Geophysical Investigation: a Case Study of Ndiechi in Ohaukwu Local Government Area; Ebonyi State

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***Abstract*: Geophysical site investigation for sitting a viable point for ground water exploration was carried out at Ndiechi in Ohaukwu Local Government Area of Ebonyi State. Electrical resistivity approach as a geophysical method was adopted with Schlumberger configuration for depth or vertical electrical sounding to delineate basement weak zone and lithologic depth respectively. Five points were examined using sounding. The least resistive point was further sounded for better vertical resolution and clarity. The curve type encountered in the study is the KH-curve type, which is a good indicative curve for groundwater exploration. The obtained sounding parameter suitably established the overburden depth of 1.5m.**

***Keywords*: Geophysical Exploration, KH-curve, Resistivity, Schlumberger, current.**

I. INTRODUCTION

Water is an essential natural resource that is not only needed for human existence but also for survival of our environment. An extensive increase in the search for adequate and quality water is as a result of its importance to man and essential need for technology (Agbo, Aluge, Azi and Nnabo, 2013). As a result of unavailability of quality water in some surface areas, many people now rely on the exploration and exploitation of groundwater especially for domestic activities. Exploration for groundwater requires a number of techniques (Wightman et al, 2003; Lawrence *et al*, 2012 and Utom*et al*, 2012). An example is electrical resistivity method. It is an efficient and economical method for determining the presence of groundwater (Arulprakasam *et al*, 2011). Geophysicists have also used it to determine the thickness of bedrock, clay, salt, water intrusion, the vertical extent of certain types of soil and the spread of groundwater contamination (Gabr*et al*, 201; Ani*et al*, 2013 and Ochuko, 2018).

One of the most widely used methods of geoelectric exploration is known as the resistivity method. In this method, current is introduced into the ground by two or more current electrodes, and the potential difference is measured between two points suitably placed with respect to the current electrodes (Aizebeokhai*et al*, 2010).The potentialdifference per unit current sent through the ground is a measure of the electrical resistance of the ground between the probes. The measured resistance is a function of the geometrical configuration of the electrodes and the electrical parameters (Criss and Champion, 1984). There are two types of resistivity measurements; one is geoelectric profiling and the other is geoelectric sounding.

Geoelectric Profiling

In profiling, the electrodes and probes are shifted without changing their relative positions. This gives the idea of the surface variation of resistance values within a certain depth. The depth is related to the current electrode separation. Resistivity profiling with a fixed depth of investigation is mainly used in locating lateral variation and thus is useful in mineral exploration.

Geoelectric Sounding

In sounding, the positions of the electrodes are changed with respect to a fixed point and the measured resistance values at the surface reflect the vertical distribution of resistivity values in a geological section. This method is popularly known as vertical electrical sounding (VES). The principle of VES was established in the 1920s (Gish and Rooney, 1925). Electrical resistivity sounding with a varied depth of penetration is useful in delineating extensive aquifers constituting horizontally stratified earth.

1.1: General Geology and Hydrogeology

a. Regional Geology

On regional broad assessment, the study area falls within the populous South East (SE), Nigeria with two geological terrains: the basement complex (massive rock terrain) and the sedimentary unit (soft rock domain). Massive crystalline rock of the South East/South West, Nigeria includes granitic rocks, gneisses quartzitic rock and mixed gneiss suites while the sedimentary environment which are consolidated include shale, mudstone and sandstones

b. Local Geology

Locally the study area is a typical consolidated sedimentary environment which is majorly underlain by shale suites.

1.2: Aim and Objectives of the Study

The overall aim of the survey is to delineate saturation zones in the area for the purpose of developing an underground hand pump water scheme for community use. Consequently, the following set objectives were borne in mind:

i. To conduct Geophysical survey in the area
ii. To delineate zones of saturation with their thickness and depth.
iii. To design and make recommendations for the drilling of a borehole or other appropriate schemes.

