Journal of the Nigerian Association of Mathematical Physics
Volume **16 (May, 2010), pp 597 - 602**

Geophysical Investigation of Ground-Water in Agbor Area of Delta State, Nigeria

***F. O. Ezomo and [1]C. N. Akujieze**
***Department of Physics, University of Benin,**
P.M.B. 1154, Ugbowo, Benin City, Nigeria.
[1]Department of Geology, University Of Benin,
P.M.B 1154, Ugbowo, Benin City, Nigeria
Corresponding author: Tel. +2348054470436

Abstract

Geophysical survey was curried out in order to investigate Groundwater existence in Agbor Area of Delta State Nigeria. This research work became necessary in order to solve the acute water shortage in the area by way of prospecting or searching for additional aquifer which would subsidize the existing one, domestically, industrially and agriculturally. Ten(10) vertical electrical sounding (VES) (uniformly distributed) was conducted in Agbor area and its environs using schlumberger electrode array. The VES were carried out with semi electrode spacing in the range Im-928m at six (06) points per decade. The results of the interpretation identified wet sand/clean sand as perched aquifer which can produce ground water to the bore-hole at a perceptible rate between depth of 90m to 140m as confirmed by a nearby driller logs of Agbor [21]. The resistivity of the aquifer detected varied from 102.4 ohm-m to 100,000 ohm-m while the thickness ranges from 31.9m to 103.7m.

.

1.0 Introduction

Nigeria is a country that is blessed with rich natural mineral resources. Prominent among these minerals include water, hydrocarbon bitumen, quartz and limestone. Water is the most widely used as it is a major necessity for the existence of life [1]. Water is known to sustain life everywhere. No wonder that historically, early settlements were associated with proximity of surface water such as springs, running streams, rivers and the like. Water can therefore make or mar the economy and life style, of a nation or a group of people [2]. The necessity of obtaining portable water within an environment is pertinent because it is a major determinant of population growth. The advent of technological advancement has made the quest for water for domestic, industrial and agricultural consumption to drift from mere search for surface water (flowing or stagnant pools) to prospecting for steady reliable subsurface or ground water from boreholes [3]. In many parts of the country today, ground water is being sought for by many companies to meet the demand of water by individual parastatals, local, state and Federal Government. Records show that the depths of aquifers or water bearing formations differ from place to place because of variational geothermal and geostructural occurrence [4]. Although Nigeria is said to have abundance of ground water, borehole studies even in parts of Niger-Delta basin of Delta state show evidence of dry wells [5].
The superiority of the geoelectrical resistivity method over other methods in the ground water prospecting or searching is confirmed by earlier research work [1-4].
This research work was carried out using geophysics to estimate the depth and thickness of the sand/aquifer/water bearing formations which are adequate for domestic water supply.

2.0 Brief geology and hydrogeology of the study area.

Agbor is underlained by Benin formation usually known for its out cropping yellow, white sands and clay which occurs in coastal Nigeria It extends from the west across the whole Niger Delta area and southward beyond the present coast line [6]. It comprises of over 90% sandstone with shale intercalation. It is coarse grained, gravelly locally fine grained, poorly sorted, subangular to well rounded and bears lignite streaks and word fragments [7]. It is a continental deport of probable environment, various structural units such as upper deltaic depositional

natural levees, oxbow fills are, identifiable within the formation, indicating the variability of shallow water

depositional medium. Very little hydrocarbon accumulation has been associated with the formation [8].

Hydrogeologically, Benin formation is very aquiferous because of low percentage of shally layers. The formation which is about 180m thick is the youngest [9].

The study area which is Agbor in Delta State, Nigeria is on latitude of about 4.50^0N and longitude of about 5.50^0E [22]

3.0 Experimental Work

ABEM SAS 300 terrameter and its SAS 2000 Booster was used as the equipment for taking surface resistivity readings. It act as both transmitter and receiver. Schlumberger array of vertical electrical sounding (VES) was employed at six (06) points per decade in accordance with the formula $10^{1/n}$ where n = 6. for the current electrode spacing (AB) or spread [10].

This resulted to spread of 1.0m, 1.47m, 2.15m, 3.16m, 4.64m, 6.81m, 10.0m, 14.7m, 21.5 etc [10].

Measurements were taken at increasing current electrode spacing so that the electric current introduced into the ground penetrated greater depths. In places, where the ground was dry, small amount of water was applied to the ground for easy penetration of current electrode into the ground which made good contact with the ground [11]

The current electrodes were expanded at six (06) points per decade while the potential electrodes remained fixed. A decrease in the potential difference across the potential electrodes necessitated a new potential electrode spacing in accordance with the schlumberger field condition of AB≥5MN where A and B are current electrodes, M and N are potential electrodes [12].

