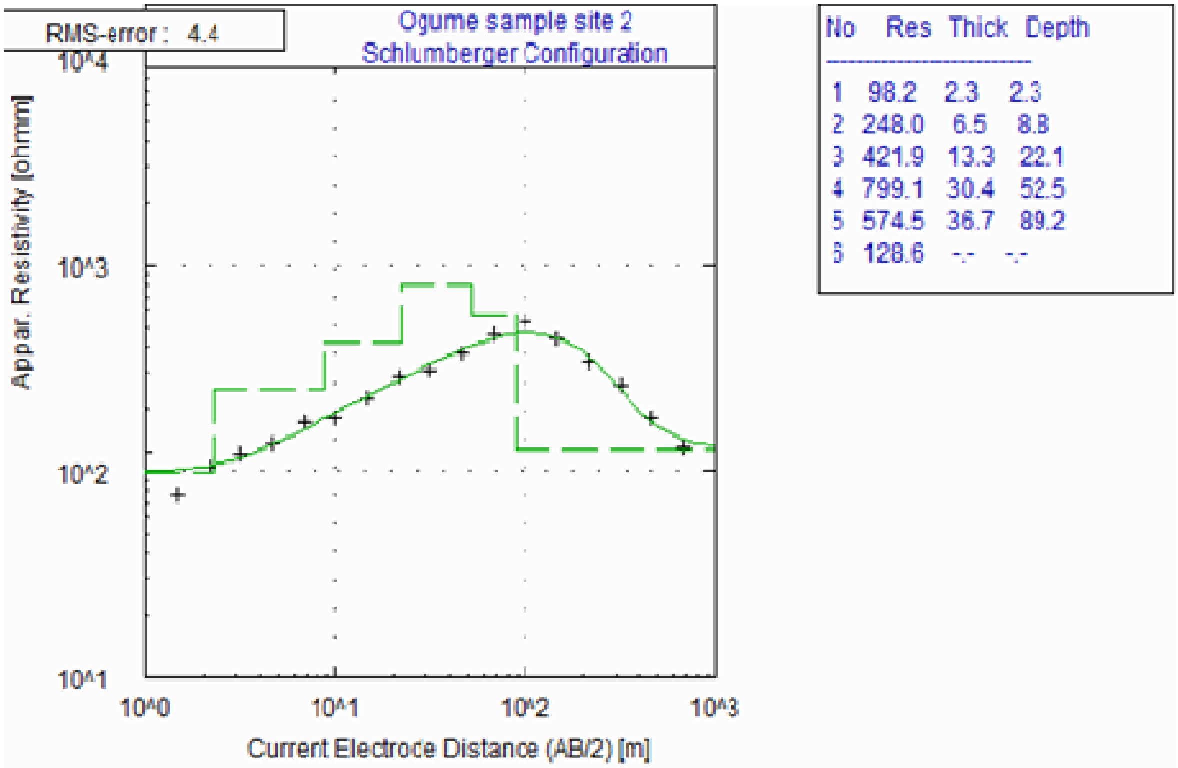

Figure 4. Sample resist graph for site 2 in Ogume.

