SUBSURFACE LITHOLOGY AND AQUIFER DELINEATION USING VERTICAL ELECTRICAL SOUNDING (VES) METHOD IN DORAYI AREA OF KANO STATE, NIGERIA

[1]Idris, A.M., [2]Ahmed, A. L., [2]Lawal, K. M., [2]Osumeje, J.O., and *[3]Ahmed, G.

[1]Department of Science Laboratory Technology, Binyaminu Usman Polytechnic, Hadejia, Jigawa State

[2]Department of Physics, Ahmadu Bello University, Zaria, Nigeria

[3]Department of Chemistry, Sule Lamido University, K/Hausa, Jigawa State

*Corresponding Author: **gaahmed2010@gmail.com**

ABSTRACT

Vertical electrical sounding (VES) method using Schlumberger array was carried out at 10 VES stations in the study area in Gwale Local Government Area of Kano state, Nigeria. Ohmega resistivity meter was used for the data acquisition. The field data obtained was analysed using computer software IPI2win, which gave an automatic interpretation of the apparent resistivity. The results suggested that 4-5 geo-electric layers existed in the area, consisting of topsoil layer, with resistivity that ranged from 15.5 ohm m to 834 ohm m and thickness which varied from 0.75m to 1.35m; weathered layer having a resistivity values ranging from 14.5 ohm m to 420 ohm m and thickness which varied from 2.05 m to 17.7 m and fractured/fresh basement layer with resistivity values which ranged from 96.8 ohm m to 7747 ohm m. The weathered layer serves as an aquiferous zone where it is extensively thick.

Key words: Aquifer, fractured, layer, resistivity, thickness, vertical electrical soundings.

INTRODUCTION

Globally, water is obtainable as either underground or surface water. Water extracted from the ground has three main uses: domestic, agricultural and industrial uses. It is more advantageous as a source of potable water due to the fact that it is usually free from biological and chemical contaminants. It needs little or no purification before it can be used. Underground water has constant temperature and chemical composition. It has far greater storage potential compared to surface water [1].

Underground water has undoubtedly gained increased recognition in many parts of the world today. Water is said to be a requisite resource for livelihood and therefore, its importance cannot be overemphasized. It is however disturbing that this important resource is becoming scarcer.

Worldwide, 1.1 billion people do not have access to safe water [2]. The scarcity of water is more intense in the developing countries where statistics show that 67% of the rural population has no access to safe water supply [3].

Groundwater is the most widespread and highly used water resource. It is of inestimable value to the residents of dry regions, being the only reliable water resource they have. The yearly consumption of groundwater world-wide is estimated to be about 1000 km^3/yr, and the global groundwater recharge is 12,700 km^3/yr [4].

Underground water has been found to be sufficient both in quantity and quality for most rural communities [5]. It was estimated that about 2 billion people in urban and rural communities in the world depend on underground water for daily consumption. The importance of underground water will grow considerably in the future, as it is a safe and qualitatively high drinking water resource. If it is used reasonably and sustainably, it can make important contribution in solving regional water crises.

With the increasing population explosion, industrialization and agricultural growth, the demand on potable water supply has increased beyond human perception [6]. In many developing countries, availability of potable water has become a critical and urgent problem and it is a matter of great concern to urban and rural communities.

About 80 % of all diseases in Kano are caused by unsafe water and poor sanitation. Water resources in Kano play a central role in the promotion of living standards, enhancing economic growth, provision of food security and livelihood, and alleviation of poverty. As in most parts of the world, Nigeria is experiencing population growth and associated demand on food production. Therefore increases in demand for water produce stress on available water resources. Since underground water cannot be easily located, a variety of scientific techniques are needed to provide information concerning its occurrence and location, hence this study.

EXPERIMENTAL

Study area

This study was conducted at Gwale Local Government Area of Kano State. It is located between longitude 11^0 56′40″ to 11^0 58′20″N and latitude 8^0 26′ 40″E to $8^0$28′20″E.

