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Geophysical determination of buried structural features at Ovbiogie village, Edo State, Nigeria.

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Abstract

The result of this paper is to determine geophysically buried structural features using Schlumberger array of vertical electrical sounding. The need to detect riversand/gravel as perched aquifer for clean water production became necessary because of limited resources of pure water in the study area. The research work was done at Ovbiogie village in Ovia North East Local Government Area of Edo State. The vertical electrical resistivity soundings were carried out with maximum current electrode spacing of* 928*m using six points per decade. Computer iterated data from the study area made the structural determination possible with resistivity values ranging from* 85*ohm-m to* 735*ohm-m and depth varying from* 1*m to* 40*m. The results obtained obviously showed the existence of the following structural features; clayey soil at a depth of* 1.0*m, sandy soil at a depth of* 3.0*m, clay and mart at a depth of* 12.6*m, river sand and gravel at a depth of* 35.1*m and basalt at a depth of infinity.

1.0 Introduction

Geophysical method of prospecting extend its wide application to delineation of buried structural features.[1] These features are amenable to oil and minerals which are of economic importance.

The rapid growth of the buried structural features and the high profits derived by the more fortunate hand and royalty owners from the associated oil/mineral which is often found by drilling on hitherto relatively worthless land, have so played on the imagination of some would be inventors of a purportedly reliable oil/water finder.[2] Fantastic claims are usually made for these devices and methods, thus, it is possible to predict the electrical resistivity, quantity of oil/minerals, thickness of he oil sand or sands and then depths, as well as the presence and quantity of other buried structural features. [3]

It is also assumed that the same techniques would be equally useful in prospecting for structural features such as gold, silver and other metals in other parts of the world.

Electrical resistivity method has gradually and continually made its way to the top in the successful search and exploitation of these subsurface structural features.

2.0 Brief local geology and hydrogeology of the study area

The study area is underlained by Benin formation. The Benin formation is known for the outcropping yellow and white sands and clay which occur in coastal Nigeria. The formation consists mainly of sands, gravels and backswamp deposits.[3] It has a structural plain because it has not been disturbed by earth movements. Intercalation of sand, clay and clayey sand are the predominant lithologies intercepted.[2]

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Hydrogeologically, the formation is very aquiferous because of low percentage of shally layers.[2]

The research area which is the Ovbiogie village in Edo State, Nigeria is on latitude of about 6^0 27’ N and longitude of about $5^0$35’ N.[4].

3.0 Experimental work

Schlumberger electrode configuration of vertical electric sounding was used for data acquisition. The equipment used was ABEM AC Terrammeter model 5310, manufactured in Sweden. It can be used in taking surface resistivity readings for both resistivity surveys and self-potential measurements.[5]

The instrument has good penetration because its operating frequency of 4HZ with transistorized amplifier means little disturbance from power lines. It is capable of measuring down to depths of 600m if given favourable conductivity conditions, usually 0.02. Siemens per metre.[5]

The resulting apparent resistivity values were plotted against the half-current electrode spacing, using a log-log graph sheet. The plot were interpreted by the famous method of partial curve matching. The partial curve matching were then subjected to computer assisted iterative model which produced sets of layer parameters in terms of their buried features lithologic equivalents known as geoelectric section.[6]

4.0 Theoretical analysis

Electrical resistivity measurements employ several types of electrode configurations when the earth is composed of horizontally stratified isotropic, and homogeneous media such that resistivity changes depend on penetration depth.[7] The schlumberger array is the most famous because of its ability to provide useful information in identifying subsurface buried features lithologies.[8] In electrical resistivity sounding, four electrodes which consist of two current electrodes A, B and two potential electrodes M,N are earthed along a straight line in the order AMNB.[6] The calculated apparent resistivity ($\ell_{a,s}$) according to Schlumberger array is

$$\ell a,s = \pi \left[\frac{\frac{AB^2}{2} - \frac{MN^2}{2}}{MN} \right] \frac{\Delta V}{I} \text{ [7]} \qquad (4.1)$$

provided $AB \geq 5MN$ [8], where AB = Current electrodes spacing in meter, MN = potential electrodes spacing in meter, ΔV = Potential difference in volts, I = Electric current in Amperes, π = Constant = $^{22}/_{7}$. The data interpretation techniques involve seeking a solution from laplace’s equation because of the electrical potential considered due to a single current source.[9]. That is, $\nabla^2 V = 0,\ r = 0$

(4.2)

where ∇^2 (del squared) is the usual Laplacian operator which can be expanded in spherical polar coordinates as

$$\frac{d^2 v}{dr^2} + \frac{2}{r}\frac{dv}{dr} + \frac{1}{r^2 \sin\theta} - \frac{d}{d\theta}\left(\sin\theta \frac{dv}{d\theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{d^2 v}{d\phi^2} = 0. \qquad \{4.3)$$

This clearly define electric potential V as a function of radial distance r.[8]

Laplace’s equation is used in interpreting apparent resistivity measurements in terms of lithology variation with penetration depths [11]. The equation assumes the earth to be locally stratified, inhomogenous and isotropic layers. It is depended on electrode configuration. Besides, it is obtained from the transformation of calculated apparent reistivities from equation (2.1).[8]

5.0 Results and discussion

The results and field or theoretical curves obtained are presented (Table 5.1 and Figure 5.1). Table 5.1 indicates sounding interpretation in Ovbiogie village, near Ekiadolor, Edo–State.

It shows the VES half current electrode spread or $^{AB}/_{2}$ (meter) as indicated in the first column with a minimum of 2 meters spread and a maximum of 928 meters spread.