II. MATERIALS AND METHOD OF ANALYSIS

The geophysical prospecting method adopted for this study is the Vertical Electrical Sounding (VES) technique of the electrical resistivity method. The ABEM SAS-1000 terrameter was employed. For adequate depth penetration, the Schlumberger electrode configuration was used with maximum current electrode separation.

2.1: Theory and Principle of Electrical Resistivity

The electrical resistivity method is an active geophysical method. It employs an artificial source which is introduced into the ground through a pair of electrodes. The procedure involves measurement of potential difference between other two electrodes in the vicinity of current flow. Apparent resistivity is calculated by using the potential difference for the interpretation. The electrodes by which current is introduced into the ground are called Current electrodes and electrodes between which the potential difference is measured are called Potential electrodes.

Electrical Resistivity approach was adopted for this research work which was carried out at Ndiechi Ohaukwu, Ebonyi State. To delineate this aquiferous unit, electrical resistivity method of geophysical investigation was adopted using Rectified Resistivity Meter (RRM) MODEL. The theory involves measuring of the earth resistance by sending a fairly large current I (mA) into the earth resistance by recording the response as potential difference (mV). The plotted resistivity values were obtained by using the working relation below.

Wenner array method was first used to soften the ground before the application of Schlumberger.

For a more reliable investigation, Schlumberger configuration was adopted

$$\rho_a = \pi R \left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right]$$

Where ρ_a = apparent resistivity of the subsurface (Ω-m), R = resistance (Ω), AB = distance between current electrodes, MN = distance between potential electrodes. The above method enhanced effective investigation (TelfordW. M *et al*, 1990).

III. RESULT AND INTERPRETATION

The sounding data were processed using manual curve matching, which involves the use of auxiliary curve and master curve. The obtained parameters were fed into the computer using resist program for iteration, to enhance better sub-surface resolution for geo-electric configurations.

The obtained/acquired profiling data were presented and profiling graphs and the sounding result were presented as curve and geo-electric section.

The sounded point 1 revealed up to four geo-electric layers. The topmost layer is the clay topsoil with resistivity value of 952.7Ωm to the depth of about 1.7m. Underlain by this layer is lateritic /unsaturated weathered shale with resistivity value of 705.4Ωm to the depth of about 18.6m indicative of a minor fractured shale. Further probe is the weathered shale (possibly fractured) with sharp decline in resistivity value of 178.9Ωm to the depth of 39.0m indicative of a water bearing zone.

The sounded point 2 revealed approximately five layers. The topmost layer is the mudstone/clay topsoil with resistivity value as high as 868.5Ωm to the lateritic unsaturated shale zone with resistivity value of 1004.9Ωm to the depth of about 18.6m. Beneath this layer is the weathered shale with water bearing capacity and a low resistivity of 160.2Ωm to the boundary depth of 41.7m to a fairly infinite depth. Groundwater potential is predicted at this sounded point.

The sounded point 3 revealed approximately four layers. The topmost layer is the clay topsoil with resistivity value as high as 805.1Ωm to the depth of about 13.3m. Underlain by this layer is the lateritic unsaturated shale zone with resistivity value of 681.8Ωm to the depth of about 31.0m. Beneath this layer is the weathered shale with water bearing capacity at a low resistivity value of 150.3Ωm to the boundary depth of 45.4m to a fairly infinite depth.

The sounded point 4 revealed about five layers. The topmost layer is the mudstone/clay topsoil with resistivity value as high as 950.3Ωm to the depth of about 9.3m. This is followed by lateritic unsaturated shale zone with resistivity value of 1318.5Ωm to the depth of about 18.2m. Beneath this layer is the weathered shale with water bearing capacity at a low resistivity of 121.2Ωm to the boundary depth of 32.2m to a fairly infinite depth. Groundwater potential is predicted at all the sounded points thus, ground water potential is comparatively predicted to be more at point 4 because of sharp resistivity drop and the fundamental curve type.

