Geophysical Investigation of Egbeta, Edo State, Nigeria, Using Electrical Resistivity Survey to Assess the Ground water Potential

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ABSTRACT

Geophysical investigation to ascertain groundwater potential was carried out in Egbeta, using one-dimensional (1D) vertical electrical sounding (VES) technique. The Schlumberger array configuration with current electrode (AB/2) spacing of 1 m to 350 m with potential electrode (MN/2) spacing of 0.25 m to 10 m was adopted. The data acquisition was carried out using PASSI 16GL-N earth resistivity meter.The resistivity sounding curves were interpreted quantitatively; this is done by partial curve matching technique and computer iteration of the interpreted resistivity curves using WINRESIST computational software. The result from this study reveals three VES curves AAK, HAKQ and HAAK, with the AAK dominant. Theaquifer depth in this study area is in the range of 59.8 m to 159.5 m. The depth to aquifer is highest in VES 1 and lowest in VES 5.The resistivity value at this location dropped from 11201.7 Ωm to 607.2 Ωm. There is likelihood of the aquifer at VES 5to becontaminated and dried up because of the thickness of the aquitard as comparedto VES 1, 2, 3 and 4 with relatively high thickness.

Keywords: *Groundwater, Geophysical, Aquitard, Aquifer, Potential, thickness*

1. INTRODUCTION

Egbeta is a small community in Edo State with a normal annual rainfall like other part of Southern part of Nigeria. This community has suffered portable drinking water due to the cost of sinking a borehole and dearth of municipal water supply for a long time. There is no available record of hydrogeological and geophysical investigation ever carried out in this community, thus this research is highly important. Even the two (2) existing hand dug boreholes were manually done without any geophysical survey and one is already contaminated. The science which is known as geophysics involves the applications of the methods of Physics to study the subsurface parts of the earth by taking measurements at or near the earth's surface [1]. These measurements are usually influenced by the internal distributions of physical properties.Groundwater is usually prospected for with geophysical methods and widely used for drinking and irrigation [2]. It is generally known thatabout 53% of the world population depends on groundwater as a source of drinking water [3]. Electrical resistivity method of geophysical exploration happens to be the most useful method in groundwater exploration, this is applied using the Vertical Electrical Sounding (VES) technique. The method has been recognized to be more appropriate for hydrogeological study of sedimentary basin [3-5]. The reason for its wide use is because the instrument is simple to handle. Also, the field logistics are easy and straight forward while the analysis of data is less tedious and economical. This is the reason why many researchers [6,7] have used this method to determine the aquifer boundaries.Nevertheless, when resistivity methods are used, restriction can be expected if ground inhomogenetiesand anisotropy are presented [8].The surface electrical resistivity method uses several techniques and instruments in its investigation and the most suitable in determining the thickness and resistivity distribution of the subsurface [9].The knowledge of the depth of water table is a critical component in many hydrological surveys, including land fill characterization, agricultural salinity management, chemical seepage movement, and water supply studies [10]. This paper provides detailed hydrogeological and geophysical information for the prospect of groundwater investigation in Egbeta and its environs.

2. THE STUDY AREA

Egbetais inOvia North East Local Government Area of Edo State, Nigeria.The neighbouring communities include Utese, Ugbowe, Uhen, Ogbese and Okada. This area is situated in the rain forest type of vegetation and is characterized by dense ever green forest. Thick vegetation, farming, high level deforestation and other main activities have affected the natural vegetation. The top soil in this area is lateritic clay sand with reddish brown coloration, why the bed rock is underlined by limestone. Figure 1 presented belowshows the study area within the geological map of Nigeria.