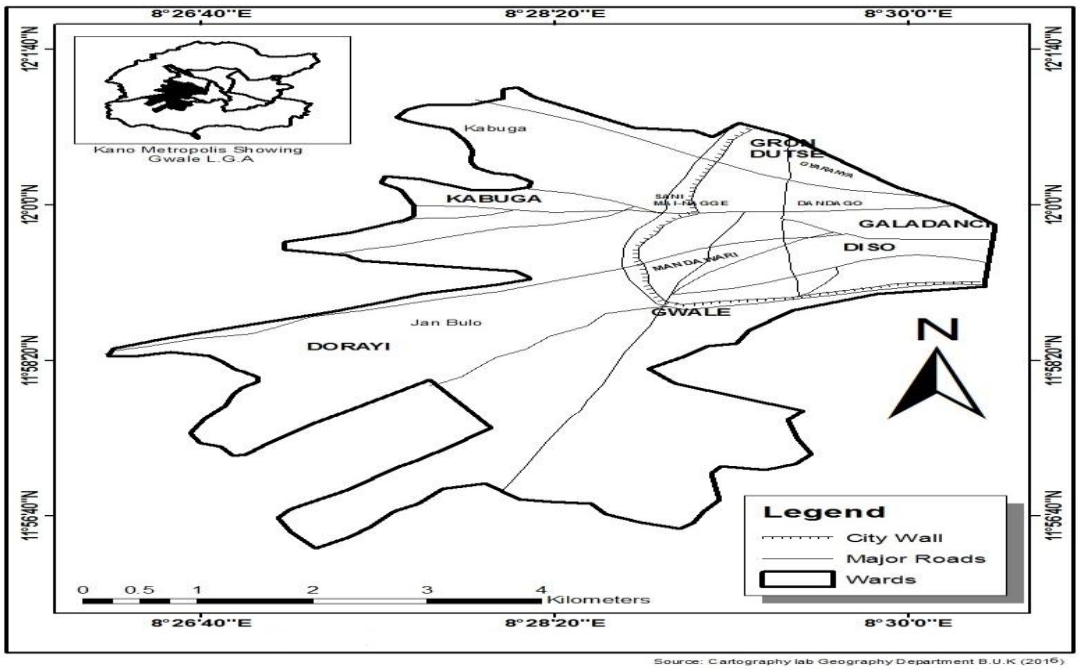


Figure 1: Map of Gwale showing the study area

The occurrence of rocks of the Younger Granites series was reported the in the study area [7-8]. They are so termed because they are Jurassic in age as well as volcanic, and occasionally of younger dykes and ridges. Kano Agricultural and Rural Development Authority identified the individual members of the Older Granite suite, but rocks of the Younger Metasediments and those of the migmatite-gneiss complex were simply grouped as the migmatite- gneiss complex in some places [9].

