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Lithostratigrahy of Nigeria An Overview

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ABSTRACT

Nigeria lies very close to the equator on the west coast Africa between latitude 4-14° N and longitude 2-15° E. The country is located at the northern end of the eastern branch of the African rift system. Geologically, Nigeria is comprised of sedimentary formations and crystalline basement complex, which occur more or less in equal proportion all over the country. The sediment is mainly Upper Cretaceous to recent in age while the basement complex rocks are thought to be Precambrian. The studied area lies between latitude 12.4-11.11°N and longitude 13.81-14.13° S. The studied area is underlain by Precambrian basement complex of southern western Nigeria. The major rock in the area is charnokite and granite rock. The granite rocks which are members of the older granite suite occupy about 65% of the total area of Akure. Three principal petrographic varieties are recognized, the fine-grained biotite granite, the medium to coarse-grained non-porphyritic biotite-hornblende granite, and the coarse-grained porphyritic biotite-hornblade granite. Also three main textural type of Charnokitic rock are also distinguished including coarse grained, massive fine grained and gneissic fine grained. The charnokitic rocks appear to have three modes of occurrence in the area, (1) the first occurrence is within what seems to be the 'core' of the granite rock as exemplified by Akure body and few smaller bodies. (2) The second is along the margins of the granite bodies as seem in Ijare and Uro Edemo-Idemo charnokitic bodies. (3) The last mode of occurrence is represented by the discrete bodies of the gneissic fine-grained charnokitic rocks within the country gneisses as seen in Ilara and also near Iju and Emirin villages. All the Charnokite in the region are dark-greenish to greenish-gray rocks with bluish quartz and greenish feldspar.

1. INTRODUCTION

Water is known to be a universal solvent. It is also one of the natural resources tapped by man, animals and plants to meet their needs for life sustenance.

The world's water resources include the entire range of natural waters on earth, either in vapour, liquid or solid form. Water is classified as surface water or groundwater. Surface water include rain water collected into rivers, lakes, reservoirs and oceans while groundwater include natural springs, well and boreholes.

Groundwater is commonly understood as water occupying the voids within a geologic stratum, groundwater is free from suspended matter and bacteria. It can be said to be pure, clear and colourless. Groundwater has greater quality than surface water.

About 495,000 children die annually of various diseases due to drinking of water that is not properly sanitized (sea, stream etc.). Most people generally require about 2.5 litres of water everyday for direct consumption. The average amount of water used domestically each day by every person is about 190 litres (Hamill and Bell, 1986).

Generally, industries require approximately one quarter to one third of the public water supply under normal conditions. The easiest and most convenient way to meet the public demand for water is to utilize surface water resources, but unfortunately, waters such as rivers, lakes, and streams are less plentiful than might be expected. It can be recorded that surface water resources account for less than 2 percent of the world's fresh water.

The latter fresh water available however is unevenly distributed while the sources that are available have been either contaminated or polluted. (Hamill and Bell, 1986). Groundwater accounts for about 98 percent of the world's usable fresh water supply and is fairly evenly distributed throughout the world. It provides a reasonably constant supply which is not completely susceptible to drying up under natural conditions like surface water (World water balance and water resources of the earth UNECO Copyright 1978).

All over the globe, groundwater has been a very good and important source of water. It has continuously been used in irrigation industries and urban centers, as well as in rural communities. It is conveniently available at point of use and possesses excellent quality that requires little or no treatment in most cases.

2. OCCURRENCE OF GROUNDWATER

The ultimate destination of rainwater is the sea, which is reached either directly through run off or indirectly via infiltration and subsurface flow. The water cycle involves movement in the atmosphere, rainfall, dew, hailstones or snowfalls, which occur over land and result in run off. Water also moves vertically and horizontally underground through infiltration to the subsurface. The continuous movement of all forms of water is the hydrogeology cycle.

In the atmosphere, water vapour condenses and may give rise to precipitation. However, not all this precipitation will reach the ground surface; some is intercepted by vegetation cover or building surfaces and then evaporates back into the atmosphere.

