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Interpretation of vertical electrical sounding points around two boreholes at samaru college of agriculture, A.B.U., Zaria-Nigeria

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ABSTRACT

Vertical Electrical Sounding (VES) was carried out around a functional and non-functional borehole at the Samaru college of Agriculture, Ahmadu Bello University, Zaria-Nigeria, with the target to investigate the causes of failure of one of the boreholesThis paper focus on the VES Points taken around the two boreholes (A and B). VES Points 1, 2 and 3 were taken around borehole A, while VES Points 4 and 5 were taken around borehole B. The sounding curves for VES 1,2 and 3 shows a four-layer geoelectric structure. The first layers for the three VES Points shows a range of resistivity values of 280ohm-m to 360ohm-m. This moderately high resistivity values could be as a result of the presence of laterites. VES 4 and 5 were made around borehole B. The sounding curves indicate a 5-layer geoelectric structure. This is in fairly good agreement with the borehole log. The high resistivity values at VES Points 4 and 5 around borehole B is an indicative of low conductivity in the subsurface structures. The VES Points 1, 2 and 3 around the existing and functional borehole A has large aquifer thickness and low depth to water table. This finding is a proof that there is a correlation between the depth to basement and depth to water table. On the other hand, the VES Points 4 and 5 around the non-functional borehole B, has small aquifer thickness and large depth to water table which could be a possible reason why the borehole failed not up to two years after it was drilled.

Key words: Resistivity, Borehole, Vertical Electrical Sounding, Groundwater.

INTRODUCTION

Resistivity geophysical surveys measure variations in the electrical resistivity of the ground, by applying small electric currents across arrays of ground electrodes. The resistivity sections are correlated with ground interfaces such as soil and fill layers or soil-bedrock interfaces, to provide engineers with detailed information on subsurface ground conditions. The resistivity of rocks is strongly influenced by the presence of ground water, which acts as an electrolyte. This is especially important in sedimentary rocks containing pore spaces. In metallic ores the resistivity can be very low, but igneous rocks that contain no water can have very high resistivity. The minerals that form the matrix of a rock are generally poorer conductors than groundwater, so the conductivity of a rock increases with the amount of groundwater it contains. This depends on the fraction of the rock that consists of pore spaces (the porosity) and the fraction of the pore volume that is water filled (Afuwai et al, 2011).

The Samaru college of Agriculture, Zaria is located at a latitude of 11º09'48.00N to 11˚10'02.00N and at a Longitude of 7˚38'06.00E to 7˚39'20.00E in the Sabon gari local government area (L.G.A) of Kaduna state, Nigeria (figure 1.) The D.C. resistivity method has been found to be quick and economical to investigating parameters like depth to aquifer, thickness of aquifer, thickness of overburden, depth and resistivity of subsurface formations.

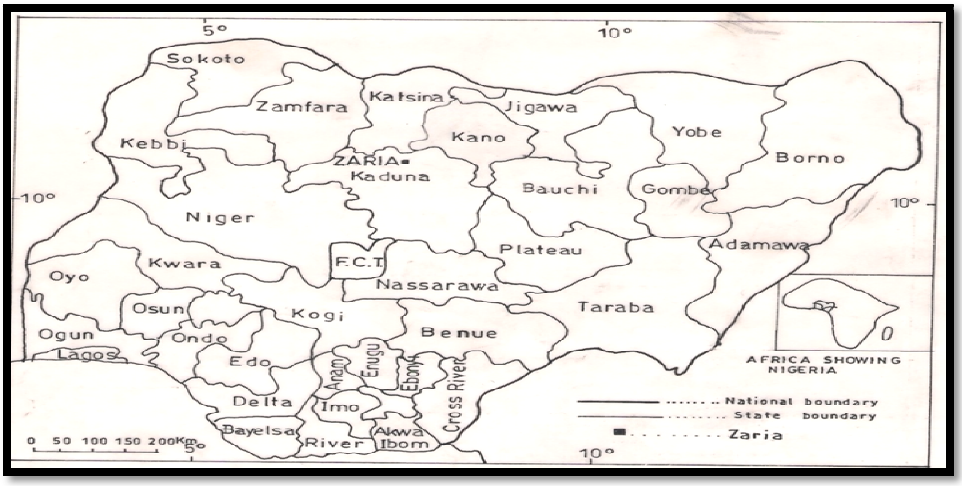

Figure1. Map of Nigeria showing Zaria-Kaduna

1. Objectives of the survey

The objectives of this study include the following:

- Determination of the aquifer thickness
- Determination of the depth to aquifer
- Determination of the depth to basement
- Identification of causes of borehole failure

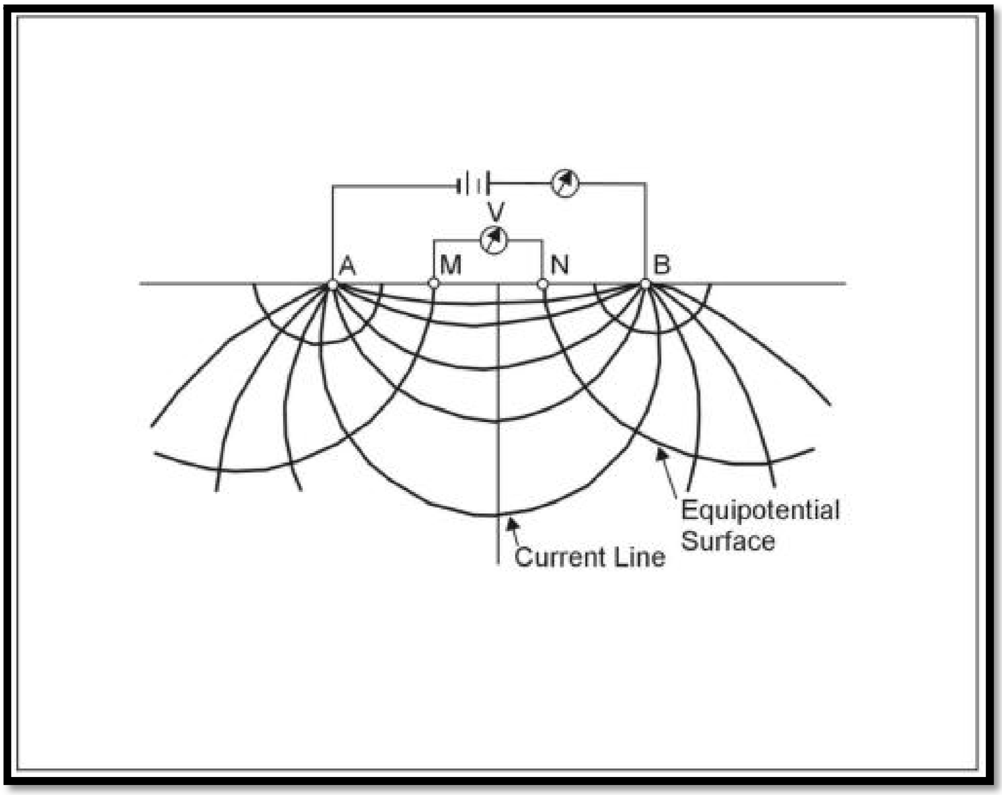

Figure2. Equipotentials and current lines for a pair of current electrodes A and B on a homogeneous half-space

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MATERIALS AND METHODS

2. Methodology and site operation

The resistivity surveys use four equi-spaced electrodes in a standard configuration. A low frequency current is applied across the outer electrodes and the voltage measured across the inner electrodes. Depth probes provide models of vertical variations in ground resistivity using an expanding electrode array offset from a central reference point, (Aboh, 2001).