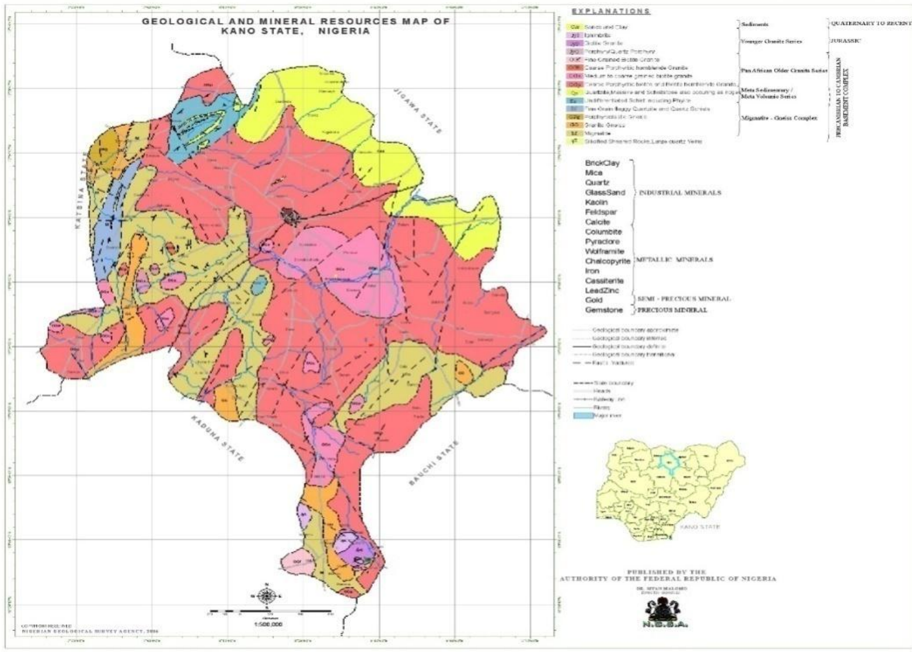


Figure 2: Geological Map of Kano State

A VES of electrical resistivity method was carried out using Ohmega resistivity meter with Schlumberger configuration. VES principle is based on the fact that sub-strata is a resistor to the flow of electric current and that any sub-surface variation in conductivity will alter the current which affects the electrical resistivity of overburden and bedrock varies considerably in relation to moisture content. Electric current is passed into the ground between two outer electrodes while the resultant potential difference is measured by two inner electrodes. The electric field produced is measured by the instrument in the form of Resistance which when multiplied by a constant (k) gives the apparent resistivity value. The electrode spacing was progressively increased keeping the centre point of the electrode array fixed. The maximum half current electrode separation (AB⁄2) was between 1 and 100m while the half- potential electrode separation (MN⁄2) was maintained between 0.5 and 10m. The apparent resistivity measured at each point was plotted on a log-log paper. The plots gave a rough idea of position and forms of the interface. A total of 10 VES points were collected. The interpretation of the field data was done quantitatively using IPI2WIN software to identify thickness and resistivity of different layers.

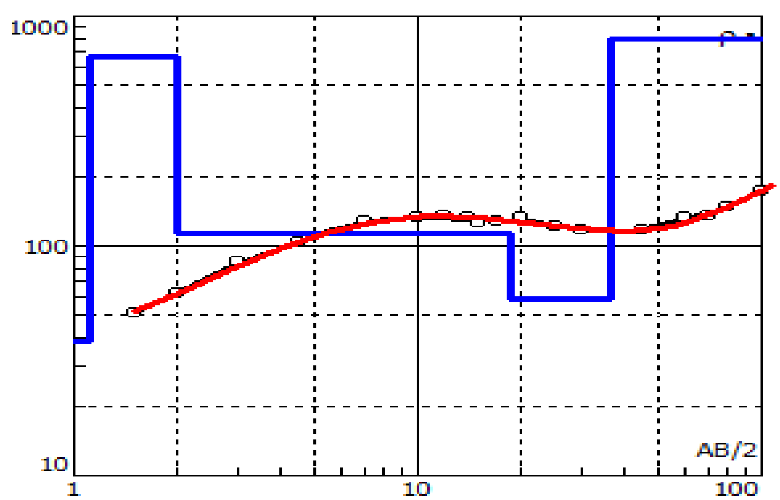
RESULTS AND DISCUSSIONS

Vertical electrical soundings, randomly distributed, were conducted in the study area. VES location point 1 is KQ curve type as shown below, characterized by $\rho_1 < \rho_2 > \rho_3 > \rho_4$. Table 1 displayed VES 1 result and interpretation with the top soil having 38.3Ωm as the resistivity value and thickness of 1.11m, the second layer has a resistivity value of 667Ωm with a thickness of 0.87m, the third layer has a resistivity value of 114Ωm with a thickness of 16.6m at the depth of 1.86m, the fourth layer has a resistivity value of 58.7Ωm which could be referred to as the aquiferous layer with thickness of 17.7m and the 5th layer represents the fresh basement with resistivity value of 794Ωm having infinite thickness.

Table 1: VES 1 result and interpretation

Layer number (N)	Resistivity, **ρ** (Ωm)	Thickness, **h** (m)	Depth, **d**(m)	Inferred lithology
1	38.3	1.11	1.11	Lateritic sand
2	667	0.87	1.99	Sandy clay
3	114	16.6	1.86	Highly decompose granitic rock
4	58.7	17.7	36.3	Weathered basement
5	794			Fresh bedrock

Apparent resistivity (Ωm)

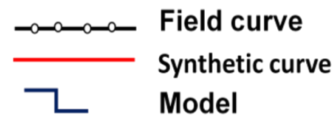


Electrode spacing AB/2

Figure 3: Computer iterated curved of VES 1

Where; **N** is the layer number,

ρ is the layer resistivity in (Ωm)
h is the layer thickness in metres and
d is interface depth in metres.