The precipitation that reaches the ground surface may flow into a stream, lake, or ocean, where it will either be evaporated or seep into the ground. Likewise, soil moisture may further percolate downward to the underlying aquifer where it may be held for several years longer.

Groundwater in Nigeria is restricted by the fact that more than half of the country is underlain by crystalline basement rock of Precambrian era. The main rock types in this geological terrain include igneous and metamorphic rocks such as migmatites and granitic gneisses.

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Generally in their unaltered form, these rocks are characterized by low porosity and permeability. Porosity in basement rocks is by induction through weathering while secondary permeability is induced by tectonic activities which manifest in the form of fractures that often act as conduits facilitating water movement.

In other words, the aquifer zones in the basement terrain include fractured/weathered rocks. The yielding capacity of a well drilled within such rock is always very enormous.

2.1 Research Methodology

I. Literature Review: All available geological/hydrological information were collected through the reading of journal, reference seminar paper (Olorunfemi M.O., 1990)
II. Data Gathering: All vertical electrical sounding data were collected from water section of the Federal Ministry of Agriculture and Water Resources Abuja, Wenner array was used in collecting the data.
III. Data Analysis: The data were interpreted by using partial curve matching technique. A computer was then used to interpret the results. From the results obtained geoelectric sections were generated.
IV. Interpretation of Results: Results obtained from each VES station were completed and interpreted in order to determine the best location for groundwater development in the study.

2.1.1Geology of the Study Area

Akure south Local Government falls within the basement complex region of Nigeria. The studied area lies between latitude 12.04-11.11 o E and longitude 13.81-14.13 o N and is underlain by precambian basement complex rocks of South Western Nigeria.

Several parts of Africa are underlain by crystalline basement complex rocks. The major types of rocks in Akure are granite rocks and charnokite.

The granite rocks which are members of the older granite suite occupy about 65% of the total area of Akure. Three principal petrographic varieties are recognized, the fine-grained biotite granite, the medium to coarse-grained non-porphyritic biotite-hornblende granite, and the coarse-grained porphyritic biotite-hornblade granite.

Rock classification is based largely on the textural characteristics. Also, three main textural types of charnokitic rocks are distinguished in Akure including: the coarse-grained variety, the massive fine-grained, and the gneissic fine-grained type. Unlike most of the older granite, the charnokite rocks do not occur in smooth rounded boulders, rather only a few low hills were formed with oval to sub-circular elongated shapes.

The charnokitic rocks appear to have three modes of occurrence in the area, the first occurrence is within what seems to be the 'core' of the granite rock as exemplified by Akure body and few smaller bodies. The second is along the margins of the granite bodies as seem in Ijare and Uro Edemo-Idemo charnokitic bodies. The first two modes of occurrence are mainly shown by the coarse-grained charnokitic variety. The last mode of occurrence is represented by the discrete bodies of the gneissic fine-grained charnokitic rocks within the country gneisses as seen in Ilara and also near Iju and Emirin villages.

All the charnokitic in the region are dark-greenish to greenish-gray rocks with bluish quartz and greenish feldspars (V. O. Olarewaju, 1997).

2.1.2 Hydrogeology of the Study Area

The major river in the town of Akure in Ondo State is the Ero River, which originates from Igbara Oke road, about 16-18 km away from the town of Akure.

Osun River is the major source of water in the town of Akure; there are other smaller rivers such as Owuruwu River which is about 60m away from Apex Nursery and Primary School, Oba Adesida, which is the Ves location. This river flows to meet Osun River at Akure road, the other rivers such as Otenre River, Omi Atamo, are smaller rivers that serve as runoff in the town; they meet Osun River at a point known as Osun Amon. Osun River flows from east to west across the town and then flows to Ise town to meet a bigger river called Ogbese in Ondo State.

2.2Result and Discussion

Field resistivity data are in terms of resistivities and depth to the bedrock. The bedrock interface has a strong electrical signal.

