Global Scientific JOURNALS

GSJ: Volume 11, Issue 7, July 2023, Online: ISSN 2320-9186

www.globalscientificjournal.com

RESISTIVITY INVESTIGATION OF GROUNDWATER POTENTIAL IN GWAGWALADA AREA COUNCIL, FEDERAL CAPITAL TERRITORY (FCT), ABUJA, NIGERIA

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ABSTRACT

A resistivity survey was carried out in order to investigate the groundwater potential in Gwagwalada Area council. The geo-electrical method used in the survey was Vertical Electrical Sounding, which was used to determine the groundwater potential of the study area. Twenty- five (25) Vertical Electrical Soundings were established using ABEM Terrameter SAS 300C using the Schlumberger configuration with a maximum current electrode spread of 100m. The results revealed that the area was underlained by three to four geo-electric layers. The top lateritic soil has resistivity values ranging from 686Ωm to 6364Ωm and thickness of 0.8m to 16.3m, the second layer is composed of sand/clay intercalation with resistivity values varying between 62Ωm and 471Ωm and thickness varying between 0.2 to18m, while the partly weathered/fresh basement layer has resistivities ranging from 2084Ωm to 11978Ωm with thickness varying between 0.3m to 16.5m. Overburden thickness contour map was established across the whole 25 VES stations and the average thickness value of the overburden was 10m. The thickness and resistivity of the aquifers with twelve VES selected for the geoelectric section have good potential for groundwater accumulation due to their overburden thickness, which is mainly weathered basement with low resistivity value.

Keywords: Resistivity, Aquifer, Schlumberger Array, Overburden thickness

Introduction

Geophysics, as its name indicates, has to do with the physics of the earth and its surrounding atmosphere. In applied geophysics several approaches maybe made to determine more accurately the exact location of a structure or deposit. It measures the apparent resistivity of soil and rock as a function of depth or position, according to (Geovision, 2000).

According to (Telford *et al* 1976),the purely scientific investigation of such subjects as the rate of evaporation of water from lakes, the chemical constitution of different rocks and waters from streams and ponds and the measurement of natural earth currents, potential variation and impurities in the atmosphere all have a definite influence on the methods of locating deposits which applied geophysicist seeks.

Before any further geophysical work such as drilling can be carried out on an area surveyed by the airborne method, a confirmation has to be made using ground survey. This is because in the airborne surveys, geological indications tend to merge into one another, thus giving an impression of only one indication (Parasnis, 1986).

Location of the Study Area

Abuja, is the Federal Capital Territory (FCT) in fig 2.2, lies within the longitude 6°27'00"E and 7°23'24"E and the latitude of 8°15'00"N and 9°12'00"N (Ideh and Sanni, 1998). Almost predominately are high grade metamorphic and igneous rocks of the Precambrian age (Mamman and Oyebanji, 2002). Generally, the North North East (NNE) and South South West (SSW) of the FCT are made of gneiss, migmatities, and granite which characterize the Northern Nigeria. The outcrop of schist belts is found along the eastern margin of the area and the belt broaden as one moves southwards, and the maximum size is found in the South Eastern region of the FCT. The geology of the FCT is the same as that of Gwagwalada. The population of it grew from 80,841 to 157,770 between 1991and 2006 (NPC, 2006) and (Uzodinma, 2004).The area like the most Northern Nigeria regions is underlain by a basement complexes. Gwagwalada consists of granite, gneiss, diorites, horn blende schist, mica schist, feldspathic, quartz schist, and migmatities. While some rock outcrops are found in various places around, some are concealed by a thin weathered layer, the underlying the FCT almost predominately are high grade metamorphic and igneous rocks of Precambrian age (Mamman and Oyebanji, 2002),. Gwagwalada enjoys higher rainfall totals than the more southerly region of the FCT. The FCT experiences heavy rainfall occurrence during the months of July, August, and September .These three-month contribute about 60% of the total rainfall in the region (Dawam, 2000).

