HYDROGEOPHYSICAL SURVEY FOR UNDERGROUD WATER IN FUGAR EDO STATE NIGERIA

Onavwie Ufuoma, Omasheye G.A.J and Ekibade Jahswill
Physics Department College of Education Warri Science Laboratory Technology Department Delta State Polytechnic Ozoro
Corresponding author's Email: ufuonavwie@yahoo.com GSM: +2348035809532

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Twelve (12) vertical electrical sounding (VES) was done using the Schlumberger electrode array configuration to obtain data and the Schlumberger automatic analysis method of interpretation was adopted. The lithological section of the study area revealed that the area is a basement complex with a thick fresh basement beneath the surface. The weathered basement is a good accumulation for underground water due to its low resistivity values. The interpretation of the data showed a resolution of nine geoelectric layers for the VES locations and a total cumulative thicknesses of 203.55m (677.82ft), and 272.29m (906.73ft) and 27l.43m (903.83ft) depth. From the geologic explanation of the subsurface materials, these values indicate a deeper probing into the aquifer zone. This study would give a guide on effective aquifer layer position in the studied locations (Fugar, Etsako Central Local Government of Edo State).

Key words: Vertical Electrical Sounding, Groundwater, Terrameter

INTRODUCTION

Electrical resistivity is commonly used for ground water investigation. It involves the measurement of apparent resistivity of soils and rocks as a function of depth or position. The resistivity of soils is a complicated function of porosity, permeability, ionic content of pore fluid and clay mineralization. The usual practice in resistively surveys is to inject current into the earth through a pair of current electrodes, and the potential difference is measured between a pair of potential electrodes. The current and potential electrodes are generally arranged in a linear array. Common arrays include the dipole-dipole array, pole-pole array, Schlumberger array and Wenner array (Asokhia, 1995).

Groundwater bearing zone is characterized by a certain number of parameters which are determined by geophysical methods such as electrical resistivity methods, seismic methods, magnetic methods, gravity methods, etc. But for this research work, the application of electrical resistivity survey method was used. The most usual parameters are porosity, permeability, transmissivity and conductivity. Electrical resistivity methods in geophysical exploration for groundwater has proven reliable (Emenike 2001), Records show that the depths of aquifers differ from place to place because of variational geo-thermal and geo-structural occurrence (Ekine and Osobonye 1996, Okwueze, 1996).

The study area and its environs lie on a flat topographical terrain. The actual site observation and information from existing geological maps classify surface sand of the study area and its environs as members of the Ajali Formation Figure 1. The Ajali Formation bears cross-bedded sandstone with associated clay and shale intervals in the bottom section (Reyment, 1964). The Ajali underlies the Nsukka and Mamu Formations. Nsukka formation which is called the Upper Coal Measure bears sandstone, shale and coal, while the underlying Mamu formation which has similar composition with the Nsukka formation has a higher frequency of coal occurrence.

METHODOLOGY

The Schlumberger array in electrical resistivity survey was adopted. In this research work, the basic field equipment for this study is the ABEM Terrameter SAS 300B which displays apparent resistivity values digitally as Computed from Ohm's