The analysis and interpretation of the surveyed data shows four geoelectric layers. The first layer is top soil, which consists of the various soil types from clayey sand to sandy clay to compact sand.

The second layer is the fresh, highly resistive basement. The fresh basement is characterized by high and infinite resistivity values, which could not be accounted for by groundwater. The third and fourth layers are the weathered zone and fractured basement, respectively, which have lower resistivity values and constitute good water zones.

2.2.1.Geoelectric Section

The quantitative interpretation of the VES data resulted in the production of numbers of geoelectric section. The section provides composite information along lithologic depth, the geoelectric section revealed four subsurface geoelectric layers.

The top layer, which consists of clayey sand and sandy clay, has resistivity values ranging from 700 hm-m to 5800 hm-m, the maximum layer thickness is 3.0m. The top soil contributes to the development of groundwater, this layer is called the layer of aeration, and the water in this deposit. Rather, it is part of a layer called the sub-surface water or zone of aeration. This zone is subdivided into three parts namely: soil water, intermediate belt, and capillary belt.

Water infiltrates into the soil from precipitation and in general constitutes all water present in the sub soil or lithosphere. The water may be evaporated from the soil, absorbed by plant roots and then transpired (soil water) or may percolate downward to the groundwater reservoir (intermediate). Water may also occur in a zone extending from the ground surface to the lower limit of porous water bearing rock formation (capillary) and is designated zone of the rock fracture.

The difference in compaction of the clayey sand is responsible for the variation in the resistivity values.

The resistivity of the second layer (weathered zone) ranges from 30o hm-m to 193o hm-m while the thickness varies between 3m to 15.0m2. The third layer is the fractured basement which has a layer thickness varying from 17.5m – 29m with resistivity values ranging between 90o hms-m to 240o hms-m. The layer will be good for groundwater accommodation if the fractures are interconnected and permeable.

The fresh basement, which is the fourth layer, is characterized by high resistivity values up to 6650o hm-m. The fresh basement is made up of infinitely resistive rock in all the stations which form the bedrock. The rock in this zone is hard, with no permeability and no water bearing potential. In fresh, non-fractured rock, the porosity is often less than 2%, as a result, run off is high and infiltration rate is very low in this zone.

The geoelectric section also shows that the depth to the bedrock varies across the sounding station.

2.2.2.Overburden Layer

The thickness of the overburden is an important hydrogeologic consideration in groundwater development in the basement terrain (Ajayi & Hassan 1990, Olorunfemi & Idonigie, 1992) because water gets into the saturated zone through the overburden. The thickness of the overburden ranges from 23.30m to 36.60m in the study area, and varies in composition.

2.2.3.Weathered Layer.

The weathered zone thickness shows the thickness of the weathered layer in all the sounding stations established across the study area, with VES 5 having the greatest of thickness of about 13m and VES 1 having the lowest thickness of about 2m. The weathered layer here is sufficiently thick for groundwater accumulation and therefore would be a recommended location for a borehole.

Variation in the weathered layer is due to the different degrees of weathering.

2.2.4.Fractured Layer

The weathered layer thickness shows the thickness of the fractured layer beneath it in all the sounding stations established across the study area, with VES 1 having the greastest thickness of about 15m and VES 2 having the smallest thickness of about 1.80m and the variation of this layer is due to the degree of fracturing.

VES 5 and VES 1 are locations that will be recommended for groundwater because they have the greatest thickness of both the weathered and fractured zones, which are good for groundwater accumulation.

VES 5 is recommended as a priority location for a borehole, because it has the thickest sequence of both weathered and fractured zones, which are good for groundwater accumulation. If the fractures are interconnected and hence permeable, the thickness of the weathered zone in this section suggests an advantage in this section over others.

The location will be good for optimum groundwater development, because of its availability in the study area; it will also be the only safe source of untreated water in Akure and also the cheapest source of good quality water supply. Its development can proceed in small increments rather than a relatively large scale financial investment which would be expected in the case of dams.