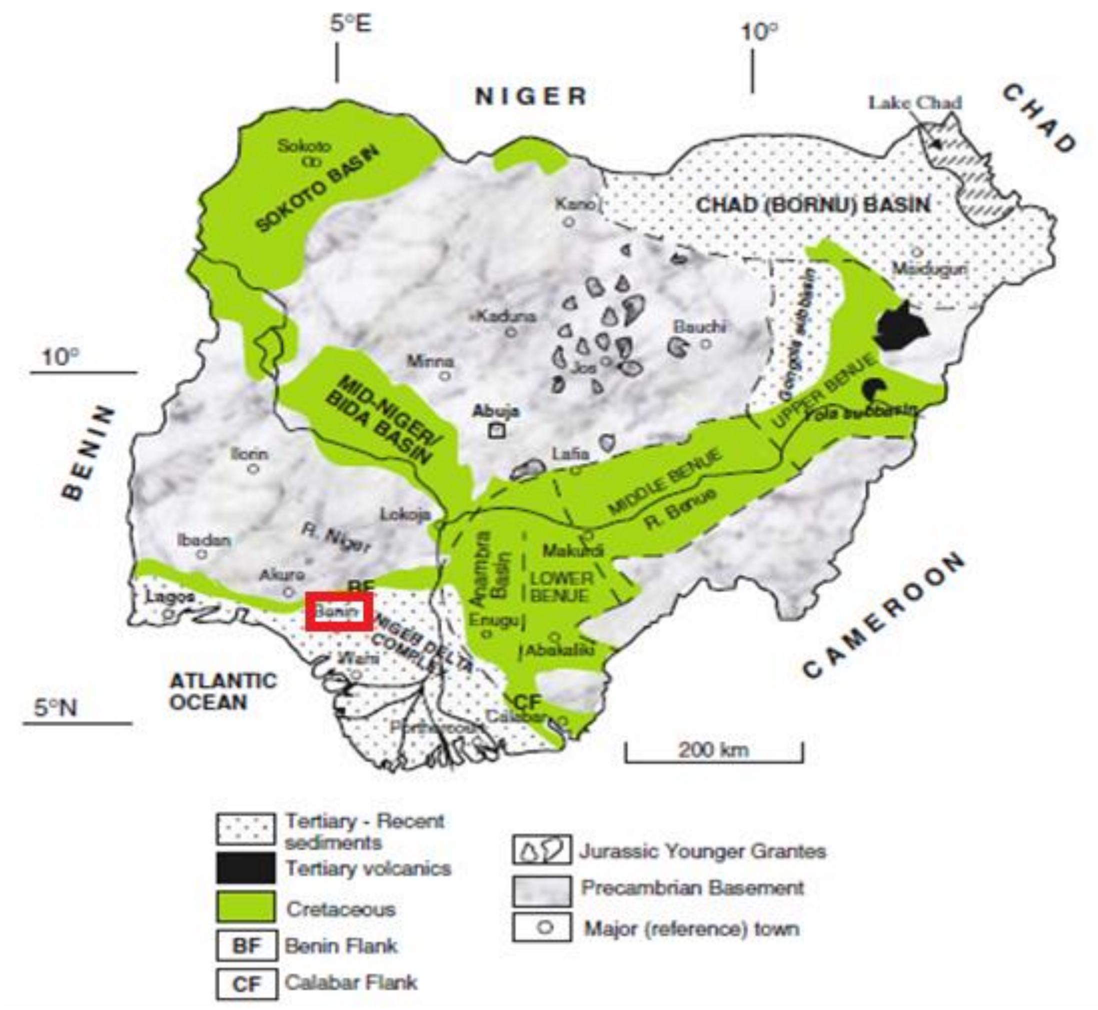


Figure 1: Geological map Nigeria showing the study area in a Red Rectangle [11]

3. MATERIALS AND METHOD

The vertical electrical sounding (VES) data in the study area were acquired using the Schlumberger configuration presented in figure 2. This was done with the aid of a PASSI 16GL-N Earthresistivity meter. The current electrode(AB/2) spacing ranged from 1.0 m to 350.0 m and the potential electrode (MN/2) from between 0.25 m to 10.0