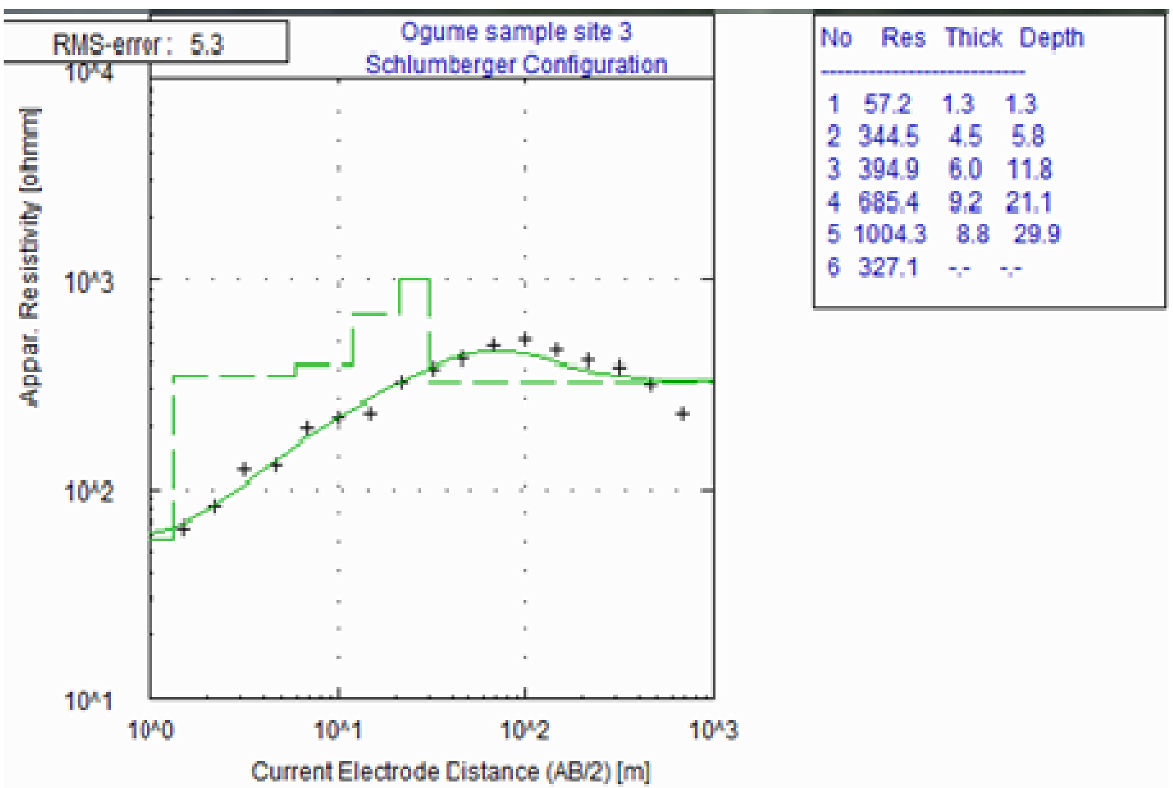

Figure 5. Sample Resist Graph for site 3 in Ogume.