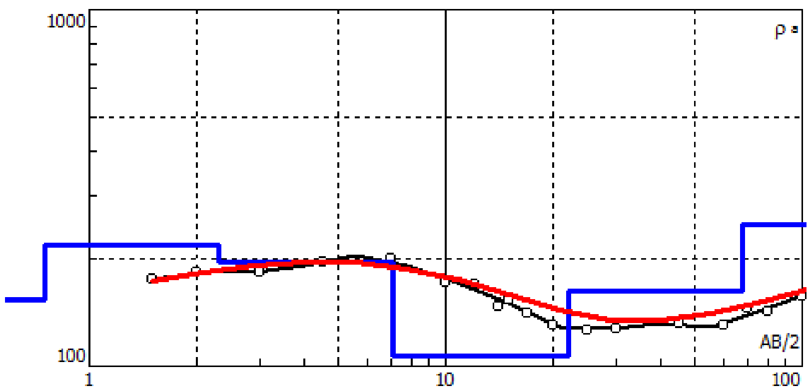


VES location points 7 is KQQ curve type as shown in figure below, characterized by $\rho_1<\rho_2>\rho_3>\rho_4>\rho_5$, table 3 displayed VES 7 result and interpretation. The first layer having a resistivity value of 154Ωm and a thickness of 0.75m shows the top soil, the second layer has a resistivity value of 219Ωm with a thickness of 1.56m at a depth of 2.31m and is considered as sandy clay, the third layer is clayey sand with a resistivity value of 195Ωm and a thickness of 4.83m and the fourth layer is highly decomposed granitic rock with a resistivity value of 107Ωm with a thickness 14.9m and fifth layer is the weathered basement with resistivity value 88Ωm and thickness of 46m and the 6th layer represents the fresh basement rock with infinite thickness.

Table 2: VES 7 result and interpretation

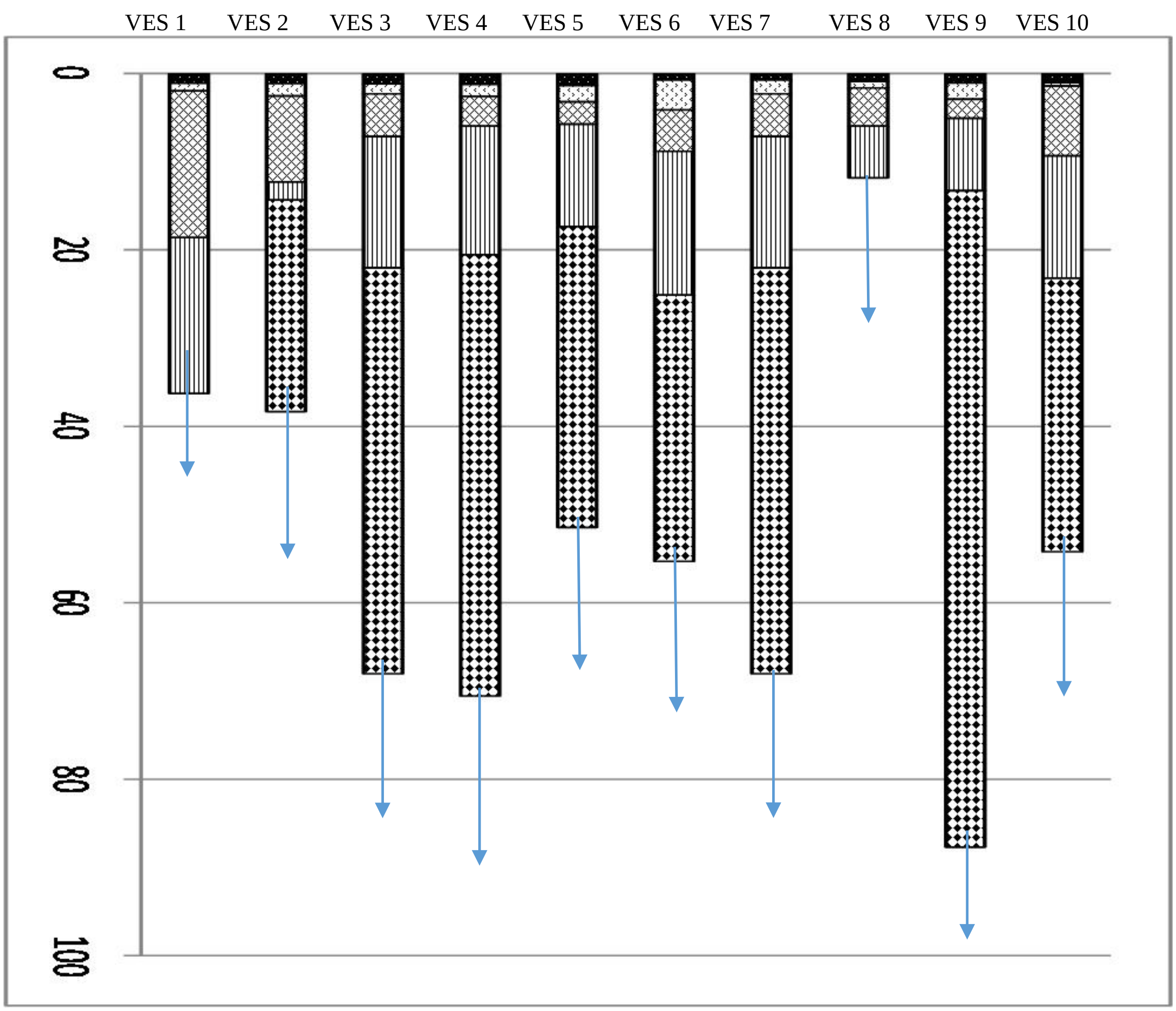
Layer number	Resistivity (Ωm)	Thickness (m)	Depth (m)	Inferred lithology
1	154	0.75	0.75	Lateritic sand
2	219	1.56	2.31	Sandy clay
3	195	4.83	7.14	Clayey sand
4	107	14.9	22	Highly decomposed
5	88	46	68	Weathered basement
6	249			Fresh bedrock