VES 5 has an advantage over VES 1, because the cost of drilling through VES 5 (weathered zone) will be cheaper and easier than drilling through the harder rock that would be necessary to develop VES 1.

VES 1: This location will be good for groundwater development if the fractures in this zone are interconnected and have permeability. The problem with this section is that the fractured basement rock is hard and difficult to drill through, which may result in damages drill bits.

VES 2: In this location, groundwater yield could be high, but would not be comparable to the likely yield of VES 1 and VES 5. VES2 cannot be recommended for groundwater because the dip of the location and also the thickness of the area could result in poor yield.

VES 4 will produce minimum groundwater yield, because of its dip and small thickness of weathered zone, which ranges from 1.70m to 7.0m.

VES 3: This location has the smallest thickness and the lowest probability of groundwater yield. This is not recommended because of the small thickness and dip as seen in the geoelectric section.

CONCLUSION

This paper is the result of a quantitative interpretation of VES data obtained in a geophysical survey over part of Akure, on a location opposite Apex Nursery and Primary School, Oba Adesida Road, Akure in Ondo State.

The interpreted results obtained from the study area are represented by a geoelectric section which shows the sequence and relationships between the subsurface lithologies.

The weathered layer and the fractured zone have been identified as aquiferous in this area. The weathered layer is thickest in VES 5 and lowest in VES 1, while the fracture basement is thickest in VES 1. These two VES stations have been identified as the most suitable locations for groundwater development in the area, with VES 5 being the best overall.

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Table 1: Summary of Layer Thickness of Resistivities.

Town	Location	VES No	Curve Type
AKURE	AKURE, 11, Opposite Apex Nursery and Primary School, Oba Adesida Road, Akure.	1	HA
		2	HA
		3	H
		4	H
		5	HA

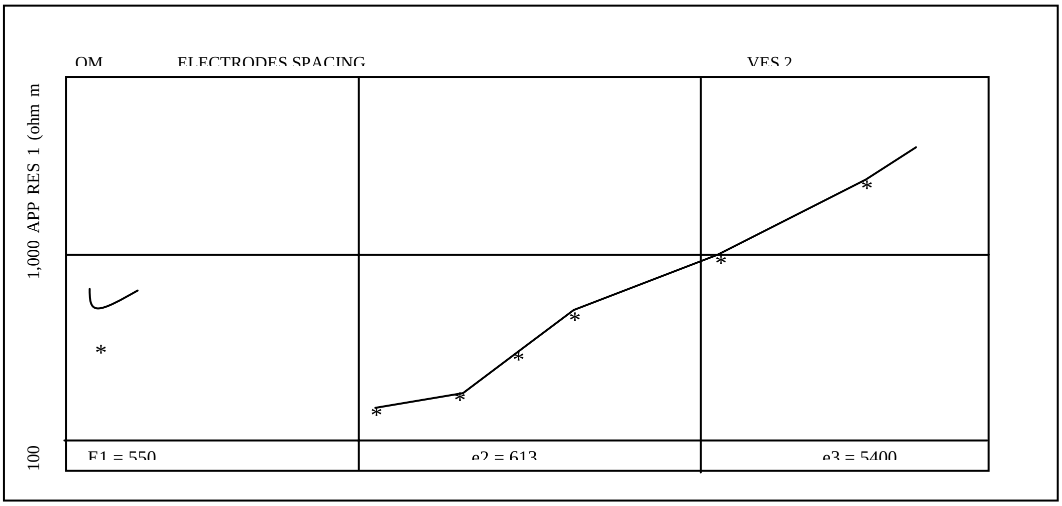
VES Num ber	Thickness			Resistivities (Ohms-m)				Overburd ened Thickness -EH(M)
L	h1	h2	h3	e1	e2	e3	e4	
1	1.20	2.98	19.08	580	193	613	5400	23.76
2	3.00	8.30	11.10	500	167	2470	6650	22.40
3	1.70	2.55	-	265	80	2565	-	4.25
4	1.15	6.70	-	170	30		-	7.85
5	1.80	14.5 8	19.58	570	63	594	2660	36.66