GSJ: Volume 11, Issue 7, July 2023
ISSN 2320-9186

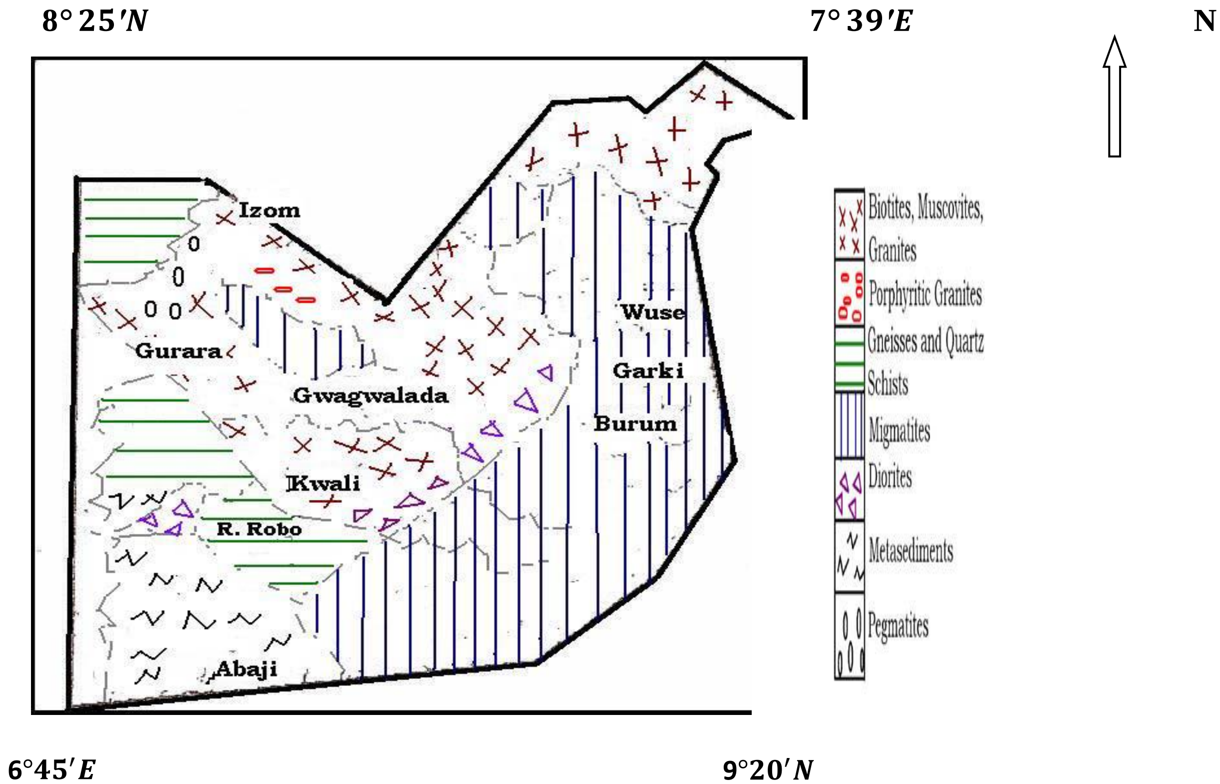

Figure 1: The Geologic map of the Federal Capital Territory (Physica

Materials and Methodology

The ABEM Terrameter SAS 300C was used in this research work for data collection in Gwagwalada. The four-electrode Schlumberger array with a maximum current electrode spacing AB/2 of 100m was used for this survey. The rod was hammered into the ground where the site is located, which serves as the mid point from which AB/2 (half spacing between current electrodes) can be measured in both directions by means of a measuring tape with respect to the required spacing from 0.3m to 5m for MN/2 (half spacing between the potential electrodes).

The current and potential electrodes were then driven down into the ground at the desired spacing as indicated along the measuring tape. The rechargeable 12V battery was connected to a SAS 300CTerrameter. The current and potential electrodes are connected to an ABEM Terrameter SAS 300C with four short cables by their clips to connect the positive and negative terminals of the Terrameter to the two potential reels and current cables. AB/2 was measured in both directions from 1.0m to 1 … tation as the midpoint … s also measured on both side… from 0.3m to 5m.