A and B are current electrodes through which current is supplied into the ground, M and N are two potential electrodes to measure the potential differences between the two electrodes and P is the VES station to be sounded. The apparent resistivity is given by $\rho_a = K(\Delta V/I)$ with K a geometric factor which only depends on electrode spacing. The apparent resistivity is the ratio of the potential obtained in-situ with a specific array and a specific injected current by the potential which will be obtained with the same array and current for an homogeneous and isotropic medium of 1Ωm resistivity (Dobrin, 1976). The apparent resistivity measurements give information about resistivity for a medium whose volume is proportional to the electrode spacing (Koefoed, 1971). Resistivity is affected more by water content and quality than the actual rock material in porous formations. The choice of sounding points was made to cover the adequate areas surrounding the two boreholes at the site so as to achieve the stated objectives. Each point sounded has its azimuth either N-S, E-W, NW-SE or NE-SW (guided by the emplaced structures) also the longitude, latitude and elevation of each VES point was taken so that the profiles can be properly posted on to the survey area.

RESULTS AND DISCUSSION

BOREHOLE A

VES 1, 2 and 3 were sounded near borehole A. The result of the resistivity-depth plot on this VES point was correlated with the borehole log (Table 1). The sounding curve shows a four-layer geoelectric structure. The first layer has a resistivity value of 367ohm-m. This moderately high resistivity could be as a result of the presence of laterites. The second layer with resistivity value of 411ohm-m is interpreted to be a weathered layer though of a lesser degree of weathering. The third and last layers are the fractured and the fresh basement rocks respectively. Results of VES interpretation shows that the depth to the basement at VES01 is 11.24m whereas, that obtained from the borehole log gives 15.70m.

Table 1. **Showing the Correlation of log for borehole A and the interpretation for VES1**

BOREHOLE A (borehole Log)
Topsoil and Laterites (5m depth)
Weathered basement (clay and sand) 12m depth
Partially weathered rock (16m depth)
Fractured basement (23m depth)
Fresh basement (infinite depth)

INTERPRETATION OF VES POINT 1
Topsoil (362Ωm) 2m depth
Weathered basement (201Ωm) 5m depth
Fractured basement (149Ωm) 7m depth
Fresh basement (infinite depth)

Table 2. Showing the interpretations of VES 2&3

INTERPRETATION OF VES2
Topsoil (392Ωm) 3.2m depth
Weathered basement(sand) 296Ωm and 8m depth
Weathered rock (112Ωm) 17m depth
Fractured basement (105Ωm) 33m depth
Fresh basement (infinite depth)
INTERPRETATION OF VES3
Topsoil (338Ωm) 3.5m depth
Weathered basement (194Ωm) 5m depth
Fractured basement (87Ωm) 18m depth
Fresh basement (infinite depth)

BOREHOLE B

VES 4 & 5 was taken close to borehole B. The sounding curves indicate a 4-layer geoelectric structure. This is in fairly good agreement with the borehole log (figure6). The first layers has a resistivity value range of 130ohm-m to 290ohm-m, with a thickness range of 1.3m to 2.6m. This layer constitutes the topsoil and laterites. A high resistivity value range of 578ohm-m to 1713ohm-m underlies the first layers. The borehole log as well as the resistivity ranges shows that this second layer is the weathered (sand) basement. The third layers have resistivity range of 517ohm-m to 1413ohm-m, and it is taken as the weathered basement with a lower degree of weathering. The fourth layer is taken as the fresh basement with infinite depth.

Table 3. Showing the Correlation of log for borehole B and the interpretation of VES4

BOREHOLE B (borehole log)
Topsoil and laterites (6m depth)
Weathered basement (clay and sand) 5m depth
Partially Weathered rock (16m depth)
Fractured basement (26m depth)
Fresh basement (infinite depth)
INTERPRETATION OF VES4
Topsoil and laterites (290Ωm) 1.3m depth
Weathered Sand (578Ωm) 4m depth
Fractured basement (1413Ωm) 6.3m depth
Fresh basement (infinite depth)