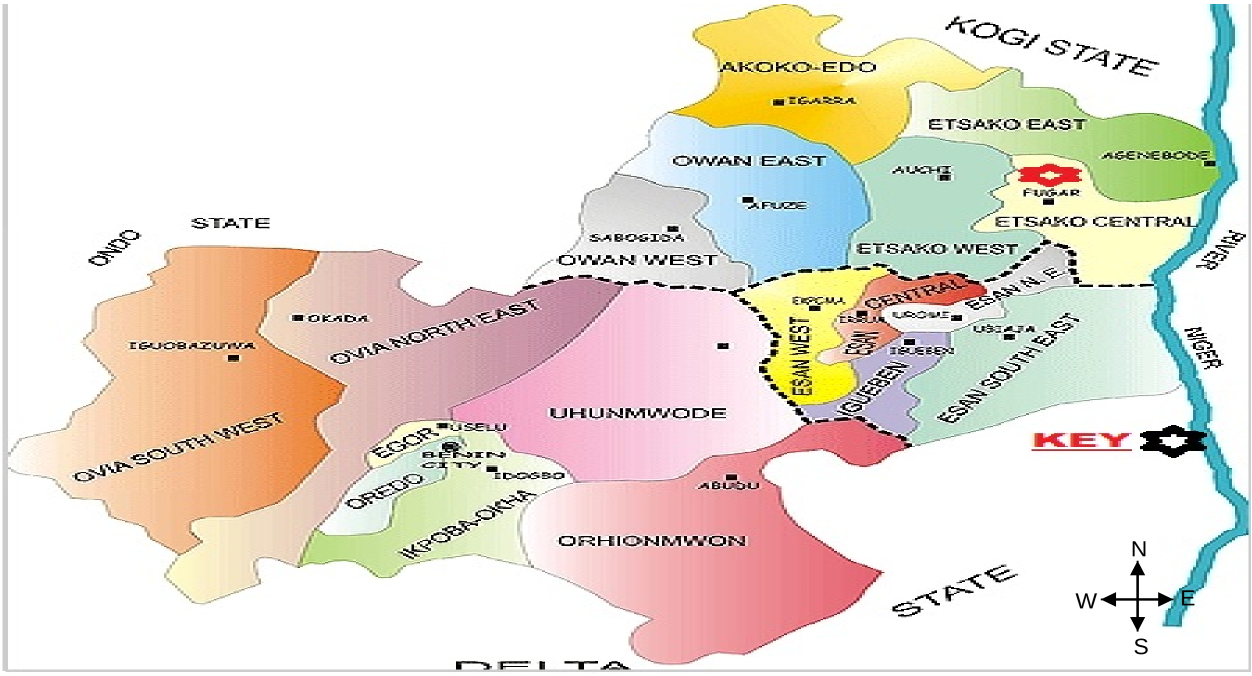

Figure 1. The map of Edo State showing studied area marked portion ( ).

law; it is powered by a 12V DC power source. Other accessories to the terrameter include the booster, four metal electrodes, cables for current and potential electrodes, harmers (3), measuring tapes, walkie talking or phones for very long spread (Asokhia, 1995). In this array, the four electrodes are positioned symmetrically along a straight line, the current electrodes are placed outside and the potential electrodes on the inside. To increase the depth range of the measurements, the current electrodes separations are progressively increased while the potential electrodes in general are left at the same position Figure 2.

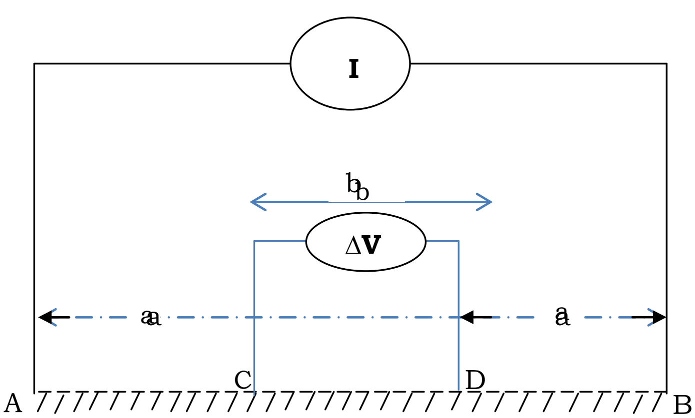

Figure 2. Schlumberger array.

When the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large, the potential electrodes separation must also be increased otherwise the potential difference becomes too low to be measured with sufficient accuracy (Koefoed, 1979). Measurements of current and potential electrode positions are marked such that AB/2 MN/2.
Where AB/2 is half of current electrode spacing and MN/2 is half of potential electrode spacing (Osemeikhian and Asokbia 1994)

Generally, site arrangement consists of a pair of current electrodes and a pair of potential electrodes. These are driven into the earth in a straight line to make a good contact with the earth. The current electrode spacing is expanded over a range of values for measurements in the field. The values of AB/2 increase as the measurement progresses while the potential electrodes separation is guided accordingly. The potential electrodes are kept at small separations relative to the current electrodes separations (Milson, 1939). One of the major advantages this method has over other methods is that only the current electrodes need to be shifted to new position for most readings while potential electrodes are kept constant for up to three or four readings (Reinhard and Frohlich, 1974).

During the exploration work (field work) taking a sounding, the ABEM Terrameter SAS 300B (Self Averaging System) performs automatic recording of both voltage and current, stacks the results, computes the resistance in real time and digitally displays it (Dorbrin and King, 1976).

