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GROUNDWATER POTENTIAL, SOUTH CORE UNIVERSITY OF AGRICULTURE COMMUNITY MAKURDI, CENTRAL, NIGERIA

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ABSTRACT

The present study was carryout in Southcore Community University of Agriculture Makurdi to determine the suitability or viability of drilling a borehole for the people in the community.

The Ohmega resistivity meter was employed using Schlumberger electrode configuration. The data generated was interpreted using WinResist software programme after generating the layers using Microsoft excel.

However, the study revealed that the area has four geoelectric layers. The aquifer zone is found on layer three {3}. The Vertical Electrical Sounding {VES 1} indicated four geoelectric layers with the aquifer zone found on layer three {3}. Layer three has a resistivity of 607.9Ωm and a thickness of 33.9m. Also in VES 2 the aquifer zone is found on layer 3 with a resistivity of 71.2Ωm and a thickness of 63.6m. The overburden thickness in the area ranges between 0.5m to approximately 1.0m.

Furthermore, a borehole was drilled in the vicinity of VES 1 at a depth of 50.0m and the lithology description recorded while drilling correlated well with the geoelectric layers. However groundwater development through borehole drilling is possible in the area.

KEYWORDS: Resistivity, Overburden Thickness, Geo-Electric, Lithology and Sedimentary

INTRODUCTION

Water is found everywhere during raining season but getting good drinking water source has always been a problem for the people in this community. It is based on this understanding that geophysical survey using schlumberger method of Vertical Electrical Sounding{VES} was employed to determine the viability of drilling a borehole for the people in this community. Carrying out studies for groundwater exploration is a herculean task that requires professionalism and experience in both data acquisition and interpretation.

Dan Hassan and Ollorunfemi {1999} used electrical resistivity method to delineate different subsurface geoelectrical layers, aquifer unit and their characteristics, the subsurface structure and its influence on the general hydeogeological condition in the North Central part of Kaduna State, Nigeria.

Emenike {2001} carried out a geophysical exploration for groundwater in a sedimentary environment: A case study from Nanka over Nanka Formation in Anambra Basin, South-Eastern Nigeria. In his work, the interpretation of five resistive curves over Nanka formation in Anambra Basin indicates that the area has high level of groundwater potential. A correlation of the curves with the lithologic log from a nearby borehole suggests that the major lithologic units penetrated by the sounding curves are laterite, sandstone and clay. The sandstone unit, which is the aquifer zone, has resistivity range of between 500 and 960 ohm-m and thickness in excess of 200m. The work reveals that the depth to the water table is 100m. The vertical electrical method was chosen for this study because the instrumentation is simple; field logistics are easy and straightforward and the analysis of data is less tedious and economical {Oseji et. al, 2005; Okwueze etal., 1996; Shichter, 1933; Whitely 1973}. The depth to water table can be determined by digging a hole progressively deeper into the ground, the depth at which groundwater begins to seep in to the hole indicates that the surrounding material is saturated with water and this marks the height of the local water {water table} where there is no surface water, {Buddemeier and Schloss, 2000}.

MATERIALS AND METHODS

Location of the Study Area

The study area is located in South Core University of Agriculture Makurdi. It is off Makurdi-Lafia road {figure 1}. The area is bounded by longitude $8^0$25'E and $8^0$50'E and latitude $7^0$40'N and $8^0$10'N on a geology map scale of 1:125000.

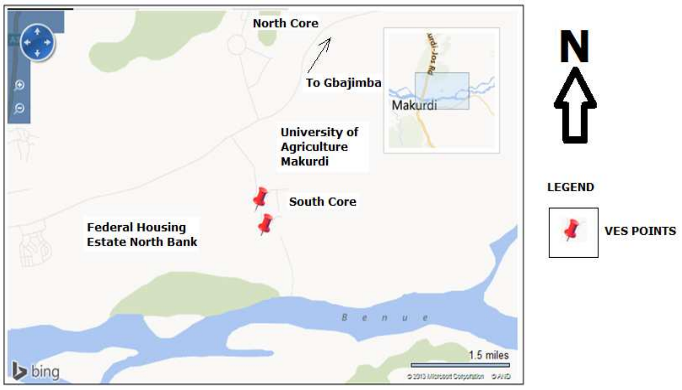

Figure 1: Sketch Map Showing Location of VES Points in the Area

Geology of the Study Area

The area is located within the Middle Benue trough; it falls within a sedimentary basin according to King {1950}, Farrington {1952}, Nwachukwu {1972} and Murat {1970} an. The trough is 80-150m wide and 800km long, NW, SW trending structures considered to have originated as an aulacogen {Hoque and Nwajide, 1984}. The triple junction rift model explains the trough originated as the failed third arm of a rift during the separation of South America from Africa during the cretaceous. Crystalline basement which outcrops in some places in the Middle Benue Trough is characterized by major and minor intrusive {Cratchley and Jones, 1965, Mccurry, 1976}.