For easy reference, a table of semi current electrode spacing (AB/2) and respective apparent resistivities for the station is shown in table 3.

4.0 Theoretical Analysis

In schlumberger array of vertical electrical sounding (VES), the earth is approximated to be composed of horizontally stratified, Isotropic and homogeneous media such that the change of resistivity is a function of depth [13]. This is the most famous array in electrical resistivity prospecting because of its ability to provide useful information in solving hydrogeological/groundwater problems. Besides smoothing interpretation techniques are much more developed for the schlumberger array than other arrays [14].

In VES, four electrodes are earthed along a straight line in the order AMNB, with AB as current electrodes and MN as potential electrodes.

The calculated apparent resistivity (λ_a) according to schlumberger array condition of AB≥5MN is

$$\lambda_a = \Pi \left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \right] \frac{\Delta V}{I} \quad [I]$$

AB = current electrode spacing in meter
MB = potential electrode spacing in meter.
DV = potential difference in Volts,
I = electric current in Amperes, $\prod$ = constart = $\frac{22}{7}$

The techniques of data interpretation involved seeking a solution to the inverse problem namely the determination of the subsurface resistivity distribution from surface measurements [15].
Kernel function represents an ideal solution to the inverse problem and it is used in interpreting apparent resistivity measurements in terms of lithology variation with depths [16]. The function assumes the earth to be locally stratified, inhomogenous and isotropic layers, and unlike apparent resistivity function, it does not depend on electrode geormetry [17]. The function can only be obtained from the transformation of measured apparent resistivities. The kernel function used in this work is obtained from [18] and [19], if the observed apparent resistivity is

$$\lambda_a(r)=r^2\int_0^{\infty}\lambda T(\lambda)J_1(\lambda r)d\lambda \ \ Where$$

Kernel function = $T(\lambda)=\int_0^{\infty}\frac{1}{r}\lambda_a(r)J_1(\lambda r)dr$

J_1 is the Bessel function of the first order, first kind and T(λ) in the transformed resistivity data arising from kernel function [19].

S/N	AB/2 (m)	APP RESIS for station 1 (ohm – m)	APP RESIS for station 2 (ohm – m)	APP RESIS for station 3 (ohm – m)	APP RESIS for station 4 (ohm – m)	APP RESIS for station 5 (ohm – m)	APP RESISTIVITY station 6 (ohm – m)
1	1.00	2395.0	1887.0	1743.0	942.0	204.0	165.0
2	1.47	3707.0	2921.0	2663.0	1303.0	198.0	130.0
3	2.15	5652.0	4259.0	3960.0	1850.0	196.0	122.0
4	3.16	7726.0	6210.0	5969.0	2752.0	198.0	161.0
5	4.64	11721.0	9237.0	9055.0	4297.0	208.0	209.0
6	6.81	18503.0	14014.0	13468.0	6377.0	229.0	261.0
7	10.00	207521.0	19253.0	21688.0	9485.0	276.0	344.0
8	14.70	36337.0	29210.0	26980.0	13030.0	323.0	437.0
9	21.50	50922.0	45205.0	40664.0	19900.0	392.0	540.0
10	31.60	67235.0	67235.0	57363.0	28866.0	505.0	583.0
11	46.40	87030.0	98038.0	87608.0	42875.0	739.0	646.0
12	68.10	110000.0	150000.0	120000.0	62104.0	1126.0	692.0
13	100.00	120000.0	220000.0	190000.0	94849.0	1761.0	886.0
14	147.00	110000.0	290000.0	280000.0	130000.0	2613.0	1066.0
15	215.00	88775.0	390000.0	440000.0	220000.0	3845.0	1278.0
16	316.00	67366.0	550000.0	650000.0	290000.0	5532.0	1693.0
17	464.00	-	670000.0	920000.0	-	4547.0	3038.0

Table 5.1: Apparent resistivities for all stations

RESULTS AND DISCUSSION

The results and field/theoretical vertical curves obtained are presented (table 5.1-5.7 and figures 5.1-5.6). The analysis of the resistivities of various lithological formation is usually ambiguous because it is possible for different rock types (lithology) to have the same resistivity [1]

However for the avoidance of doubt, this studies is restricted to computer inversion where sounding curves were generated using computer software IP12WIN and WINRESIST to provide a model showing the layer thicknesses and resistivities. A preliminary model was inserted into the software program which calculated the sounding curve model automatically. It then adjusted the model and calculates a new sounding curve that better fits the field data. This process was repeated until a satisfactory or match fit was obtained between the model and the field data. This computer model process is called inversion. Figure 5.1-5.6 below shows the various curves obtained for all stations [20].

