



# THE RELEVANCE OF GEOPHYSICAL INVESTIGATION PRIOR TO BOREHOLE DEVELOPMENT

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**Abstract** - Geophysical investigation involving electrical resistivity method has been carried out at Ijapo and Oba-Ile in Akure, Ondo-State where primary data were acquired from two existing borehole points that are not productive and also, secondary data were collected from an organization named Ondo-State Water Corporation for three existing borehole points that are productive with the view to delineate the geoelectric characteristics of these areas and the factor(s) responsible for the non-functionality of boreholes in these area. The schlumberger array configuration was used for the data acquisition. The half current electrode (AB/2) used ranged from 1 to 50m. The quantitative interpretation of the Vertical Electrical Sounding (VES) curves involved the use of partial curve matching and computer iteration techniques. The results showed that VES 1, VES 2 and VES 3 from productive borehole points have good geoelectric parameters. These points are underlain by three geologic layers which are topsoil, weathered layer and fractured basement, while VES 4 and VES 5 from unproductive borehole points have very poor geoelectric parameters. This study showed that geophysical investigations of those unproductive borehole points were not carried out before the drilling. It is therefore recommended that geophysical investigation to reveal the geology of subsurface must first be carried out prior any borehole development to avoid waste of time and resources.

**Key words:** *Geoelectric Parameters, Schlumberger, electrical resistivity, Curve-Matching, Vertical Electrical Sounding.*

## I. INTRODUCTION

The science of geophysics applies the principles of physics to the study of the earth. Geophysical investigations of the interior of the earth involve

taking measurements at or near the earth's surface that are influenced by the internal distribution of physical properties. Analysis of these measurements can reveal how the physical properties of the earth's interior vary vertically and laterally. Keary and Brooks, M. (1984). In several geophysical survey methods it is the local variation in a measured parameter, relative to some normal background value, that is of primary interest. The electrical geophysical survey method is the detection of the surface effects produced by the flow of electric current inside the earth. Baker, R.D. (1981); Beard, L.P. and Morgan, F.D. (1991). The electrical techniques have been used in a wide range of geophysical investigations such as mineral exploration, engineering studies, geothermal exploration, archaeological investigations, permafrost mapping and geological mapping. Keller, G.V. and Frischknecht, F.C. (1996). The Vertical Electrical Sounding (VES) has proved very popular with groundwater prospecting due to simplicity of the techniques. Okhue, E.T. and Olorunfemi, M.O. (1991); Olayinka, A.I. et al. (1992,1997,1999,2004).

The importance of groundwater as a water supply source to the socio-economic development of any nation is tremendous. However, the difficulties in exploration and exploitation usually encountered in the basement areas where aquifers are both isolated and separate into distinct part or compartment, requires the use of multi-disciplinary approach involving, geological and hydro-geological mapping and geophysical investigations to ensure success. Ako, B.D. and Olorunfemi, M.O. (1989); Bello, A.A. and Makinde V. (2007); Dan-Hassan, M.A. and Adekile, D.A. (1991).

Presently, it is physically evident that the large urban sector in Ondo-State relies on groundwater for more than 95% of its water needs constituting a great water supply challenge. Water wells are poorly located and



abortive tube wells are often drilled due to partial or total negligence of geophysical investigation techniques. These wells are susceptible to drought

and contamination especially in dry weather condition (dry season). The figure 1 below shows the locational map of the study area.



Figure 1: Locational map of Akure showing the study area (From [web.kalid.com.cn](http://web.kalid.com.cn))

## II. MATERIALS AND METHODS

There are several geophysical surveying methods but Electrical Resistivity (ER) methods has been used for the investigation of underground water supplies. The electrical resistivity method investigates subsurface conditions by measuring the resulting potential differences across the ground when current is sent into the ground by means of electrodes. In electrical resistivity (ER) surveying, artificially generated electric currents are introduced into the ground and

the resulting potential differences are measured at the surface. Deviations from the pattern of potential differences expected from homogeneous ground provide information on the form and electrical properties of subsurface inhomogeneity. Two electrodes are used to supply a controlled electrical current to the ground. The lines of current flow adapt to the subsurface resistivity pattern so that the potential difference between two points on the ground surface can be measured using a second pair of electrodes. Figure 2 illustrates the flow of current from a single surface electrode while figure 3



illustrates the generalized form of the electrode configuration used in resistivity measurements.