From the theory we have that the potential at C due to A is

$$V_c = \frac{\rho I}{2\pi}\left\{\frac{1}{a - b/2} - \frac{1}{a + b/2}\right\}$$

Where

a = midpoint = distance between the current electrodes and station.

b = distance between potential electrodes

ρ = layer resistivity

The potential at D due to A becomes

$$V_D = \frac{\rho I}{2\pi}\left\{\frac{1}{a + b/2} - \frac{1}{a - b/2}\right\}$$

The potential difference dV between the two potentials is therefore given by

$$dV = V_C - V_D$$

$$\therefore dV = \frac{\rho I}{2\pi}\left\{\frac{1}{a - b/2} - \frac{1}{a + b/2}\right\} - \left[\frac{\rho I}{2\pi}\left\{\frac{1}{a + b/2} - \frac{1}{a - b/2}\right\}\right]$$

$$dV = \frac{\rho I}{2\pi}\left\{\frac{2}{a - b/2} - \frac{2}{a + b/2}\right\}$$

$$dV = \frac{\rho I}{2\pi}\left(\frac{8b}{4a^1 - b^2}\right)$$

$$dV = V_C - V_D$$

$$dV = \frac{pl}{2\pi}\left\{\frac{l}{a + b/2} - \frac{l}{a - b/2}\right\} - \left[\left[\left\{\frac{1}{a + b/2} - \frac{1}{a - b/2}\right]\right]\right.$$

$$dV = \frac{pl}{2\pi}\left\{\frac{2}{a - b/2} - \frac{2}{a + b/2}\right\}$$

$$dV = \frac{pl}{2\pi}\left(\frac{8b}{4a^1 - b^2}\right)$$

Divide through by I and make P the subject of the formular and write $^{dv}/_{I}$ as R

$$i.e. \qquad P = 2 + R\left[\frac{4a^2 - b^2}{8b}\right]$$

$$p = KR$$

where k is geometric factor

$$P = 2\pi\left[\frac{4a^2 - b^2}{8b}\right]$$

This equation explains how measured resistance

The apparent resistivity value is the product of the geometric factor and the resistance recorded in the resistivity meter. In each station, several soundings and apparent resistivity values will be obtained by expanding the current electrode spacing after each reading as required by Schlumberger array for deeper penetration into the earth and structural responses. The geometric factor, K, for Schlumberger configuration was used,

RESULTS AND DISCUSSION

From the results shown in Figure. 3 nine geoelectric layers encountered resistivities as shown in the model parameters of both locations. VES 1 curve is HK curve type with $\rho_1 > \rho_2\ \rho <_3 > \rho_4$. (Asokhia, 1995) VES 2 Table 1 and Figure 4, 3 curves are also found to appear [1K curves type with p1 > p, <p3 > p4]. The eighth layer of models I, 2 and 3 with thicknesses 70.80m, 111.00m and 134.00m, resistivities 592.00Ωm, 1820.00Ωm and 19800.00Ωm corresponds to a total depth of 203.55m (677.82ft), 272.29m (906.73ft) and 271.42m (903.83Ω) respectively. The VES results of the locations present a high aquifer prospects Table 2 to 4.

CONCLUSION

The studied area revealed that the area is a basement complex with a thick fresh basement beneath the surface. The fresh basement is overlaid with weathered basement. The weathered basement is a good accumulation for underground water due to its low resistivity values. The interpretation of the data showed a resolution of nine geoelectric layers for