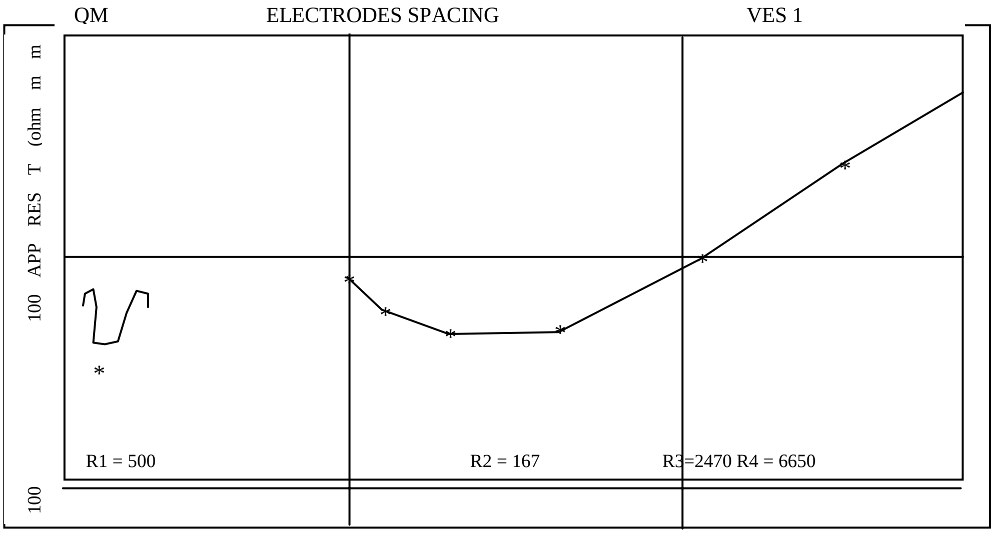
Table 2: Resistivity in Sounding Station.

VES Station	Thickness of 1st Layer (m)	Thickness of 1st Layer (m)	Thickness of 1st Layer (m)	Depth of Bedrock (m) Overburden Thickness	Weathered Layer Thickness (m)	Resistivity of the Weathered Layer (ohm-m)
1	1.70	2.98	19.08	23.70	19.08	613
2	3.00	8.30	11.10	22.40	11.10	247
3	1.70	2.55	-	4.25	2.55	86
4	1.15	6.70	-	7.85	6.70	30
5	1.80	14.58	19.00	35.38	19.00	594

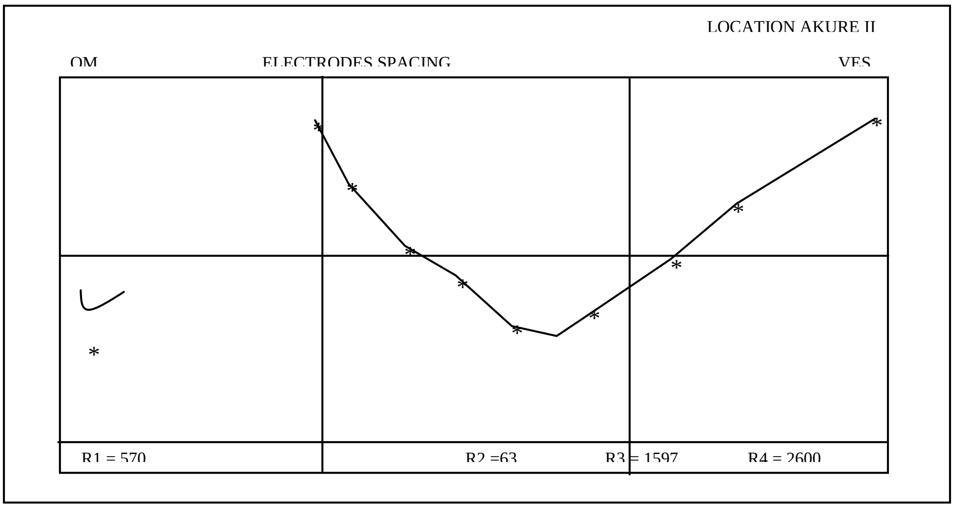
Table 3: Classification of VES Curves.