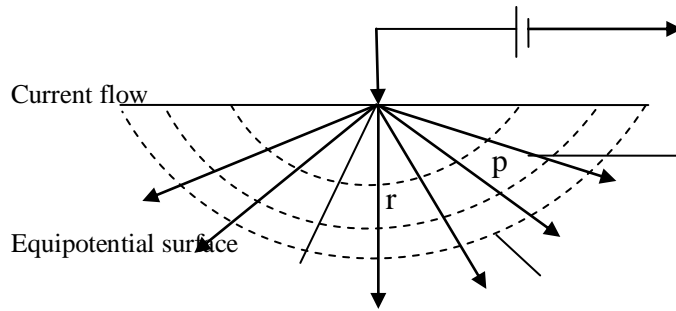


Figure 2: Current flow from a single surface electrode.

$$\Delta V = \rho I / 2\pi [(1/r_{AC} - 1/r_{CB}) - (1/r_{AD} - 1/r_{DB})]$$

$$\Delta V = \rho I / 2\pi (1/r_{AC} - 1/r_{CB} - 1/r_{AD} + 1/r_{DB})$$

$$\rho = \frac{\Delta V}{I} \left[ \frac{2\pi}{\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) - \left(\frac{1}{r_{AD}} - \frac{1}{r_{DB}}\right)} \right] \tag{i}$$

$$\rho = R \cdot G$$

R is electrical resistance (ohms)

G is geometric (or form) factor

$$G = \left[ \frac{2\pi}{\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) - \left(\frac{1}{r_{AD}} - \frac{1}{r_{DB}}\right)} \right]$$

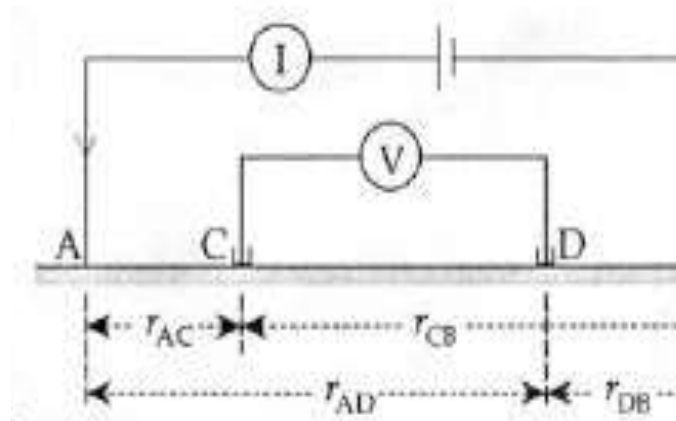


Figure 3: General four-electrode configuration for resistivity measurement.

When the ground is uniform, the resistivity calculated from the above equation should be constant and independent of both electrode spacing and surface location. When the surface is inhomogeneous, the resistivity will vary with the relative positions of the electrodes.

Equation (i) above is the basic equation for calculating the apparent resistivity for any electrode configuration.

**Schlumberger Configuration:** In this, the current and potential pairs of electrodes have a common mid-point but the distance between adjacent electrodes differs. This is shown in figure 4 below.

(In Figure 2.1, electrodes A and B are current electrodes while electrodes C and D are potential electrodes.)

$$V_C = V_A + V_B$$

$$V_C = \rho I / 2\pi r_{AC} - \rho I / 2\pi r_{CB}$$

$$V_C = \rho I / 2\pi [1/r_{AC} - 1/r_{CB}]$$

Similarly,

$$V_D = \rho I / 2\pi [1/r_{AD} - 1/r_{DB}]$$

The potential difference measured between electrodes C and D is  $\Delta V = V_C - V_D$ .