Table 5.2: Lithology for Station 1

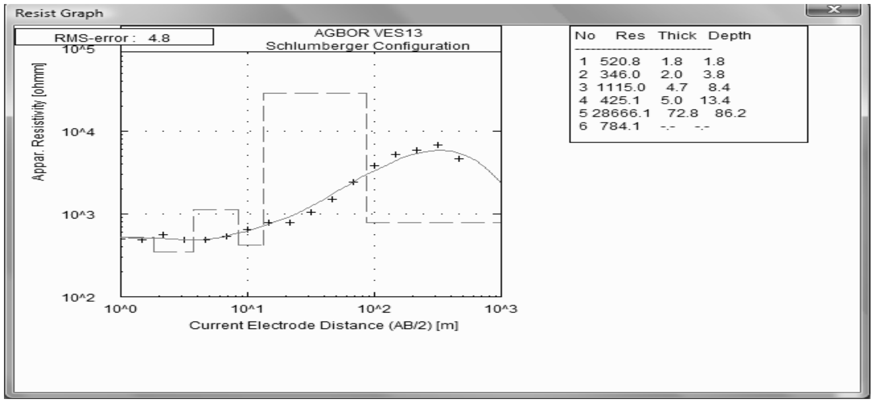


Fig 5.1: Iterated Sounding Curve for Station 1

Table 5.3: Lithology of Station 2

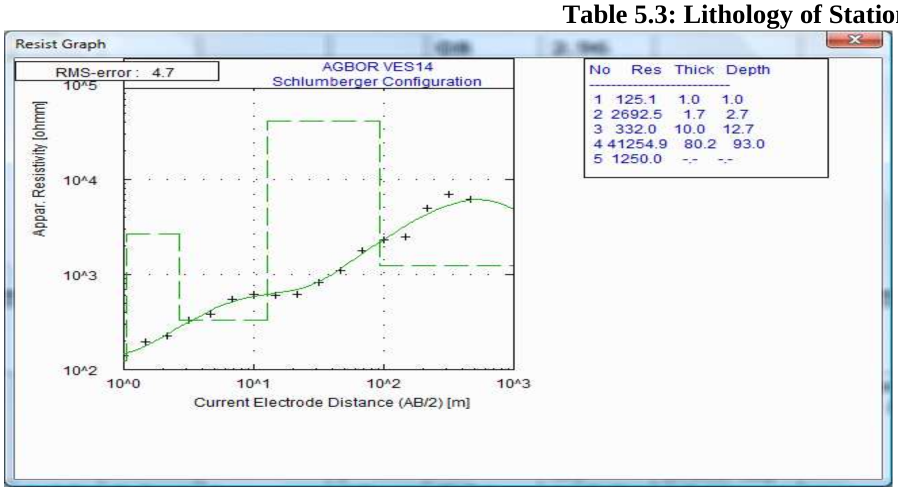
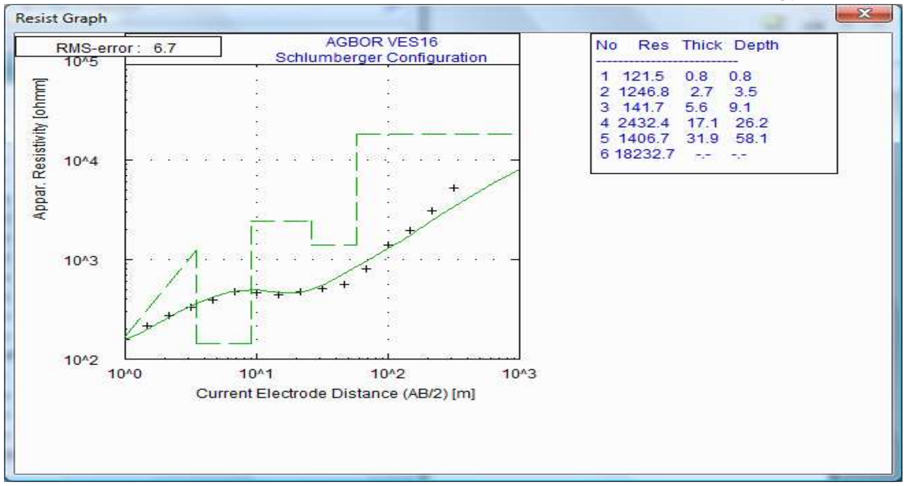