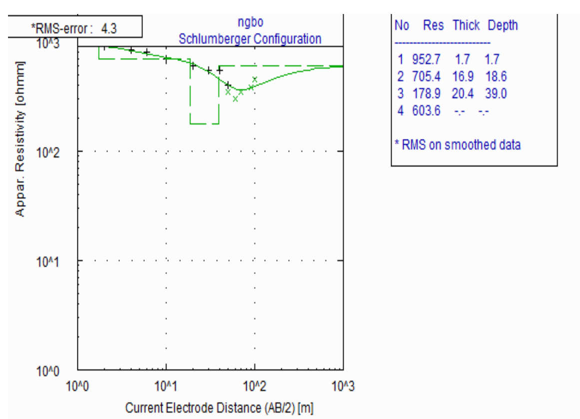

Fig. 1: Point 1; VES curve of Schlumberger configuration at Ndiechi

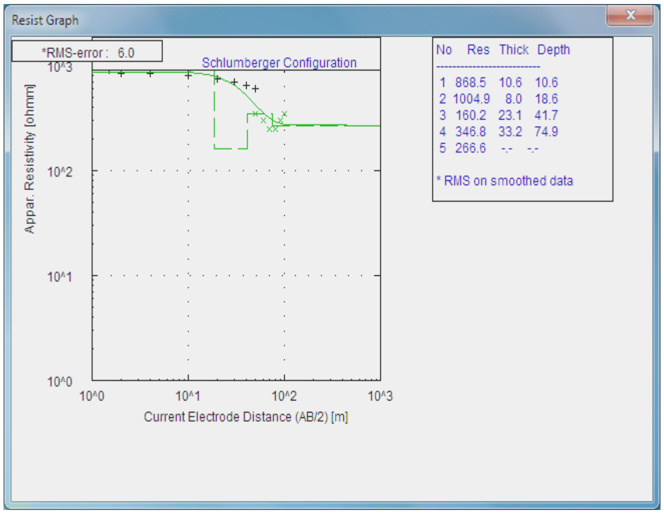

Fig. 2: Point 2; VES curve of Schlumberger configuration at Ndiechi

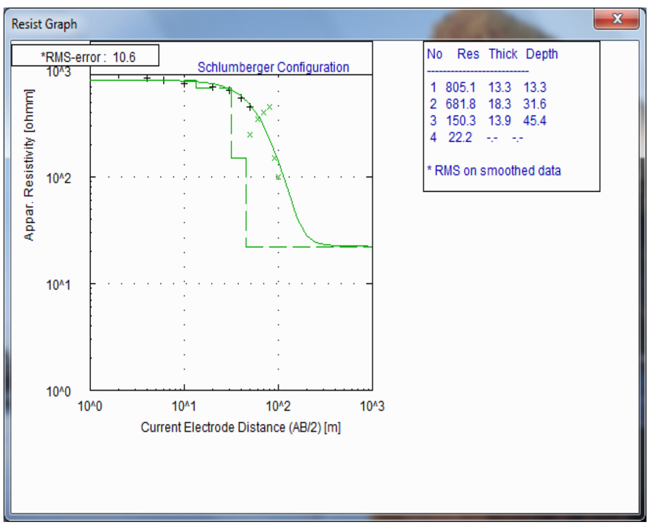

Fig. 3: VES curve of Schlumberger configuration at Ndiechi

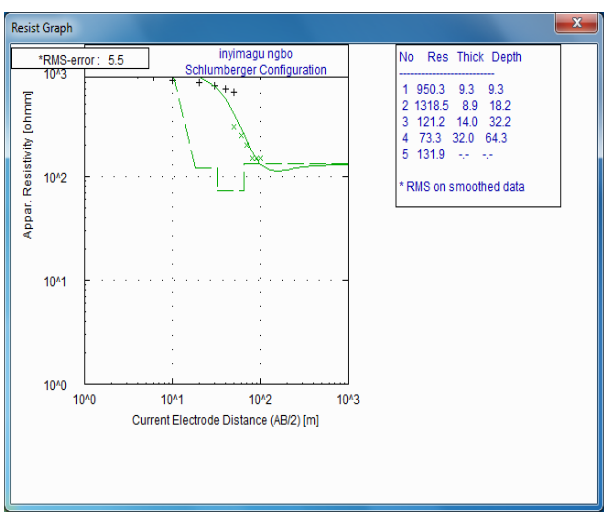

Fig. 4: VES curve of Schlumberger configuration at Ndiechi

IV. CONCLUSION

From the results, it was observed that the profiling chart, iterated geo-electric parameter value suitably established an overburden unit depth of about 1.5m and a total drill dept of 39m.

However, it is predicted that groundwater is potentially available at large quantity within the sounded areas. It is recommendable to access ground water within the study area at a reasonable drill depth. The volume of groundwater here can stand the test of time even during dry season.

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REFERENCES

[1] Agbo, G. A., Aluge, U. D., Azi A. O. and Nnabo .P., (2013). Investigation of Flood Prone Areas in Oferekpe Ikwo Local Government Area, Ebonyi State, using Electrical Resistivity method, *International Journal of Science and Research (IJSR)*,Vol. 4, **2319-7064.**

[2] Aizebeokhai,A.P., Alile, O.M, Kayode, J.S. and Okonkwo, F.C. (2010). Geophysical Investigation of Some Flood Prone Areas in Ota, Southwestern Nigeria, *American-Eurasian Journal of Scientific Research* 5 (4): 216-229.

[3] Ani D. Chinedu1, Arewa J. Ogah (2013). Electrical Resistivity Imaging of Suspected Seepage Channels in an Earthen Dam in Zaria, North-Western Nigeria, *Open Journal of Applied Sciences*, 3, 145-154.