Geologically Benue State is underlain by both sedimentary and basement rocks {Jika and Mamma, 2014}. The Asu River group which is Albian in age is unconformably lying on the basement. The Asu River group is succeeded by the Ezeaku Formation which is Turonian in age. Recent alluvial deposits are found along the valleys o the rivers and other low-lying areas. A section of River Benue consist of recent alluvial flood plains deposits that overlie the Turonian Makurdi sandstones. The lithostratigraphy of middle Benue Trough has been described by many writers.

The Asu River group consist of shale, sandstone and limestone {Figure 2}, it is the oldest dated sedimentary rock unit in the Middle Benue Trough {Whiteman, 1982}. Simpson {1955} and Reyment and Barbar {1956} were of the view that the Asu River Group was deposited in a moderately deep water environment during the Albian, with abundant ammonites, foras, radiolarian and pollens. On the other hand the Ezeaku Formation is believed to represent typical shallow water deposit, consisting mainly of hard grey to black shales and siltstones. Facies changes to sandstones and sandy shales are common {Figure 2}. The thickness of this Formation varies and locally may be up to 100m thick. The Ezeaku Formation was deposited in the Turonian transgressive phase but in a shallow marine environment. The fossils in the Formation include vascocerastids, pelecypods, gastropods, echinoids, fish teeth, decapods and plant fragments {Reyment, 1965}.

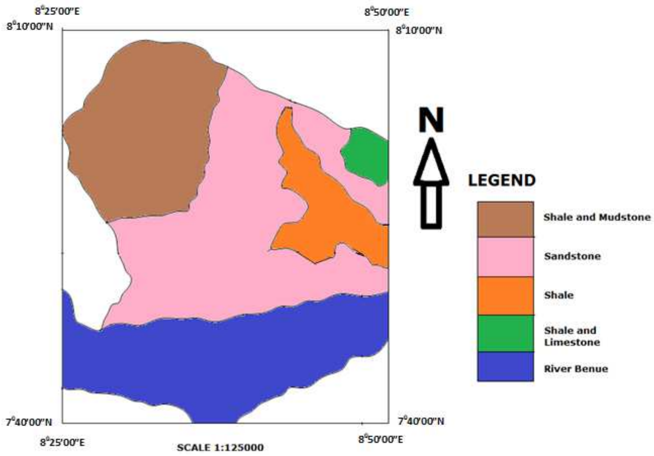

Figure 2: Geology Map of the Study Area from Nigerian Geological Survey Agency Map of Benue State 2004

Theory and Principle of Electrical Resistivity Method

Collecting an electrical resistivity data requires putting an electrical current in to the ground {measured in amperes) and measuring the potential {measured in Volts}. With these two values an apparent resistivity can be calculated. The current supply is a direct current or low frequency alternating current.

In ohms law

$$j = \sigma E \quad (1)$$

Where σ= Conductivity $\{\Omega m\}^{-1}$

E= Electric field $\{Vm^{-1}\}$

J= Current density = $\{A/m^2\}$

Electric field is equal to Laplace of potential

Thus $E = \frac{d}{dr}V$ (2)

But

$$\sigma = \frac{1}{\rho} \quad (3)$$

$$j = \frac{1}{\rho} E = \frac{I}{A}$$

I=current in Amperes {A}; A= Area of a sphere which is given by $4\pi r^2$

Since we are dealing with the earth surface which is half a sphere the area becomes $2\pi r^2$