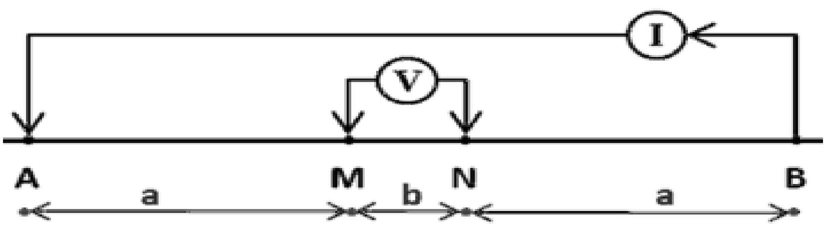


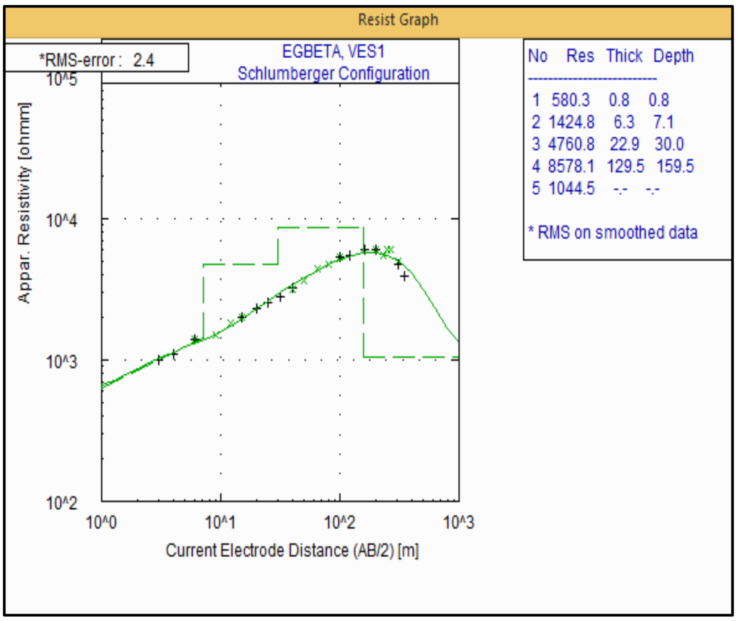
Figure 2: Electrode Configuration for Schlumberger Array

The quantitative interpretation of the resistivity sounding curves were carried outusing partial curve matching technique and computer iteration of the interpreted resistivity curves. Partial curve matching method involves a segment matching of the sounding curves with theoretical Schlumberger layer. The interpretation was done manually by matching the VES curves segment by segment, starting from small electrode spacing gradually to larger electrode spacing. The process involves taking the apparent resistivity data in ohm-meter obtained from the study area and plotting it against the electrode spacing in meters on a transparent double logarithmic paper, to obtain a curve of best fit with the axis of the two graphs parallel to each other, and then use the WINRESIST computational software.

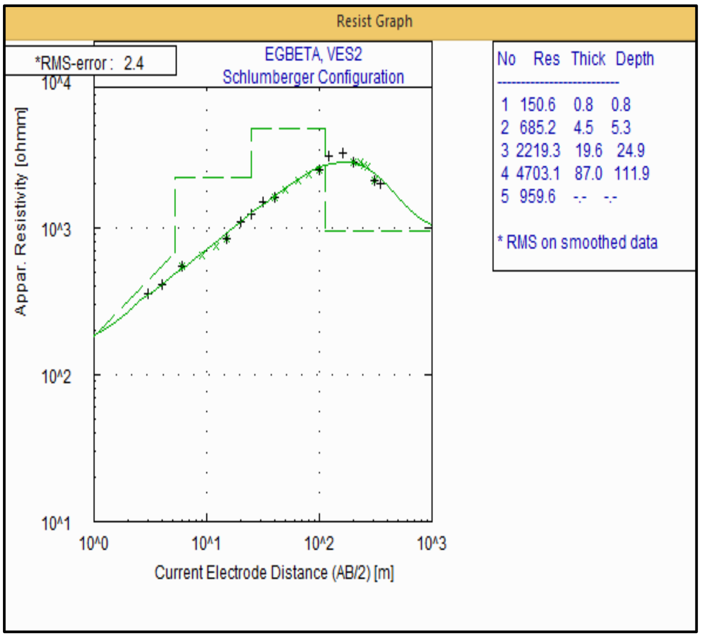
4. RESULTS

The results of this research work are presented in figures and table. Figures 3 and 4 below show the sounding curves and the VES geoelectric sections for the 1D sounding, and Table 1 shows the VES data and the delineated lithologies in the study area.