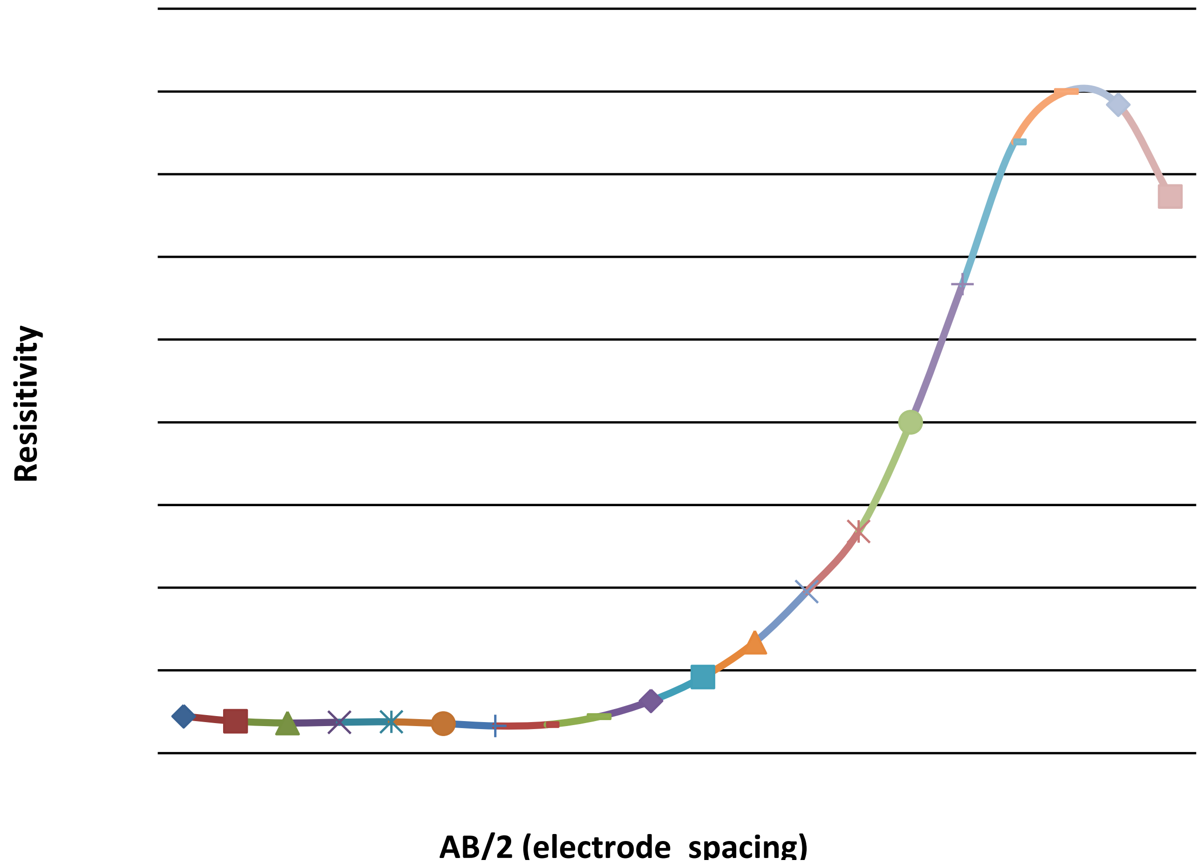

Figure 3. A graph of resistivity (Ωm against distance AB/2 for VES 1 Parameters). RMS error (%): 2.05