Data Analysis, Interpretation and Discussion

According to Todd (1980), the electrical resistivity method of all surface geophysical methods has been applied most widely in groundwater exploration studies; this is because it can clarify the zone and it is inexpensive (Mazac *et al* 1985). The electrical resistivity method can be best employed to estimate the thickness of the overburden and the thickness of weathered/fractured zones with reasonable accuracy (Zohdy *et al* ,1974.)

From Table 1, it is evident that the only type of three-layer VES sounding curve obtained in this area is the H-type, however, also existing number of 4-layered type of VES curve namely (QH,HK- type) in basement complex terrain,the intermediate layer of the H-type is commonly water saturated and often characterized by low resistivity, high porosity , low specific yield and low permeability(Jones,1985

Table 1: Interpretation of VES 25

VES STATION	LATITUDE (E)	LONGITUDE(N)	RESISTIVITY (ΩM)	THICKNESS (M)	DEPTH (M)	LAYER TYPE	CURVE TYPE
1	8.59255˚	7.04848	7407.0	0.9	0.9	Topsoil	H-Type
			208.5	8.2	9.0	Weathered layer	
			8082.3	__	_	Fresh basement	
2	8.59341	7.04911	27 96.8	1.0	1.0	Topsoil	H –Type
			156.9	8.1	9.0	Weathered layer	
			2505.0	_	_	Fresh basement	
3	9.06849	7.01164	1403.3	0.5	0.5	Topsoil	H-type
			145.0	7.9	8.4	Weathered layer	
			3152.3	-	-	Fresh basement	
4	9.06810	7.01196	2882.4	0.5	0.5	Topsoil	H-type
			83.1	4.7	5.2	Weathered layer	
			3306.2			Fresh basement	
5	9.00500	7.06052	2134.4	1.1	1.1	Topsoil	H-type
			367.8	11.6	12.8	Weathered layer	
			2084.2	-	-	Fresh basement	
6	9.00495	7.06005	6304.1	0.5	0.5	Topsoil	H-type
			471.1	10.3	10.8	Weathered layer	
			5865.6	-	-	Fresh basement	
7	9.01472	7.03625	3180.7	0.8	0.8	Topsoil	H-type
			303.5	16.5	17.3	Weathered layer	
			6549.0			Fresh	

						basement	
8	9.01436	7.03526	5952.5	1.1	1.1	Topsoil	H-type
			207.7	6.0	7.1	Weathered layer	
			2603.1	-	-	Fresh basement	
9	9.03826	7.03826	6364.3	1.1	1.1	Topsoil	H-type
			193.1	7.4	8.5	Weathered layer	
			3796.2	-	-	Fresh basement	
10	9.03792	7.03923	707.2	1.7	1.7	Topsoil	H-type
			131.0	3.7	5.4	Weathered layer	
			1466.3	-	-	Fresh basement	
11	9.05552	7.00102	915.7	1.0	1.0	Topsoil	H-type
			96.2	7.0	8.1	Weathered layer	
			8054.3	-	-	Fresh basement	
12	9.05558	7.00040	748.2	1.5	1.5	Topsoil	H-type
			96.2	7.2	8.7	Weathered layer	
			12397.6	-	-	Fresh basement	
13	9.07799	7.03712	1086.6	1.7	1.7	Topsoil	H-type
			154.8	16.3	18	Weathered layer	
			3314.7	-	-	Fresh basement	
14	9.07752	7.03748	690.9	0.9	0.9	Topsoil	H-type
			61.7	6.3	7.2	Weathered layer	
			11978.4	-	-	Fresh basement	
15	9.07597	7.08966	559.4	0.7	0.7	Topsoil	H-type
			57.9	6.1	6.9	Weathered layer	
			7105.5	-	-	Fresh basement	
16	9.07579	7.09023	694.0	0.6	0.6	Topsoil	H-type
			57.2	6.1	6.7	Weathered layer	
			13360.2	-	-	Fresh	