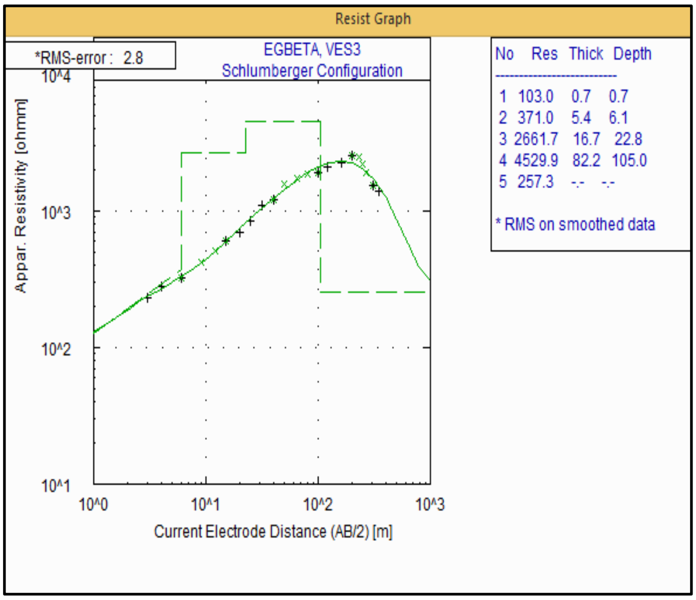
VES 1



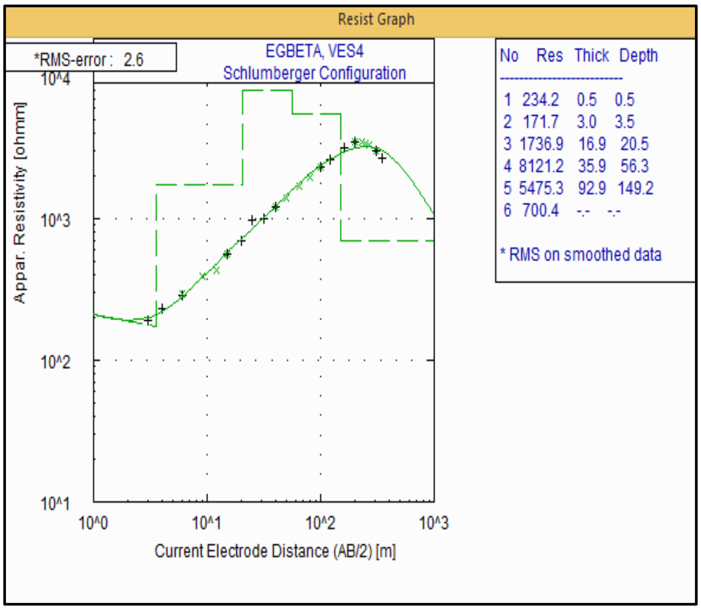
VES 2



VES3



VES 4



VES 5