Fig 5.2: Iterated Sounding Curve for Station 2

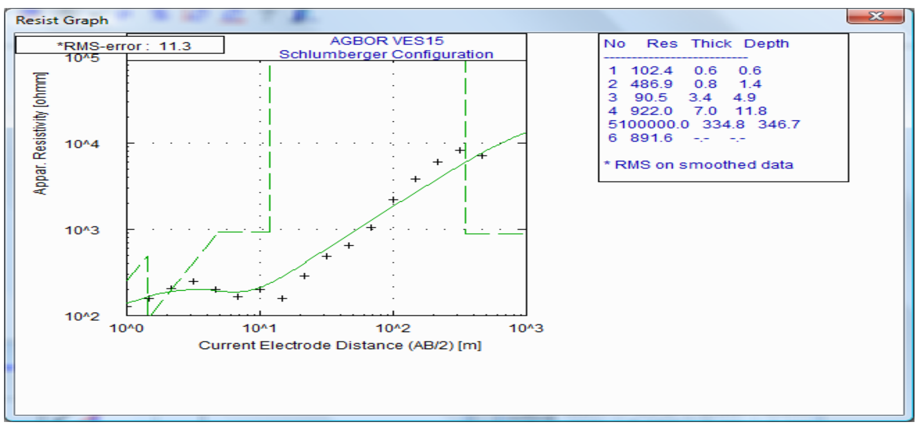
Table 5.4: Lithology for Station 3



No	Res	Thick	Depth
1	121.5	0.8	0.8
2	1246.8	2.7	3.5
3	141.7	5.6	9.1
4	2432.4	17.1	26.2
5	1406.7	31.9	58.1
6	18232.7	-.-	-.-

Fig 5.3: Iterated Sounding Curve for Station 3

Table5.5: Lithology for Station 4

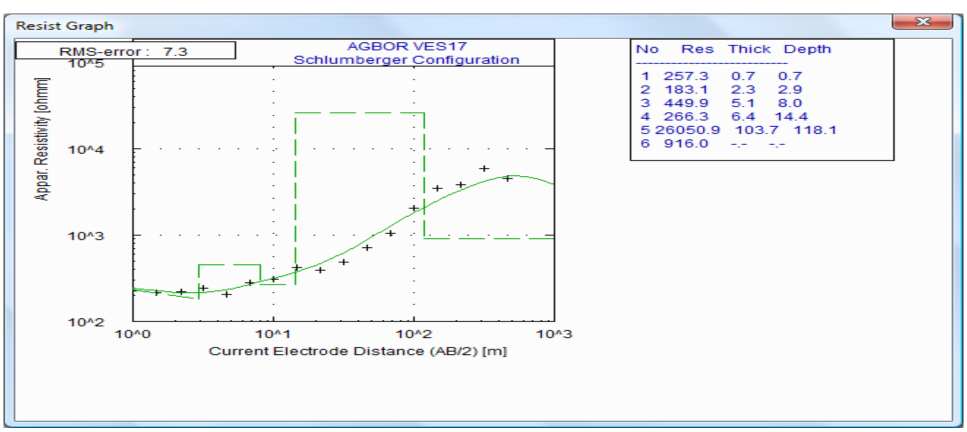


No	Res	Thick	Depth
1	102.4	0.6	0.6
2	486.9	0.8	1.4
3	90.5	3.4	4.9
4	922.0	7.0	11.8
5	100000.0	334.8	346.7
6	891.6	-.-	-.-

* RMS on smoothed data

Fig 5.4: Iterated Sounding Curve for Station 4

Table 5.6: Lithology for Station 5



No	Res	Thick	Depth
1	257.3	0.7	0.7
2	183.1	2.3	2.9
3	449.9	5.1	8.0
4	266.3	6.4	14.4
5	26050.9	103.7	118.1
6	916.0	-.-	-.-