						basement	
17	9.06934	6.57741	1205.7	1.2	1.2	Topsoil	H-type
			211.7	6.9	8.1	Weathered Layer	
			4776.8	-	-	Fresh basement	
18	9.07017	6.57737	2227.1	1.1	1.1	Topsoil	H-type
			112.9	8.6	9.7	Weathered layer	
			6362.2	-	-	Fresh basement	
19	9.07128	7.06004	1615.9	1.0	1.0	Topsoil	QH-type
			2691.9	1.7	2.7	Weathered layer	
			47.5	8.4	11.1	Fractured layer	
			2158.5			Fresh basement	
20	9.07129	6.57035	1839.2	1.7	1.7	Topsoil	QH-type
			911.3	0.8	2.5	Weathered layer	
			54.5	6.3	8.8	Fractured layer	
			2519.6	-	-	Fresh basement	
21	9.08717	6.57953	889.5	0.4	0.4	Topsoil	H-type
			80.8	7.5	7.9	Weathered layer	
			3698.8	-	-	Fresh basement	
22	9.08683	6.57954	1154.9	1.1	1.1	Topsoil	HK-type
			225.5	2.0	3.1	Weathered layer	
			3400.8	10.6	13.7	Fresh basement	
			119.7	-	-	Fractured layer	
23	9.09714	7.03931	785.0	0.8	0.8	Topsoil	HK-type
			64.2	1.5	2.3	Weathered layer	
			2065.6	7.0	9.4	Fresh basement	
			12.1	-	-	Fractured layer	
24	9.09773	7.03955	1385.8	0.8	0.8	Topsoil	HK-type

			378.9	2.5	3.5	Weathered layer	
			2938.4	9.3	12.8	Fresh basement	
			382.9	-	-	Fractured layer	
25	9.07908	7.04914	686.2	1.0	1.0	Topsoil	HK-type
			116.3	1.8	2.7	Weathered layer	
			1646.4	7.3	10.1	Fresh basement	
			127.3	-	-	Fractured layer	

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VES 1 is a H-type curve which consists of 3 layers of topsoil with resistivity value of 7407.0 Ωm, thickness of 0.9m,and depth of 0.9m respectively, the weathered layer consists of a resistivity value of 208.5 Ωm, thickness of 8.2m and depth of 9.0m, and fresh basement with resistivity value 8082.3 Ωm.

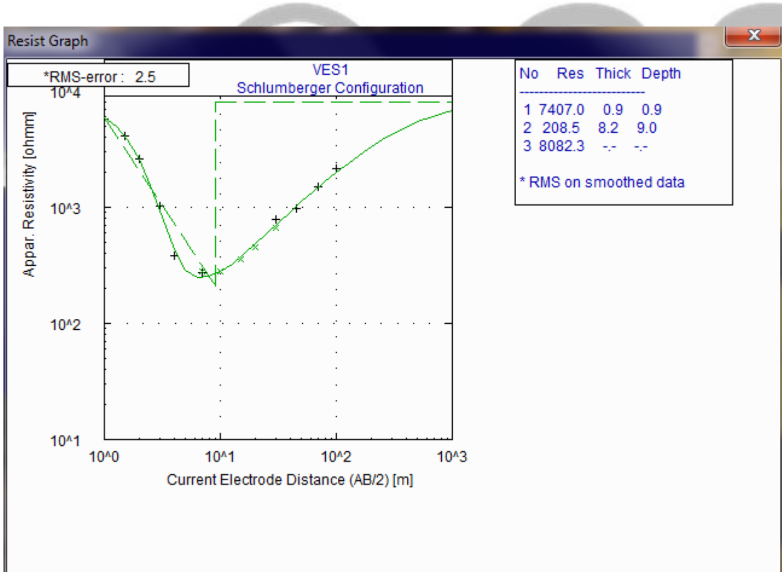

Figure 2: A typical H-type curve

A typical QH-type curve which consistsof 4 layers of topsoil with a resistivity value of 1615.9Ωm, thickness of 1.1 m, and depth of 1.1 m,respectively, the weathered layer consists of a resistivity value of 2691.9 Ωm, with a thickness of 1.7m and depth of 2.7m, the fractured layer with resistivity value 47.5Ωm, thickness of 8.4m and depth of 11.1m, lastly the fresh basement with resistivity value of 2158.5 Ωm