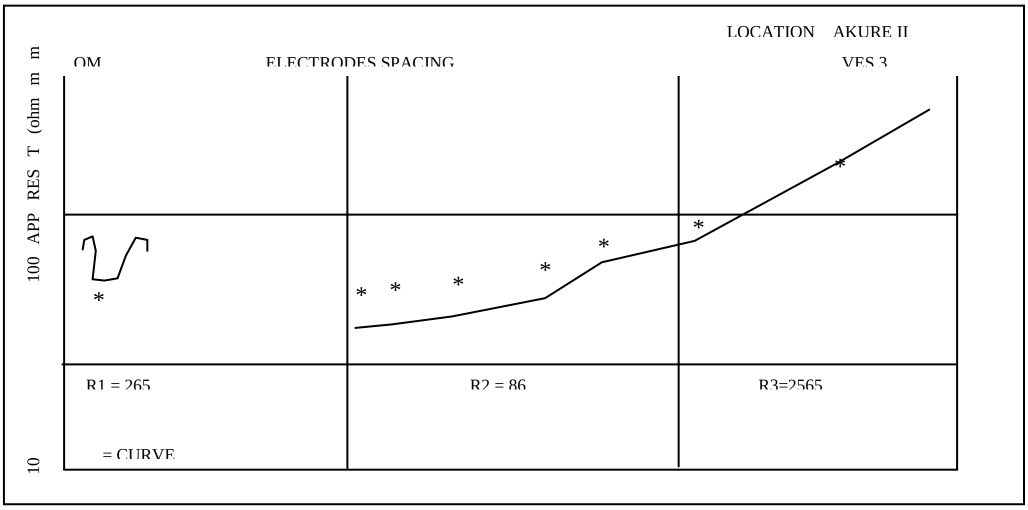
LOCATION AKURE

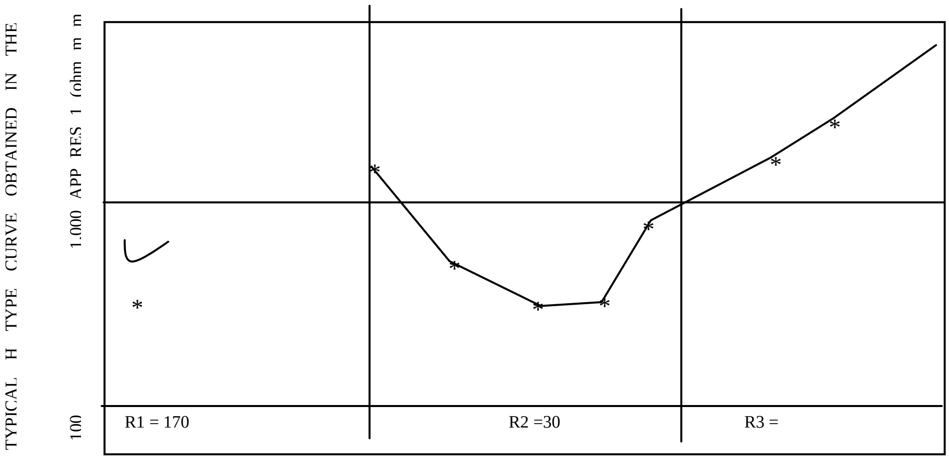




TYPICAL HA TYPE CURVE OBTAINED IN THE




LOCATION AKURE II
OM
ELECTRODES SPACING
VES 3
100 APP RES T (ohm m m
R1 = 265
R2 = 86
R3=2565
= CURVE
10


TYPICAL H TYPE CURVE OBTAINED IN THE
1.000 APP RES 1 (ohm m m
100
R1 = 170
R2 =30
R3 =