Apparent resistivity (Ωm)



Electrode spacing AB/2

Figure 4: computer iterated curved of VES 7



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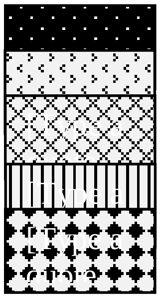

Top soil

Sandy clay

Highly decomposed granitic rock

Weathered basement

Fresh bedrock

CONCLUSION

The aim of Vertical electrical sounding is to determine the different geo-electric layers in the subsurface, the aquifer units and their characteristics, as well as general hydro-geological condition. Three layered-type curves were obtained from the VES points in the study area. They have varying geologic characteristics, showing different degree of weathering and other second porosity in form of fracturing of the bedrock. Plots of some calculated apparent resistivity in ohm-m against electrode spacing in m were presented. These layers were grouped as follows: - first layer - top soil lateritic sand or laterite, second layer – sandy clay or clayey sand or clay, third layer – highly decomposed granitic rock , fouth layer – Weathered basement and the fifth layer- Bedrock.

REFERENCES

1. Ademilua, O. L. & Talabi, A. O. (2012). The Use of Combined Geophysical Survey Methods for Groundwater Prospecting: In a Typical Basement Complex Terrain; Case Study of Ado – Ekiti, Southwest, Nigeria. *Research Journal in Engineering and Applied Sciences*, 1, 362-376.
2. WHO/UNICEF (2000). Global Water Supply and Sanitation Assessment Report, Joint Monitoring Programme for Water Supply and Sanitation (JMP), Geneva.
3. Rosen, S. & Vincent, J. R. (1999). Household Water Resources and Rural Productivity in Sub- Saharan Africa: A Review of the Evidence. Development Discussion Paper No. 673, Harvard Institute for International Development, Harvard University.
4. Mygatt, E. (2006). Eco-Economy Indicators-Water Resources. http://www.earth-policy.org/index.php?/indicators/C57/. Accessed on November, 2017.

5. McCurry, P. (1989). A general review of the geology of the Precambrian to Lower Palaeozoic rocks of northern Nigeria, In: Kogbe, C. A. (Eds.), *Geology of Nigeria*. Rock View Limited, Nigeria.
6. Ariyo S. O. & Adeyemi, G. O., (2009). Role of Electrical Resistivity Method for Groundwater Exploration in Hard Rock Areas: A Case Study from Fidiwo/Ajebo Areas of Southwestern Nigeria, *Pacific Journal of Science and Technology*, 1(10), 483-486.
7. Falconer, J. D. (1911). *The geology and geography of Northern Nigeria*, MacMillan, London.
8. Hazell, J. R. T., Cratchley, C. R. & Preston, A. M. (1988). The Location of aquifers in crystalline rocks and alluvium in Northern Nigeria using combined electromagnetic and resistivity techniques. Q. *Journal of Engineering and Geology*, 21,159- 175.
9. Kano State Agricultural and Rural Development Authority (KNARDA) (1989). Rural water supply project, Vol. II, Summary of Hydro-geological Data. Final Report, WARDROP Engineering Inc. 24 p. plus Appendices.