The VES was conducted at Ovbiogie village near Ekiadolor in Ovia North East Local Government area of Edo State on a bearing of N125^0E. The weather condition was cool and cloudy with a temperature of about 27^0C. The analysis of the resistivities of various buried structural features formations is usually ambiguous in geophysical exploration work because it is possible for different lithology to with have the same resistivity.[10] This overlapping of resistivity values for the same lithological formations is seen in [10], [1].

However, we usually integrate the results of the interpreted VES curve shown in Figure 5.1 with the local or general lithologies of the area [6]. The buried structural features found in the area are shown in Table 5.2.

The results of the VES curve in Figure 5.1 shows a five layer geoelectric structure with a top layer whose resistivity is 490.0 ohm-m underlained by higher resistivity layer of 735.0 ohm-m. The third layer has a resistivity of 85.7ohm-m. The fourth and fifth layers have resistivities of 117.1 ohm-m and 314.3 ohm-m respectively.

Integrating the resistivity results with the general geology of the survey area and using the lithologies of nearby borehole, [4] geoelectric interpretations were obtained. This showed that the first layer which extends to a depth of 1m is composed of clayey soils. The second layer with a thickness of 2m is made up of sandy soils. The third layer with a thickness of 9.6m is composed of clay and mart. The fourth layer with a thickness of 22.5m is composed probably of river sand and gravel. The fifth layer is probably composed of Basalt.

The maximum depth penetrated was 35.1m. The total transverse resistance was 5415.22 ohm-squaremeter and the total longitudinal conductance was 0.30 9 ohm.

Table 5.1: Ves Results at Ovbiogie Village near Ekiadolor, Edo State, Nigeria**.**

S/N	**$^{AB}/_2$ (Meters)**	**Computed apparent resistivity (ohm-*m*)**
1	1	490
2	1.47	520
3	2.15	560
4	3.16	600
5	4.64	650
6	6.81	700
7	10	750
8	14.7	820
9	21.5	900
10	31.6	1,100.00
11	46.4	1,400.00
12	68.1	2,200.00
13	100	2,600.00
14	147	3,000.00
15	215	4,000.00
16	216	6,000.00
17	464	7,000.00

Table 5.2: Various buried structural features/lithologies encountered

Layer	**Resistivity (ohm-*m*)**	**Height (*m*)**	**Depth (*m*)**	**Lithology/Buried Features**
1.	490.0	1.0	1.0	Clayey soils
2.	735.0	2.0	3.0	Sandy soils
3.	85.7	9.6	12.6	Clay & mart
4.	117.1	22.5	35.1	River sand and gravel
5.	314.3	Infinity		Basalt

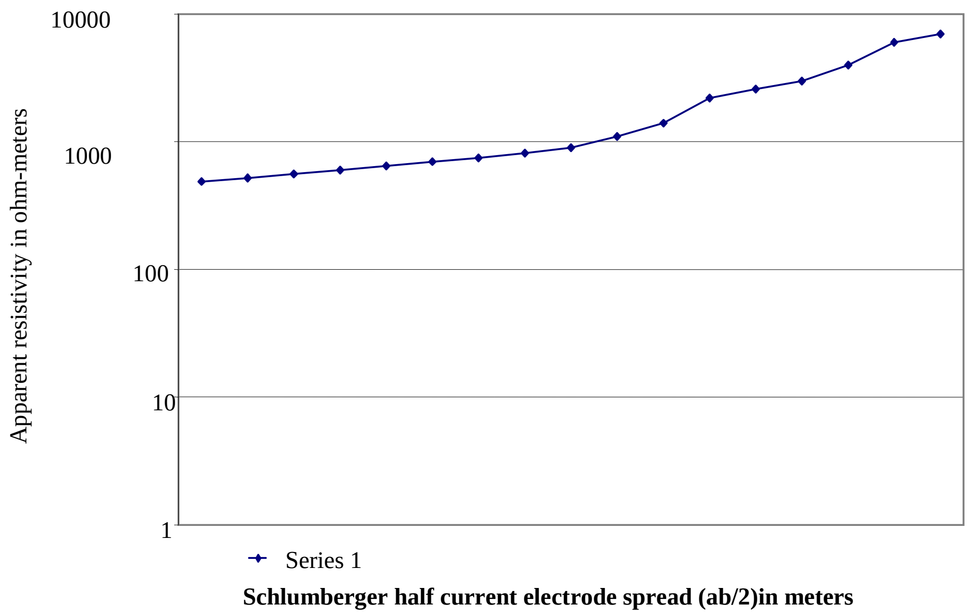

Figure 5.1: Theoretical Ves Curve at Ovbiogie Village, Near Ekiadolor, Edo State, Nigeria.

6.0 Conclusion

The research work proved the importance of VES for delineation of buried structural features at Ovbiogie village, Edo State. The results of the interpreted VES data revealed clayey soils, sandy soils, clay/mart, river-sand/gravel and Basalt as buried structural features. The research area is very aqueferous because sandy soils, clay/mart, and riversand/gravel have high porosities and permeabilities. Porosity and permeability are two vital factors associated with rock determining the rate of groundwater flow. Porosity is the percentage of the volume of the rock that is open space (pore space) and it determines the amount of water that a rock can contain. Permeability is a measure of the degree to which the pore spaces are interconnected and the size of the interconnections. Low porosity usually results in low permeability. Permeable rocks will easily allow water pass through them.

River-sand or gravel which is one of the buried structural features intercepted at a depth of about 35.10m is a very good perched aquifer and hence recommended for water production because it may not dry up for a long time after seeking of borehole in the area.

Electrical resistivity method has proved its usefulness in delineation of buried structural features clayey soil, sandy soil, clay/mart, river sand/gravel and Basalt intercepted at a depth of about 1.0m, 3.0m, 12.6m and 35.1m below sea level.

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