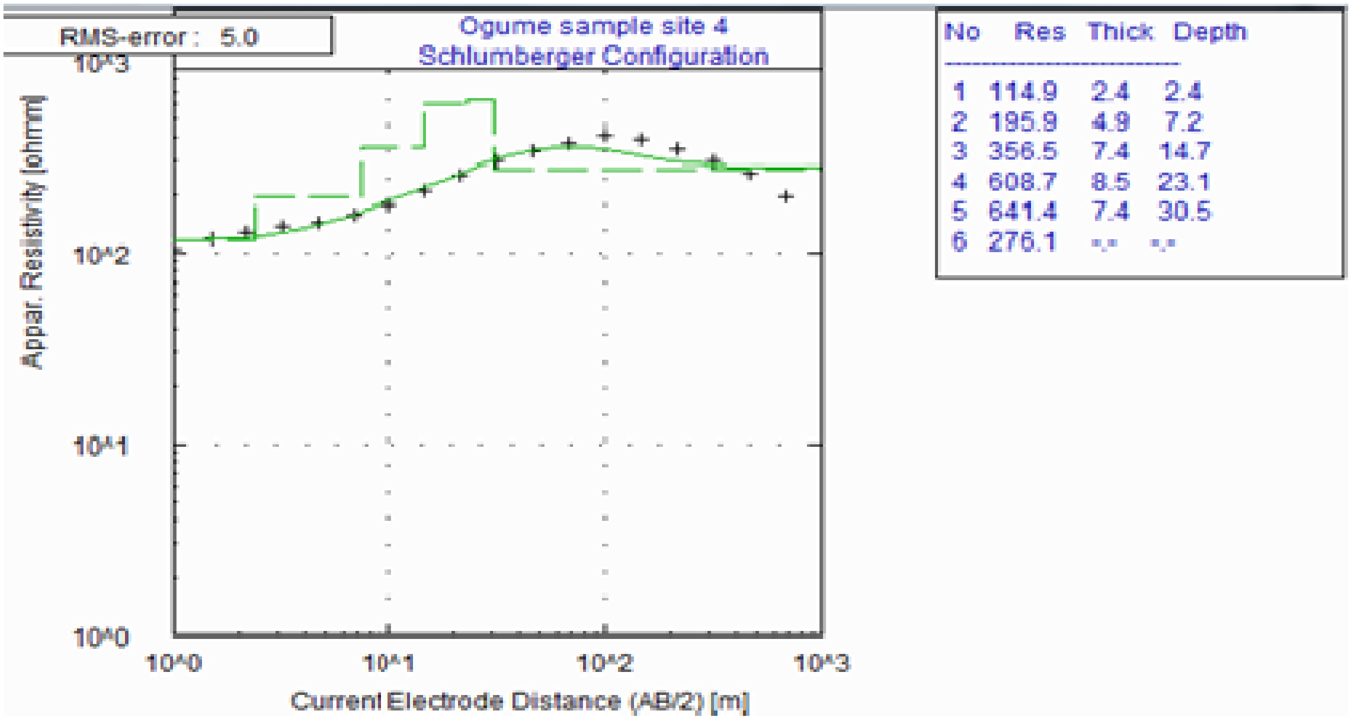

Figure 6. Sample resist graph for site 4 in Ogume.

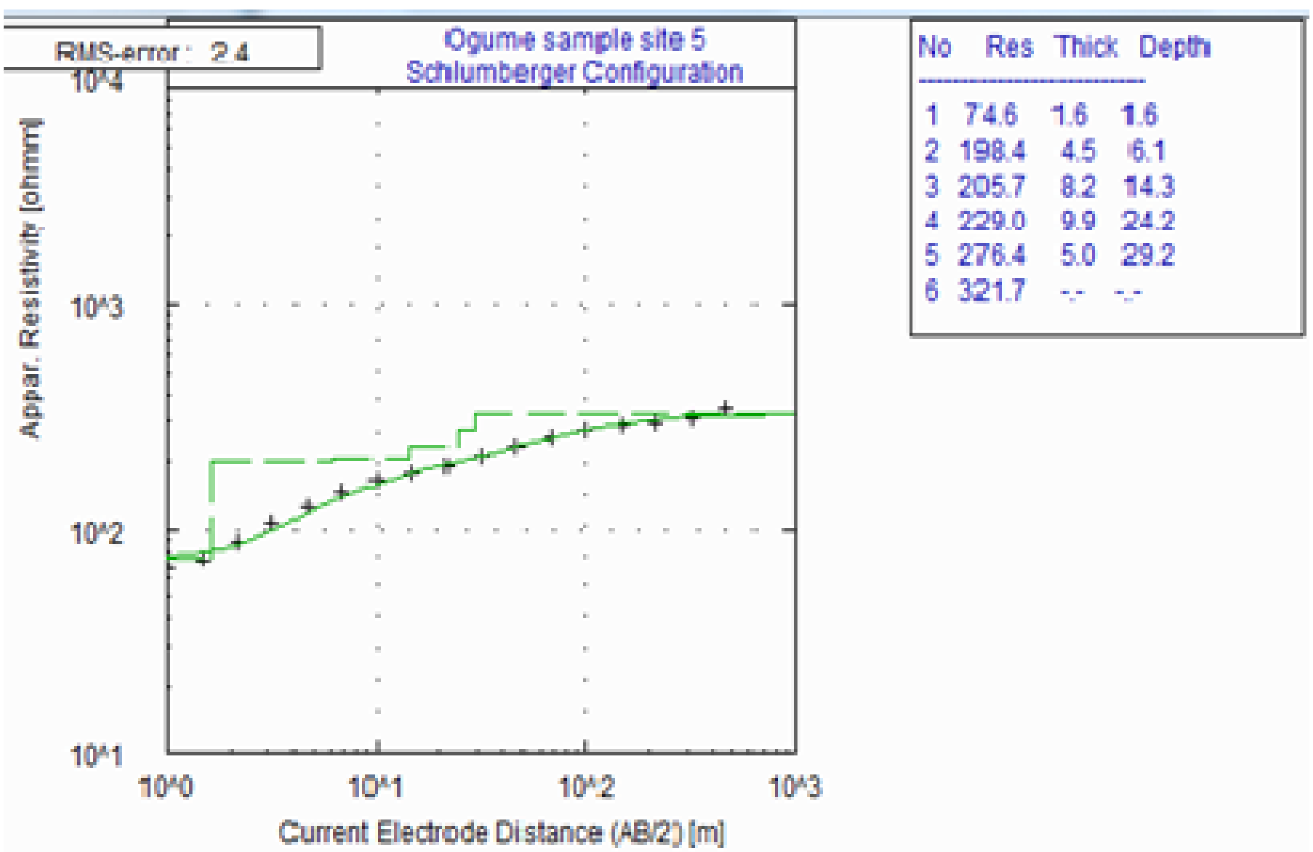

Figure 7. Sample resist graph for site 5 in Ogume.