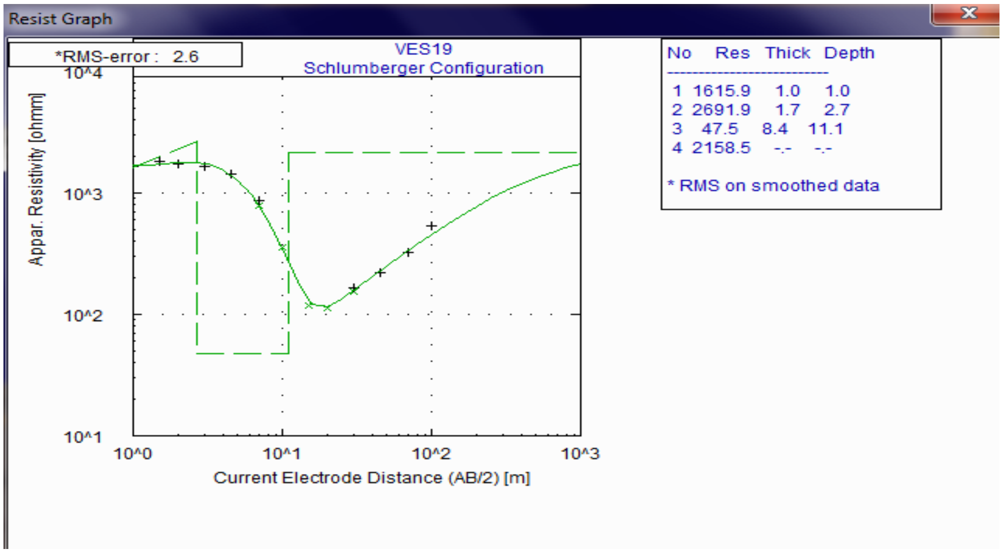

Figure 3: A Typical QH-type curve

This is a HK-type curve which consists of 4 layers of topsoil with a resistivity value of 1154.9Ωm, thickness of 1.1 m, and depth of 1.1 m, respectively, the weathered layer consists of a resistivity value of 225.5 Ωm, with a thickness of 2.0m and depth of 3.1m, the fractured layer with resistivity value 3400.8Ωm, thickness of 10.6m and depth of 13.7m, lastly the fresh basement with resistivity value of 119.7 Ωm.

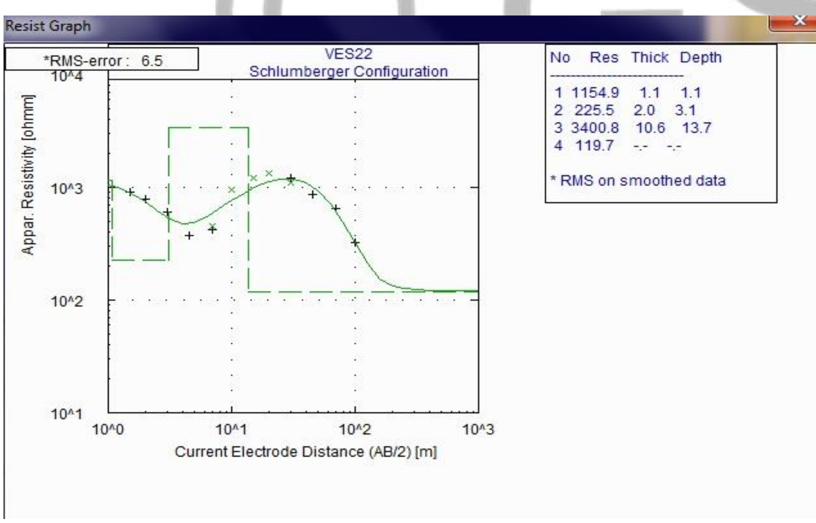

Figure 4: A typical HK -type curve

Result and Discussion

The result of the VES interpretationwas used to generate various basement maps such as 3D, overburden thickness, and topsoil resistivity map. Fresh basement is characterized by a high resistivity value which is close to 1000Ωm in almost all the locations. The overburden is assumed to include all materials above the presumably fresh basement.