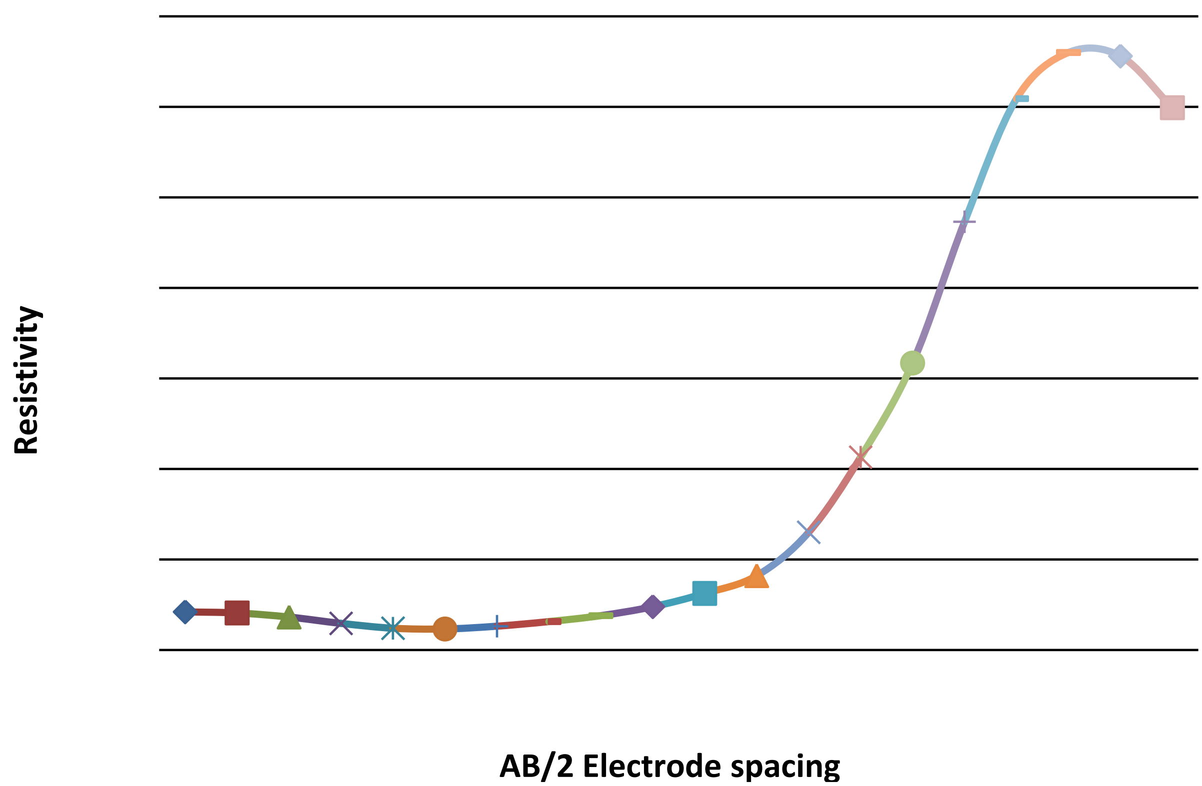

Figure 4. A graph of resistivity (Ωm against distance AB/2 for VES 2).

Table 1. VES 1 readings observed (field) and computed (theoretical) data.

AB/2	Observed resistivity value	Computed resistivity value
1.00	45.11	44.44
1.47	36.33	38.49
2.15	34.77	36.33
3.16	39.70	37.23
4.64	37.61	37.76
6.81	37.09	35.64
10.00	29.77	32.78
14.70	34.58	34.34
21.50	46.72	44.06
31.60	73.03	63.06
46.40	87.83	91.95
68.10	119.00	134.10
100.00	189.00	195.23
147.00	297.00	268.00
215.00	380.00	400.00
250.00	456.98	567.00
300.00	700.00	739.00
400.00	789.00	800.00
500.00	708.00	784.00
600.00	658.00	673.00

Table 2. Geoelectric parameters obtained from the study area (VES 1).

Geoelectric layer	Resistivity (ohm-m)	Thickness (m)	Cumulative
1	60.70	0.50	0.50
2	21.50	0.99	1.49
3	47.80	4.00	5.49
4	11.30	7.60	13.09
5	98.00	13.50	26.59
6	12900.00	58.80	85.39
7	11400.00	75.90	168.29
8	1820.00	111.00	272.29
9	773	Infinity	Infinity

the VES locations and the total cumulative thicknesses of 203.55m (677.82ft), 272.29m (906.73ft) and -27l.43m (903.83ft).

This research has provided information and the quantity the depth to groundwater (aquifer) the ground water and probably the thickness of the aquiferous unit in Fugar. This information is going to be relevant to the development of an effective water scheme for the area and possibly beyond other areas underlain by the formation.

Table 3. VES 2 readings observed (field) and computed (theoretical) data.

AB/2	Observed resistivity value	Computed resistivity value
1.00	41.43	42.05
1.47	39.6	40.88
2.15	36.46	36.36
3.16	27.96	29.36
4.64	24.09	24.00
6.81	25.50	23.19
10.00	27.10	26.27
14.70	31.86	31.34
21.50	36.5	37.92
31.60	42.77	47.78
46.40	65.31	62.50
68.10	82.30	82.07
100.00	106.54	130.00
147.00	108.49	213.00
215.00	200.08	317.00
250.00	318.67	473.00
300.00	599.89	609.00
400.00	620.66	660.00
500.00	605.00	656.00
600.00	580.00	599.00

Table 4. Geoelectric parameter obtained from the study area (VES 2).

Geoelectric layer	Resistivity (ohm-m)	Thickness (m)	Cumulative thickness (m)
1	40.90	0.52	0.52
2	21.50	1.10	1.62
3	17.20	4.50	6.12
4	34.40	17.20	23.32
5	164.00	25.80	49.12
6	820.00	37.40	88.52
7	1390.00	48.90	137.42
8	19800.00	134.00	271.42
9	1360.00	Infinity	Infinity

RMS error (%): 1.90.

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