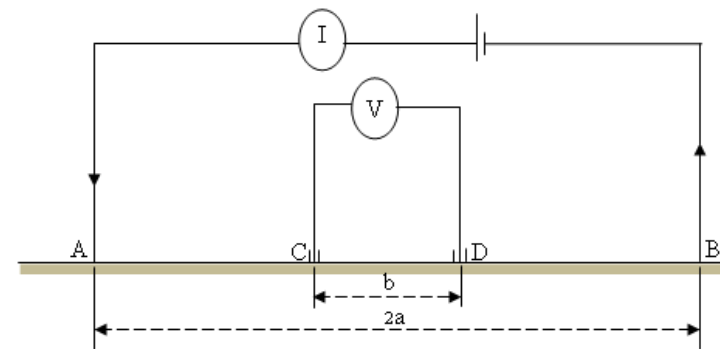


Figure 4: A typical Schlumberger electrode configuration.

$$CD \leq AB / 5$$



Substitution of this condition into equation (i) yields;

$$\rho_a = \pi \frac{V}{I} \frac{[4a^2 - b^2]}{4b}$$

$$G = \pi \frac{[4a^2 - b^2]}{4b}$$

### Data Acquisition

Primary data were acquired from Ijapo and Oba-Ile at two unproductive borehole points while the secondary data were obtained from Ondo-State Water Corporation Alagbaka, Akure for the three productive boreholes. The primary data were acquired following the methodology described above.

### Data Analysis

The VES data consist of electrode spacing and apparent resistivity. The apparent resistivity values obtained were plotted against the electrode spacing on bi-logarithm coordinates (for both Primary and Secondary data) and a preliminary interpretation was carried out using partial curve matching involving two-layer master curve and the appropriate auxiliary charts. The layered earth model obtained later served as input for an inversion algorithm using WIN RESIST. Keller, G.V. and Frischknecht, F.C. (1966).

### III. RESULTS AND DISCUSSION

The representative of the curves obtained using WIN RESIST software is presented in figure 6 below.

Table 1 shows the curve characteristics for each VES station. The results showed that VES 1, VES 2 and VES 3 which represent the productive boreholes have good geoelectric parameters. These points are underlain by three major layers which described the geological structure of these points. The resistivity values for their first layer (topsoil) are 66.0Ωm, 42.9Ωm and 292.5Ωm with respective thicknesses of 1.4m, 2.7m and 0.5m. While their second layer (weathered layer) has resistivity values of 21.0Ωm, 11.4Ωm, 40.4Ωm and thicknesses are 12.4m, 8.4m and 10.1m respectively. Their third layer (fractured basement) has resistivity values of 82.5Ωm, 158.7Ωm and 235.9Ωm indicating that this layer is highly fractured and will be a prolific source of groundwater. Nevertheless, VES4 and VES5 carried out at the unproductive borehole points have poor geoelectric parameters. VES 4 and VES 5 points are underlain by four and three geologic layers respectively. The resistivity values of their first layer are 374.5Ωm and 388.2Ωm with respective thicknesses of 0.7m and 1.6m. Their second layer has resistivity values of 270.2Ωm and 584.1Ωm with respective thicknesses of 2.9m and 10.0m while the third layer for VES4 has resistivity value of 237.0Ωm with thickness of 5.6m. And their last layer has resistivity values of 5508.2Ωm and 1517.0Ωm. This reveals that these points (VES 4 and VES 5) cannot be a prolific source of groundwater. Table 2 shows the results summary.