The shape of the VES curves depends on three factors: the thickness of each layer, the number of layers in the subsurfaces and the ratio of the resistivity of the layer.

First layer (Lateritic topsoil) composition varies from clay, sandy clay, clayey sand,and laterite with resistivity values ranging between 2134Ωm to 6304Ωm .The layer thickness varies between 0.5m to 1.1m and the depth of 0.5m to 1.1; the second layer (Weathered/Fractured) is characterized by resistivity values ranging between 208Ωm to 471Ωm. The layer thickness varies between 6.0m to 16.5m and the depth of 7.1m to 17.3. Lastly, the partly weathered/Fresh Basement layer, which is the third layer,consists of a fresh and partly weathered basement with resistivity values ranging from 2084Ωm to 6549Ωm. However, the thickness of this layer varies from 0.5m to 16.5m

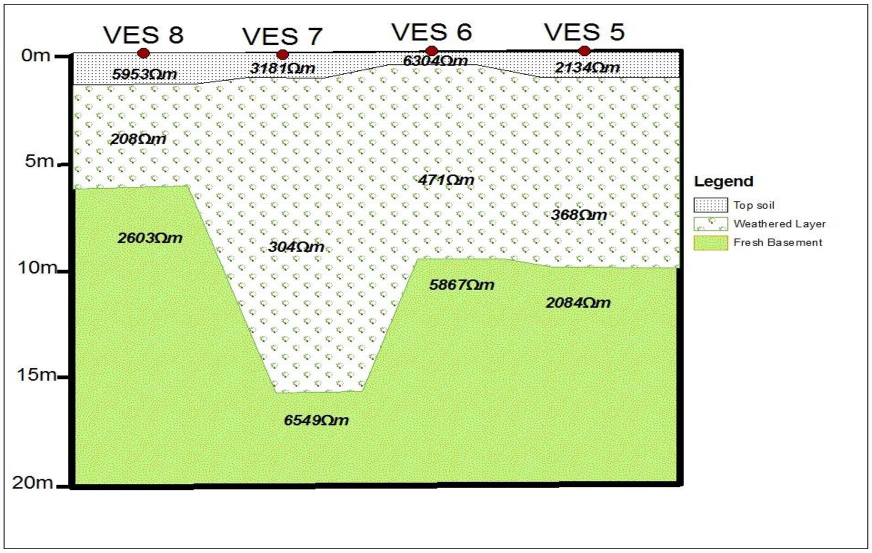

Fig 5: Geoelectric section across VES 8, 7, 6,

First layer (Lateritic topsoil) composition varies from clay, sandy clay, clayey sand, and laterite with resistivity values ranging between 758Ωm to 6364Ωm. The layer thickness varies between 1.0m to 1.7m and the depth of 1.0m to 8.1m; the second layer (Weathered/Fractured) is characterized by resistivity values ranging between 96Ωm to 193Ωm. The layer thickness varies between 3.7m to 7.4m and the depth of 5.4m to 8.7m. Lastly, the partly weathered/Fresh Basement layer, which is the third layer, consists of a fresh and partly weathered basement with resistivity values ranging from 1466Ωm to 12398Ωm . However, the thickness of this layer varies from 3.7m to 7.4m