Table 4. Showing the interpretations of VES5

INTERPRETATION OF VES5
Topsoil and laterites (130.6Ωm) 2.6m depth
Weathered basement (1713Ωm) 5.5m depth
Fractured basement (516.5Ωm) 11.5m depth
fresh basement (infinite depth)

The Borehole B, where VES 4&5 where sounded, is not functional. Records have it that the borehole failed about 6weeks after drilling and commissioning. From the interpretations of VES 4&5; the thicknesses of the water bearing layers are small, ranging from 2m to 8m, also the depth to basement is small; ranging from 6m to 11m. It can be deduced that the aquifer does not have enough water underground to sustain the borehole. Unlike in the case of Borehole A, where the interpretations of VES Points 1, 2 and 3 showed that the area where Borehole A is sited has large aquifer thickness; ranging from 8m to 18m and large depth to basement; ranging from 7m to 33m which are good criteria for groundwater potential.

N	ρ	h	d	Alt
1	290	1.27	1.27	-1.269
2	578	2.88	4.15	-4.148
3	1413	2.16	6.31	-6.31
4	3821			

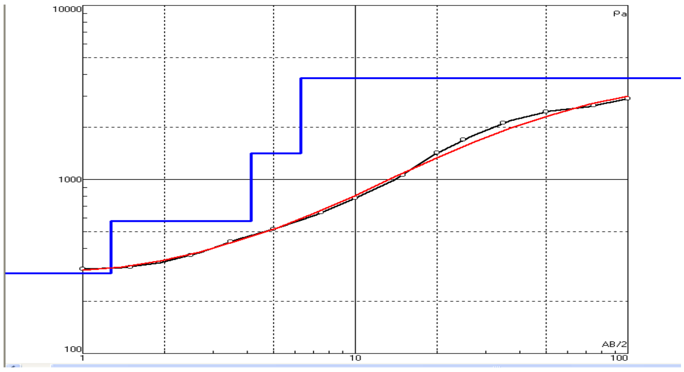

Figure4. Shows the interpretation and Digitized/field curve of VES Point 4

N	ρ	h	d	Alt
1	130.6	2.633	2.633	-2.6325
2	1713	2.856	5.489	-5.489
3	516.5	5.97	11.46	-11.459
4	738.9			

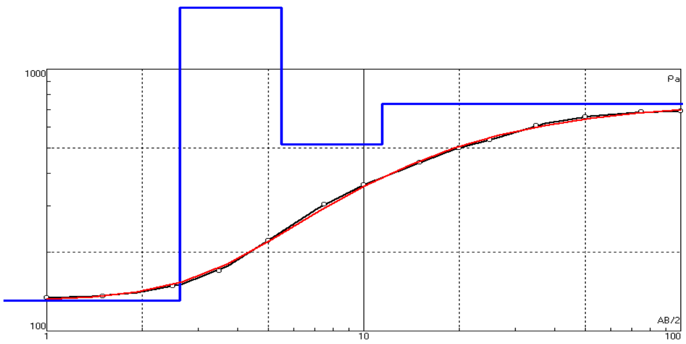

Figure5. Shows the interpretation and Digitized/field curve of VES Point 5

CONCLUSION

The survey area is dominated by mainly four layers, namely: Topsoil, Weathered basement, fractured basement and Fresh basement. The aquifer thickness is made up of the thicknesses of the weathered basement and the fractured basement. At Borehole A, where the interpretations of VES Points 1, 2 and 3 were made showed that the area where Borehole A is sited has large aquifer thickness; ranging from 8m to 18m, and large depth to basement; ranging from 7m to 33m which are good criteria for groundwater potential. The Borehole B, where VES 4&5 where sounded, is not functional. Records have it that the borehole failed about 6weeks after drilling and commissioning. From the interpretations of VES 4&5; The thicknesses of the water bearing layers are small, ranging from 2m to 8m, also the depth to basement is small; ranging from 6m to 11m. It can be deduced that the aquifer at the non-functional borehole does not have enough water underground to sustain the borehole.

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