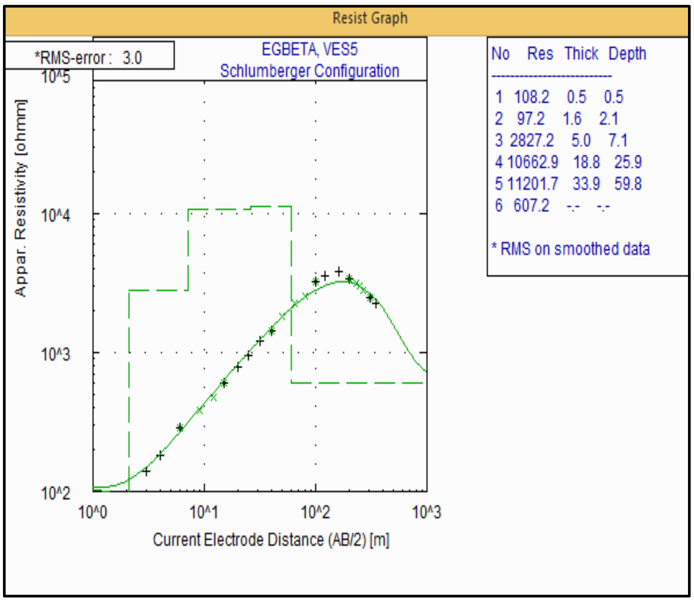
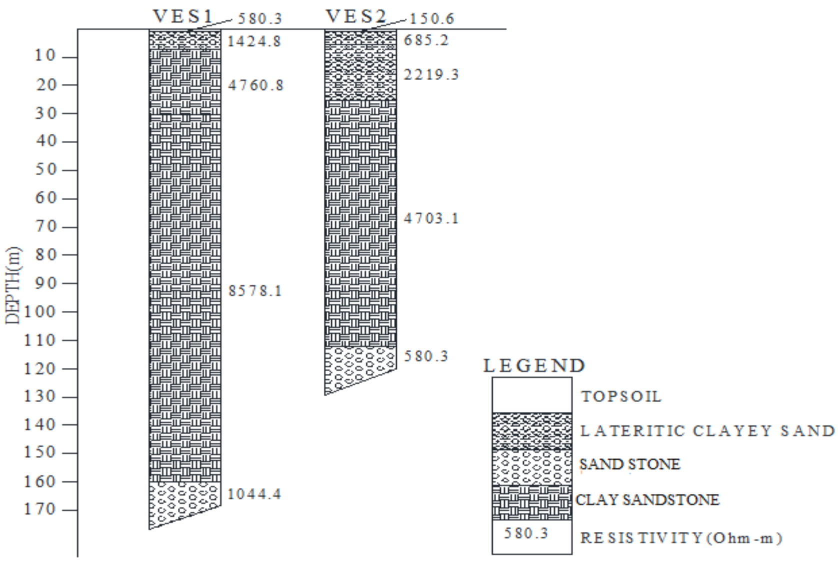
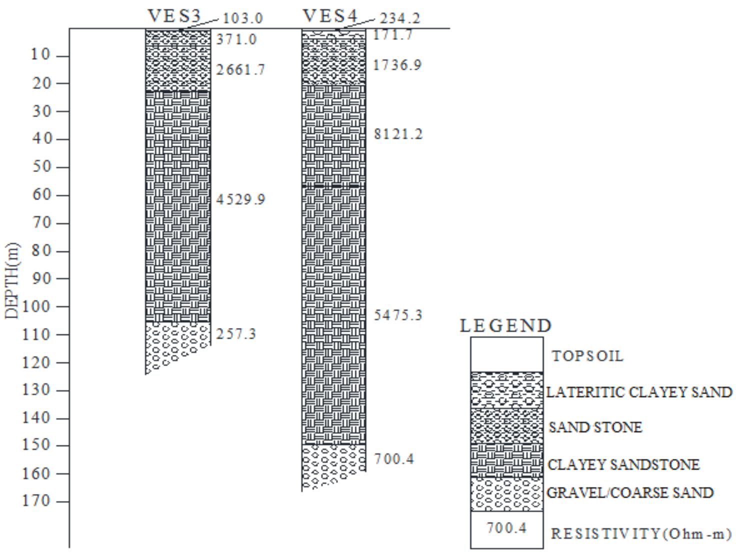