Table 2. Sample lithology of Ogume.

Sample site	Layer No.	Resistivity (Ωm)	Layer thickness (m)	Real depth (m)	Lithology	Curve type
	1	193	1.7	1.7	Fine white top soil	
	2	366	3.7	5.4	Sandy Clay	
	3	1470	9.4	14.8	Shale	AK
	4	6349	38.1	52.9	Shale & Silt	$\rho_1 < \rho_2 < \rho_3 > \rho_4$
VES 1	5	3858	5.8	58.8	Silt	
	6	2875	6.7	65.5	Small grain sand	
	7	1008	…...	…..	Medium grain sand	
	1	98.2	2.3	2.3	Fine white top soil	
	2	248.0	6. 5	8.8	Clayey sand	
VES 2	3	421.9	13.3	22.1	Silt	AK
	4	799.1	30.4	52.5	Silt	$\rho_1 < \rho_2 < \rho_3 > \rho_4$
	5	574.5	36.7	89.2	Medium to coarse grain sand	
	6	128.6	…..	….	Gravely sand	
	1	57	1.3	1.3	Fine top soil	
	2	345	4.5	5.8	sandy clay & silt	
	3	395	6.0	11.8	Silt	AK
	4	687	9.2	21.1	Silt	$\rho_1 < \rho_2 < \rho_3 > \rho_4$
VES 3	5	327	8.8	29.9	Medium to coarse Grain sand	
	6	1004	…..	…..	Gravely sand	
	1	115	2.4	2.4	Fine white top soil	
	2	196	4.9	7.2	Silt	
	3	357	7.4	14.7	Silt	AK
VES 4	4	609	8.5	23.1	Small Sand grains	$\rho_1 < \rho_2 < \rho_3 > \rho_4$
	5	641	7.4	30.5	Medium sand grains	
	6	276	….	….	Gravely sand	
	1	75	1.6	1.5	Fine white top soil	
	2	198	4.5	6.1	Silt	
	3	205	8.2	14.5	Silt	A
VES 5	4	229	9.9	24.2	Small Sand grains	$\rho_1 < \rho_2 < \rho_3 < \rho_4$
	5	276	5.0	29.2	Medium sand grains	
	6	322	….	…..	Gravely sand	

(Lowrie, 2002; Dobrin and King 1965).

RESULTS AND DISCUSSION

The analysis shows that Ogume consists mainly of six layers as in the Table 2. Two curve types were deduced from plots in the study area. Seven sites have of AK curve type while three have A curve type. The sample plots here indicate that VES 1 to 4 are AK curve type, while VES 5 is A-curve type (Okwueze et al., 1991) (Figure 3 to 7). Six distinct layers were obtained generally. The top soil consists of fine white loose soil to a depth of 2.5 m. This is underlain by sandy clay formation to a depth of about 7 m and followed by a very thick layer of silt to a depth of about 27 m. The viable aquifer is within 28 m depth. However, water bearing formations exist 12 and 17 m depth where changes in formation are distinct (Akpokodje and Etu-Efetobor, 1967, 1990). Static water level is at 20 m. The survey shows that potable water is most viable at 27 to 30 within and around the Ogbagu Grammar School. These deductions