[4] Criss, R.E., and Champion, D.E., 1984, Magnetic properties of granitic rocks from the southern half of the Idaho batholith--Influences of hydrothermal alteration and implications for aeromagnetic interpretation: Journal of Geophysical Research, Vol. 89, no. B8, p. 7061- 7076.

[5] Wightman, W. E., Jalinoos, F., Sirles, P. and Hanna, K. (2003). Application of Geophysical Methods to Highway Related Problems. Federal Highway Administration, Central Federal Lands Highway Division, *Lakewood, CO Publication*, Pp. 04-021.

[6] Lawrence, A.O and Ojo T.A (2012), The use of combined geophysical survey methods for groundwater prospecting in a typical basement complex terrain: case study of Ado-Ekiti southwest Nigeria*Res. J. Eng. Appl. Sci*.362376.

[7] .Utom, A.U, Odoh, B.I. and Okoro, A.U. (2012). Estimation of aquifer transmissivity using Dar Zarrouk parameters derived from surface resistivity measurements: a case history from parts of Enugu town (Nigeria), *J. Water Res.* (5), Pp. 123-137.

[8] Arulprakasam,V, Sivakumar, R and Gowtham, B. (2011). Determination of hydraulic characteristics using electrical resistivity methods: a case study from Vanur watershed, Villupuram District, Tamil Nadu IOSR, *J. Appl. Geol. Geophys*. (14), Pp. 51-63.

[9] Gabr, A., Murad, A., Baker, K H; Bloushi, H. Arman, S Mahmoud, (2012). The use of seismic refraction and electrical techniques to investigate groundwater aquifer, United Arab Emirates (UAE) Conference Proceedings, Water Resources and Wetlands, 14th –16th September, 2014.

[10] Ochuko Anomohanra, (2018). Hydrogeophysical and hydrogeological investigations of groundwater resources in Delta Central, Nigeria, *Journal of Taibah University for Science*, Volume 9, Pp 57-68.

[11] Telford W.M, Geldart L. P, Sheriff R. E. (1990). Applied Geophysics; Cambridge University Press.