Fig 5.5: Iterated Sounding Curve for Station 5

Table 5.7: Lithology for Station 6

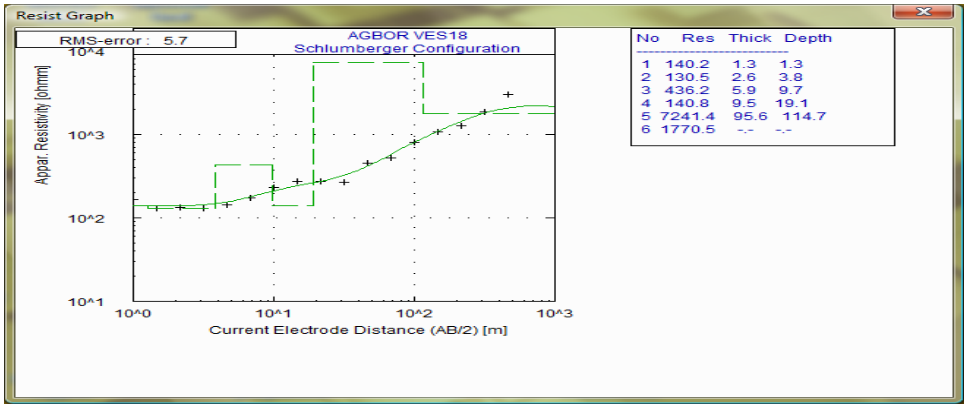


Fig 5.6: Iterated Sounding Curve for Station 6

By integrating the results of the sounding curves with a nearby bore-hole lithology/logs(11), the various lithologies for all the stations were obtained. These are shown in tables 5.1-5.7 above [10]
All the VES stations have six lithological layers having resistivities from 100 ohm- m to 100,000 ohm-m and depths varying from 1.0m to 350.0m. water bearing formations or aquifers was encountered in all the VES stations at depth of 90m to 140m and resistivities varying from 700 ohm –m to 2000.0 ohm-m

Conclusion

From the results of computer iteration, the study areas have water bearing formations or aquifers as shown in tables 2-7 because of the existence of wet sand/sand. This falls within the range of water bearing formations depth of 90m to 140m as confirmed by a nearby driller logs of Agbor [21]. Agbor is filled with lateritic Sand, grainsand and coarse sand which again is in accordance with Benin formation which consist of sand with clay intercalation. Hence the studied area may hold good prospect for underground water in view of the probable thick aquifer.

References

[1] F.O. Ezomo and S.O. Ifedili (2006): African Journal of Sciences Vol. 9, No 1, pp2195-2203
[2] F.O. Ezomo and J.O. Nanu (2006): African Journal of Sciences Vol. 9, No 1 pp21 62-2169
[3] F.O. Ezomo and T. Bunonyo (2006): Journal of Applied science Vol. 11, No 1 PP 7569-7579
[4] F.O. Ezomo and S.O Ifedili (2005): Journal of Applied Science Vol. 9, No 3 Pp. 6579-6588.
[5] Osemeikhian, J.E.A and Asokhia, M.B. (1994): Applied Geophysics, Santos Services Ltd Lagos, Nigeria, Pp 96-113
[6] Reyment, M.A. (1965): Aspect of the Geology of Nigeria Ibadan University Press, Ibadan, Nigeria. P. 1650
[7] Kogbe, C.A (1976): Geology of Nigeria, Elizabeth Press, first published P1145.
[8] William Lowrie (1997): Fundamental of Geophysics, Cambridge University Press, pp 206-217

[9] Okwueze, E.E. (1996): Global Journal Pure and applied Sciecnes Vol 12. pp210-211
[10] Mooney, H.M (1977): Handbook of Engineering Geophysics, Vol 2: Electrical Resistivity Bison instruments, Inc 5708 West 36th street, Minnesoa,, U.S.A
[11] Keller, G.V and Frischnenct (1996): Electrical methods in Geophysical prospecting, New York, Pegamon Press P.519
[12] Telford, W,M et al (1975): Principle of Applied Geophysics, the Cambridge University Press U.K
[13] Instruction Manual (1961): Atlas Coppoo Abem A.C. P.O. Box 20086, 516120, Broma,, Sweden
[14] Chilton, J.P and Foster S.S.D (1995): Hydrogeological Journal vol 3, pp 36-49.
[15] Ghosh, D.P (1971a): Geophysical prospecting. Vol 19 (4), 192-217

[16] Ghosh, D.P. (1971b): Geophys. Prosp 19 (4): 765-775
[17] Zohdy, A.A.R (1965): Geophysics, 30, 644-660
[18] Kunetz, G (1966): Principles of direct current resistivity prospecting, No, 2. Geopubl. Association Geoexploration.
[19] Maillet, R (1947): Geophysics, 12 (4), 529-556
[20] Okolie, E.C. (2004): Geophysical investigation of aquifer potential in Delta State using Electrical resistivity and seismic refraction methods Published Ph.d thesis, Ambrose Alli University, Ekpoma, Edo State, Nigeria
[21] Agbor Bore-hole log (2009); Profile of Bore-hole lithology for Agbor, Agbor water resources, bore-hole division, Agbor, Delta State, Nigeria
[22] Omorogbe, O. (2005): Federal information center Akpakpava road, Benin City, Edo state