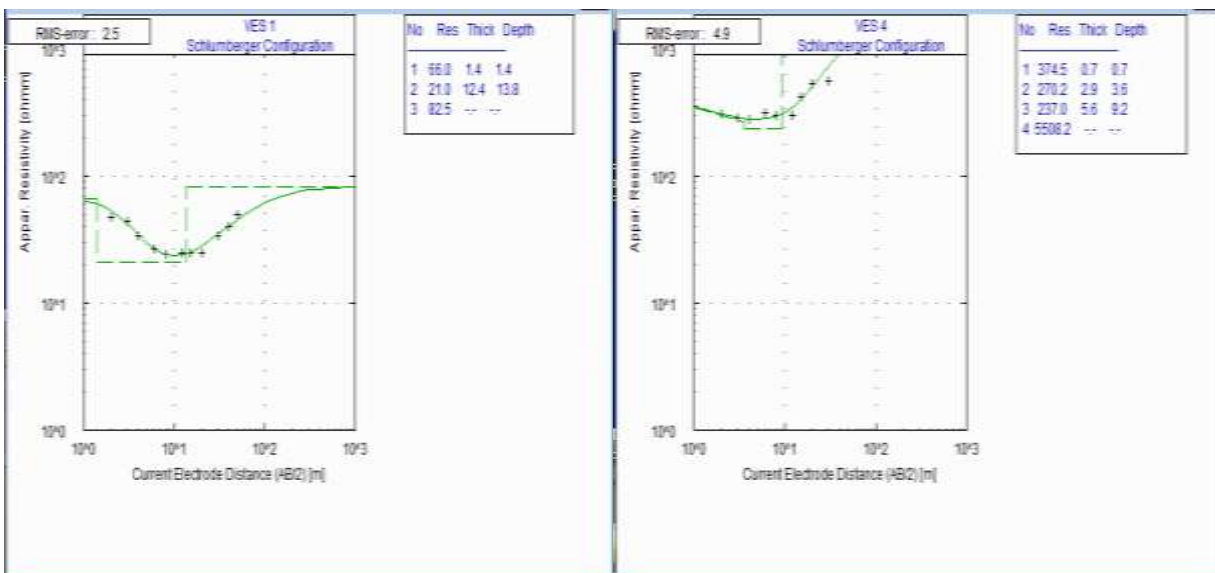




Figure 6: Representative VES curves

TABLE 1: CHARACTERISTIC CURVES FOR EACH VES STATION

VES STATIONS	SOUNDING CURVE	CHARACTERISTICS	NUMBER OF LAYERS
1(OBA ADESIDA )	H	$\rho_1 > \rho_2 < \rho_3$	3
2 (OYEMEKUN )	H	$\rho_1 > \rho_2 < \rho_3$	3
3 (IDANRE ROAD)	H	$\rho_1 > \rho_2 < \rho_3$	3
4 (IJAPO)	QH	$\rho_1 > \rho_2 > \rho_3 < \rho_4$	4
5(OBA ILE)	A	$\rho_1 < \rho_2 < \rho_3$	3

TABLE 2: SUMMARY OF LAYER RESISTIVITY AND THICKNESS

NAME OF VES	RESISTIVITY ( $\Omega$ M)	THICKNESS (M)	DEPTH (M)	CURVE TYPE	PROBABLE LITHOLOGIC UNIT
OBA ADESIDA (VES1)	66.0	1.4	1.4	H	Laterite
	21.0	12.4	13.8		Weathered layer
	82.5				Fractured basement
OYEMEKUN (VES2)	42.9	2.7	2.7	H	Laterite
	11.4	8.4	11.1		weathered layers
	158.7				Fractured basement
IDANRE ROAD (VES3)	292.5	0.5	0.5	H	Laterite
	40.4	10.1	10.6		Weathered layer
	235.9				Fractured basement
IJAPO (VES4)	374.5	0.7	0.7	QH	Laterite
	270.2	2.9	3.6		Hard laterite
	237.0	5.6	9.2		Fractured basement
	5508.2				Fresh basement
OBA ILE (VES5)	388.2	1.6	1.6	A	Laterite
	584.1	10.0	11.6		Fractured basement
	1517.1				Fresh basement



#### IV. CONCLUSION AND RECOMMENDATION

This study has revealed that geophysical investigations of those unproductive borehole points were not carried out before the drilling; simply because the results indicated that these points lack potentials for groundwater accumulation. To this sense, it is very essential to always carry out geophysical surveys prior to borehole drilling for better understanding of the hydrogeology potential of the subsurface in order to select promising borehole sites.

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