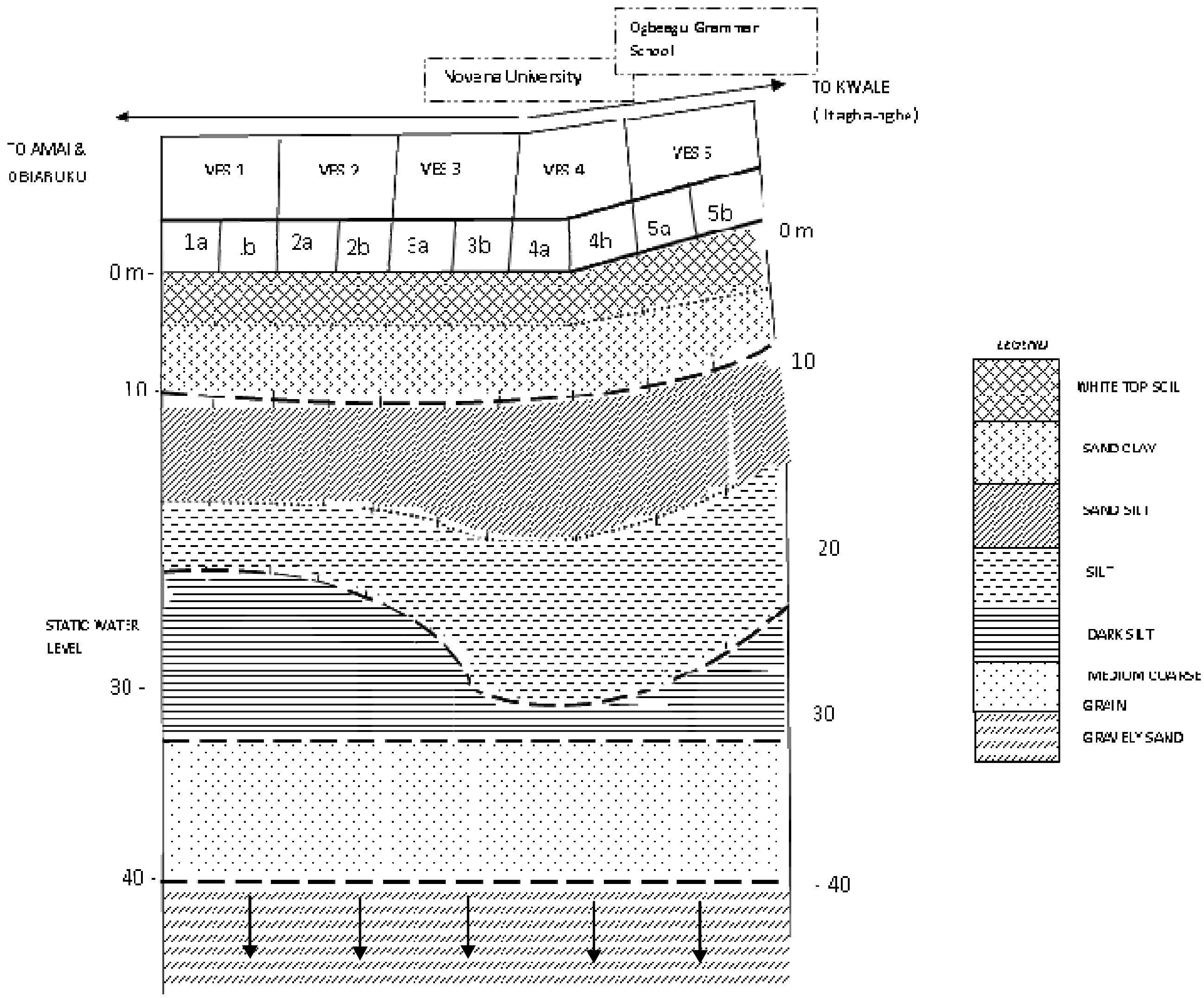

Figure 8. Geoelectric section of Ogume, Delta State.

are actually in consonance with direct log results.

CONCLUSION

The top soil consists of whitish fine loose soil to a depth of 2.5 m. This is underlain by sandy clay formation to a depth of about 7 m and followed by a very thick layer of silt to a depth of about 27 m (Figure 8). Thus there is heavy silt deposit in Ogume, Delta State which can be harnessed for commercial and industrial utilities. This is specifically important as a blend of Silt and cement is very effective in structural plastering, smoothening, production of durable ceiling boards and engineering/ road and other construction works. Hence, the presence of heavy silt deposits in Ogume, must be fully harnessed to make the town true “treasure land” for builders and construction companies that source for this vital but rear mineral. The presence of silt here has greatly affected the characteristics of available groundwater. Viable aquifer is within 25 to 28 m depth with evidence of false aquifer at about 17 m depth. Static water level is at 20 m. The availability of groundwater here is highly dependent on rainfall, formation porosity and permeability. The silt prevents peculation of impurities into the subsurface leading to very high quality groundwater resource in Ogume. However, the absence of water filled hand-dug wells in Ogume is because of the relative ease of water peculation through silt than through clay. Hence hand-dug wells in Ogume have water at far depth of about 13 m. The survey shows that aquifer is most viable at 28 m within and around Ogbagu Grammar School where there is evidence of thick silt deposits which prevents peculation of undesired materials that may contaminate groundwater. These findings are in consonance with direct log results.

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