Thus

$$j = \frac{1}{\rho} \frac{d}{dr} [V] = \frac{I}{2\pi r^2}$$

$$\frac{1}{\rho} \frac{d}{dr} [V] = \frac{I}{2\pi r^2}$$

Solving for change in V

$$dV = \frac{\rho I}{2\pi r^2} dr$$

Taking integral on both sides

$$\int dV = \int \rho I \frac{1}{2\pi r^2} dr$$

Taking boundary condition on the left hand side from 0-V and on the right hand side from 0-r we will have

$$V = \frac{\rho I}{2\pi r} \qquad (4)$$

This equation is for potential a distance r from the electrode

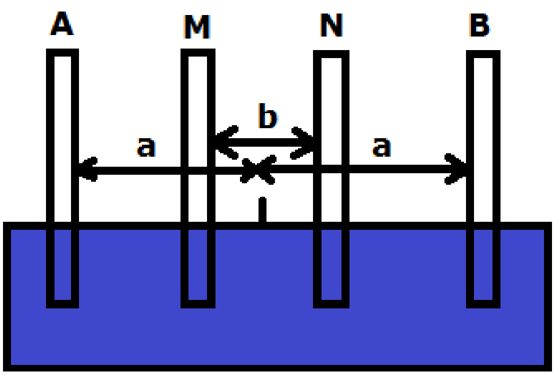

Figure 3: Schlumberger Electrode Configuration

Potential at M is given by

$$V_m = \frac{\rho I}{2\pi} \left[\frac{1}{AM} - \frac{1}{MB} \right] \qquad (5)$$

Potential at N

$$V_m = \frac{\rho I}{2\pi}\left[\frac{1}{AN} - \frac{1}{NB}\right] \quad (6)$$

Resultant potential

$$V = Vm - V_N$$

$$V = \frac{\rho I}{2\pi}\left[\left\{\frac{1}{AM} - \frac{1}{MB}\right\} - \left\{\frac{1}{AN} - \frac{1}{NB}\right\}\right] \quad (7)$$

From figure 3

$$AM = \frac{2a-b}{2} \quad MB = \frac{2a+b}{2}$$

$$AN = \frac{2a+b}{2} \quad NB = \frac{2a-b}{2}$$

Substituting these parameters in equation {7} and solving for ρ

$$\rho = R\pi\left[\frac{a^2}{b} - \frac{b}{4}\right] \quad (8)$$

Where

$$K = \pi\left[\frac{a^2}{b} - \frac{b}{4}\right] \quad (9)$$

K is known as the Geometrical factor for Schlumberger electrode configuration; R is the resistance in ohms measured from the instrument and ρ is the resistivity in Ωm.

RESULTS AND DATA PRESENTATION

The data collected were analyzed using WinResist software programme and the result revealed that there are four geoelectric layers in the area. The area revealed type KH curves Figure 6 and Figure 7. The resistivity curve for both VES 1 and VES 2 revealed four geoelectric layers with their resistivity, thicknesses and depth respectively figure 6 and figure 7. The data collected are presented in table 1 and table 2. The data collected were first plotted on Microsoft Excel with the summation of apparent resistivity versus current electrode spacing figure 4 and figure 5.

The current electrode spacing AB/2{m}, potential electrode spacing MN/2{m} resistance R{Ω}, geometric factor K, apparent resistivity ρ {Ωm} and the summation of apparent resistivity ∑ρ were equally presented in Table 1 and Table 2. The plot of the summation of apparent resistivity versus the current electrode spacing revealed the layers, thicknesses and depth figure 4 and figure 5 these data were further inputted in the WinResist software programme to give figure 6 and figure 7. The data revealed that groundwater development through borehole drilling is possible in the area. The borehole lithology descriptions obtained during drilling were correlated with geoelectric layers figure 8. The water bearing layer in VES 1 from the geoelectric section is layer 3 which have a resistivity of 607.9Ωm and a thickness of

33.9m. In VES 2 the water bearing zone is layer 3 which have a resistivity of 71.2 Ωm and a thickness of 63.6m. The water bearing rock unit is siltstone and the overburden thickness in the area ranges between 0.5-1.0m.

Table 1: Resistivity Data Acquired in Southcore UNIAGRIC Makurdi VES 1

AB/2{m}	MN/2{m}	{K}	R{Ω}	P{Ωm}	∑ρ
1	0.2	7.54	26.80	202	202
1.5	0.2	17.4	5.522	96	298
2	0.2	31	2.063	64	362
2.5	0.2	49	1.021	50	412
3	0.2	70	0.6837	48	460
4	0.2	125	0.4096	51	511
5	0.2	196	0.2983	58	569
6.5	0.2	332	0.1466	49	618
8	0.2	502	0.0757	38	656
10	0.2	785	0.0497	39	695
8	1.5	65	0.5704	37	732
10	1.5	102	0.3772	38	770
13	1.5	175	0.2124	37	807
16	1.5	266	0.1436	38	845
20	1.5	417	0.1102	46	891
25	1.5	652	0.0767	50	941
30	1.5	940	0.0553	52	993
25	5	188.5	0.2700	51	1044
30	5	274.8	0.1942	53	1097
40	5	494.6	0.1203	60	1157
50	5	777.15	0.08334	65	1222
65	5	1318.8	0.05684	75	1297
80	5	2001.75	0.02892	58	1355