Figure 3: Sounding Curves for VES 1 to VES 5





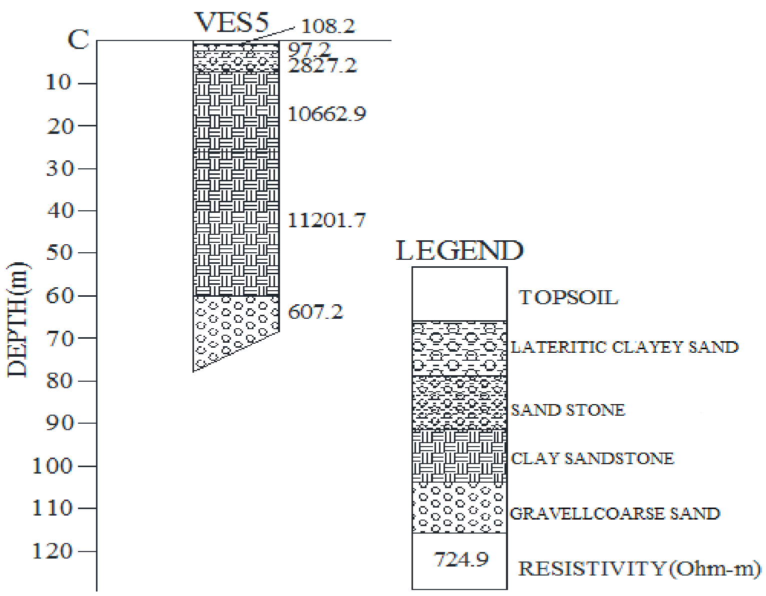


Figure4: Geoelectric Sections for the VES Survey

Table 1: VES Data and the Delineated Lithologies in the Study Area

VES NO	LAYERS	RESISTIVITY(Ω m)	THICKNESS(m)	DEPTH(m)	CURVE TYPE	INFERRED LITHOLOGY
1	1	580.3	0.8	0.8	**AAK**	Top soil
	2	1424.8	6.3	7.1		Lateritic Clayey Sand
	3	4760.8	22.9	30.0		Sand stone
	4	8578.1	129.5	159.5		Gravel/Coarse Sand
	5	1044.5	----	----		Sand
2	1	150.8	0.8	0.8	**AAK**	Top soil
	2	685.2	4.5	5.3		Lateritic Clayey Sand
	3	2219.3	19.6	24.9		Sand stone
	4	4703.1	87.0	111.9		Gravel/Coarse Sand
	5	959.6	----	----		Sand
3	1	103.0	0.7	0.7	**AAK**	Topsoil
	2	371.0	5.4	6.1		Lateritic Clayey Sand
	3	2661.7	16.7	22.8		Sand stone
	4	4529.9	82.2	105.0		Gravel/Coarse Sand
	5	257.3	----	----		Sand
	1	234.2	0.7	0.7		Top soil
	2	171.7	3.0	3.5		Lateritic clayey Sand

4	3	1736.9	16.9	20.5	**HAKQ**	Sand stone
	4	8121.2	35.9	56.3		Clayey Sandstone
	5	5475.3	92.9	149.2		Gravel/Coarse Sand
	6	700.4	----	----		Sand
5	1	108.2	0.5	0.5	**HAAK**	Topsoil
	2	97.2	1.6	2.1		Lateritic Clayey Sand
	3	2827.2	5.0	7.1		Sand stone
	4	10662.9	18.8	25.9		Clayey Sandstone
	5	11201.7	33.9	59.8		Gravel/Coarse Sand
	6	607.2	----	----		Sand

5. DISCUSSIONS

The vertical electrical sounding (VES) data were presented as depth sounding curves and geoelectric sections shown in figures 3 and 4 respectively.They were obtained by plotting apparent resistivity values against electrode spacing. The depth sounding curves are classified based on layer resistivity combinations. The curve types obtained in the study include the AAK, HAKQ, and HAAK types. The most dominant curve type obtained in this study area is the AAK type which is obtained at VES 1, 2 and 3 with five-layer subsurface model, while VES 4 and 5 both havesix-layer subsurface model, with first layer containing the top soil, followed by the lateritic clayey sand, sandstone, clayey sandstone, gravel/coarse sand and the sand in the lower aquifer region. The resistivity values in these areas are in the range of 257.3 Ωm to 8578.1 Ωm, while the depth of aquifer is in the range of 105.0 m to 159.5 m. The highest drop in resistivity values and thickness of the aquitard was observed at VES 1, with values of 7533.6 Ωm and106.1 m respectively. The HAKQ curve type with a six-layer subsurface model was observed at VES 4. The depth of the aquifer at this location is 149.2 m with thickness of aquitard of 57 m. The drop in the resistivity value at this location is from 5475.3 Ωm to 700.4 Ωm. VES 5 with HAAK curve type is a six-layer subsurface model with aquifer depth of 59.8 m and thickness of aquitard of 15.1 m. The resistivity value at this location dropped from 11201.7 Ωm to 607.2 Ωm.

6. CONCLUSION

The lithological parameters of the subsurface in this area has been effectivelydefined.The results from this study showed clearly that Vertical Electrical Sounding (VES) technique is very good in delineating groundwater potential and the conditions that favour groundwater exploration in Egbeta.There is possibility for the aquifer at VES 5 to be polluted and dried up because of the thickness of the aquitard as compared to VES 1, 2, 3 and 4 with relatively high thickness.

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