Table 2: Resistivity Data Acquired in Southcore UNIAGRIC Makurdi VES 2

AB/2{m}	MN/2{m}	{K}	R{Ω}	P{Ωm}	∑ρ
1	0.2	7.54	94.87	715	715
1.5	0.2	17.4	27.31	475	1190
2	0.2	31	9.427	292	1482
2.5	0.2	49	4.217	207	1689
3	0.2	70	1.810	127	1816
4	0.2	125	0.5623	70	1886
5	0.2	196	0.2629	52	1938
6.5	0.2	332	0.1365	45	1983
8	0.2	502	0.09022	45	2028
10	0.2	785	0.04076	32	2060
8	1.5	65	0.6769	44	2104
10	1.5	102	0.3235	33	2137
13	1.5	175	0.1829	32	2169
16	1.5	266	0.1203	32	2201
20	1.5	417	0.0695	29	2230
25	1.5	652	0.03374	22	2252
30	1.5	940	0.0468	44	2296
25	5	188.5	0.1220	23	2319
30	5	274.8	0.1564	43	2362
40	5	494.6	0.0909	45	2407
50	5	777.15	0.06176	48	2455
65	5	1318.8	0.0326	43	2498
80	5	2001.75	0.0269	54	2552

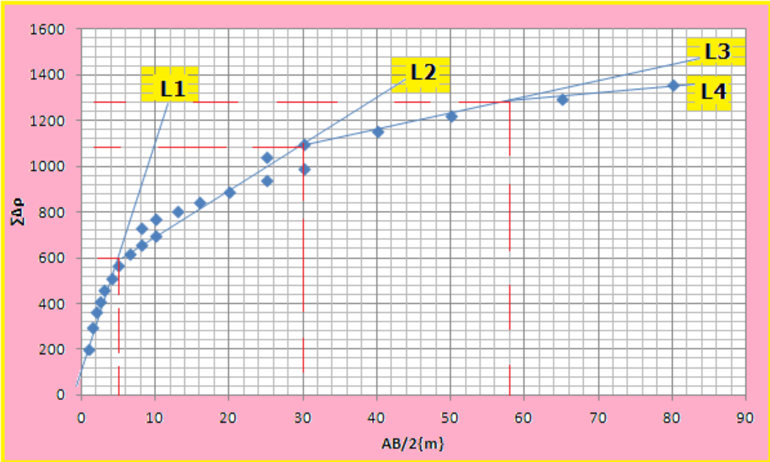

Figure 4: A Plot of Summation of Apparent Resistivity versus Current Electrode Spacing of VES 1

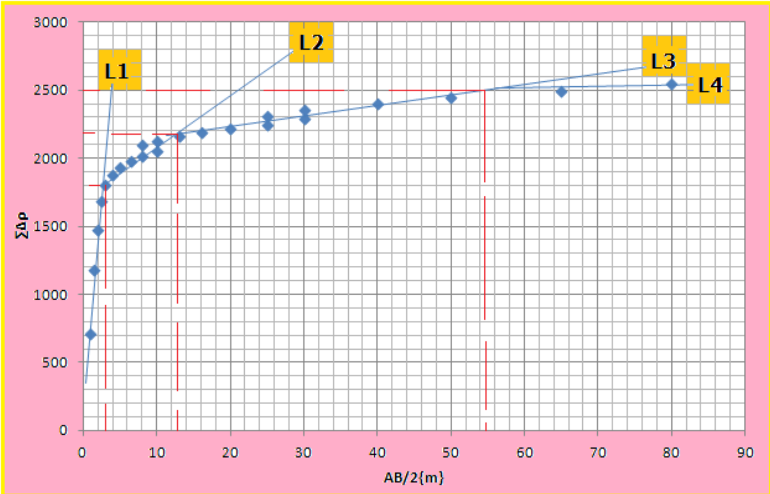

Figure 5: A Plot of Summation of Apparent Resistivity versus Current Electrode Spacing of VES 2

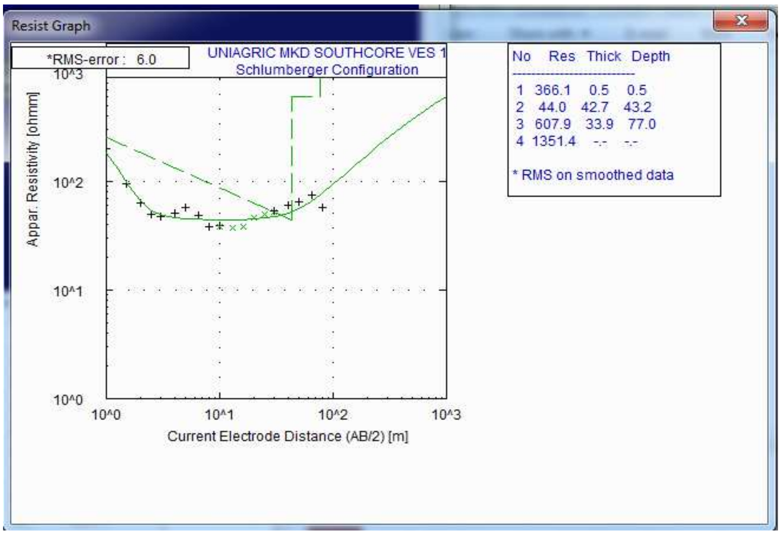

Figure 6: Interpreted VES 1 Curve

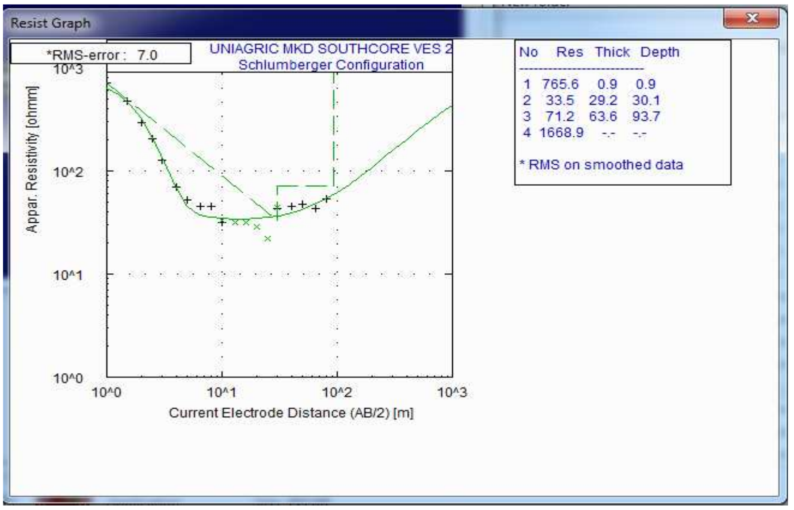

Figure 7: Interpreted VES 2 Curve

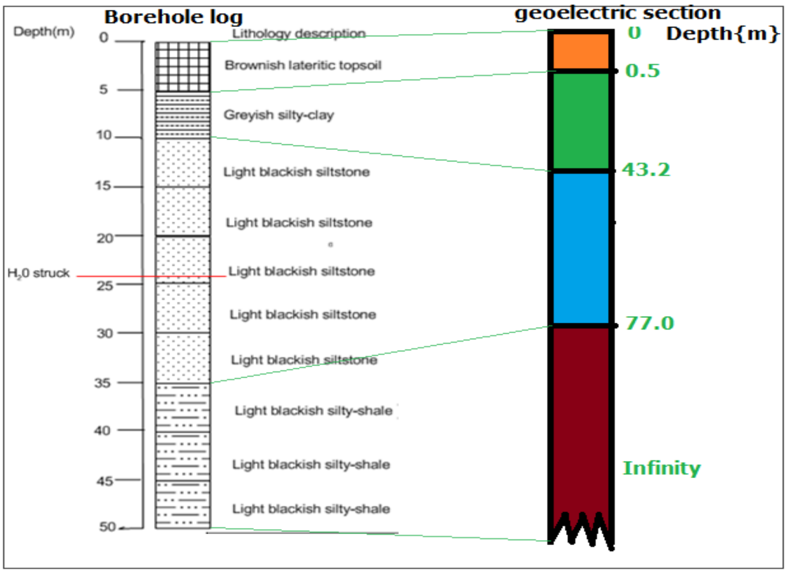

Figure 8: Correlation of Borehole Lithology Description with Geoelectric Layers

CONCLUSIONS

The objective of this research was to determine whether it was possible to drill a borehole for Southcore community University of Agriculture Makurdi. However this study shows clearly that groundwater development through borehole drilling is possible for the people in this community. The study carried out in this community revealed that the aquifer zones are found in layer three from the study. A borehole was drilled in the vicinity of VES 1 to a depth of 50.0m to confirm our result.

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