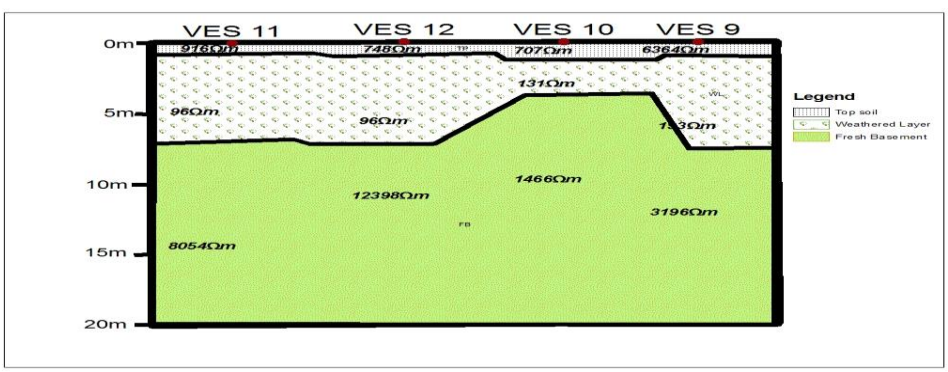

Figure 6: Geoelectric Section across VES 11, 12, 10, 9

First layer (Lateritic topsoil) composition varies from clay, sandy clay, clayey sand, and laterite with resistivity values ranging between 686Ωm to 1616Ωm. The layer thickness varies between 0.9m to 1.7m and the depth of 0.9m to 1.7m; the second layer (Weathered/Fractured) is characterized by resistivity values ranging between 48Ωm to 155Ωm. The layer thickness varies between 1.7m to 16.3m and the depth of 2.7m to 18m. Lastly, the partly weathered/Fresh Basement layer, which is the third layer, consists of a fresh and partly weathered basement with Resistivity values ranging from 1646Ωm to 11978Ωm. However, the thickness of this layer varies from 7.3m to 8.4m. The study of this layer shows that the resistivity value of fresh bedrock often exceeds 1000 Ωm, but where it is fracture /sheared and structured with fresh water, the resistivity often reduces to below 1000 Ωm (Olayinka and Olorumfemi, 1992)

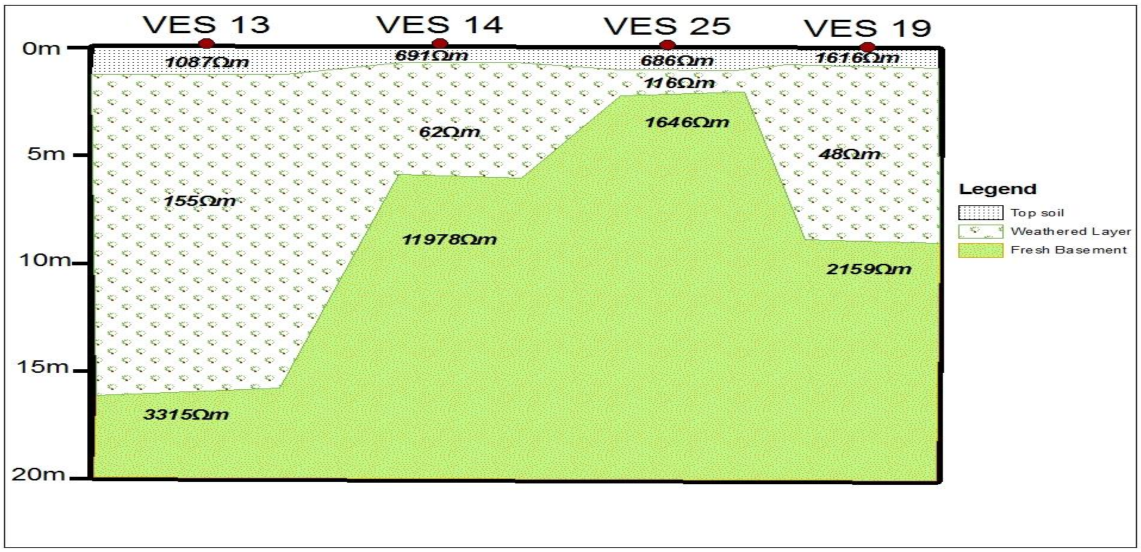

Figure 7: Geoelectric section across VES 13, 14, 25, 19

The Overburden Thickness Contour Map

The overburden is assumed to include all materials above the presumably fresh basement. The depth to the bedrock varies from 3.5m to 16.5m, and the average depth to the bedrock is 10.0m (fig 8).The overburden thickness contour map (Figure 8) shows that the weathered basement has an increasing thickness value towards the north-eastern and north-western axis which suggests the presence of an aquiferous zone.

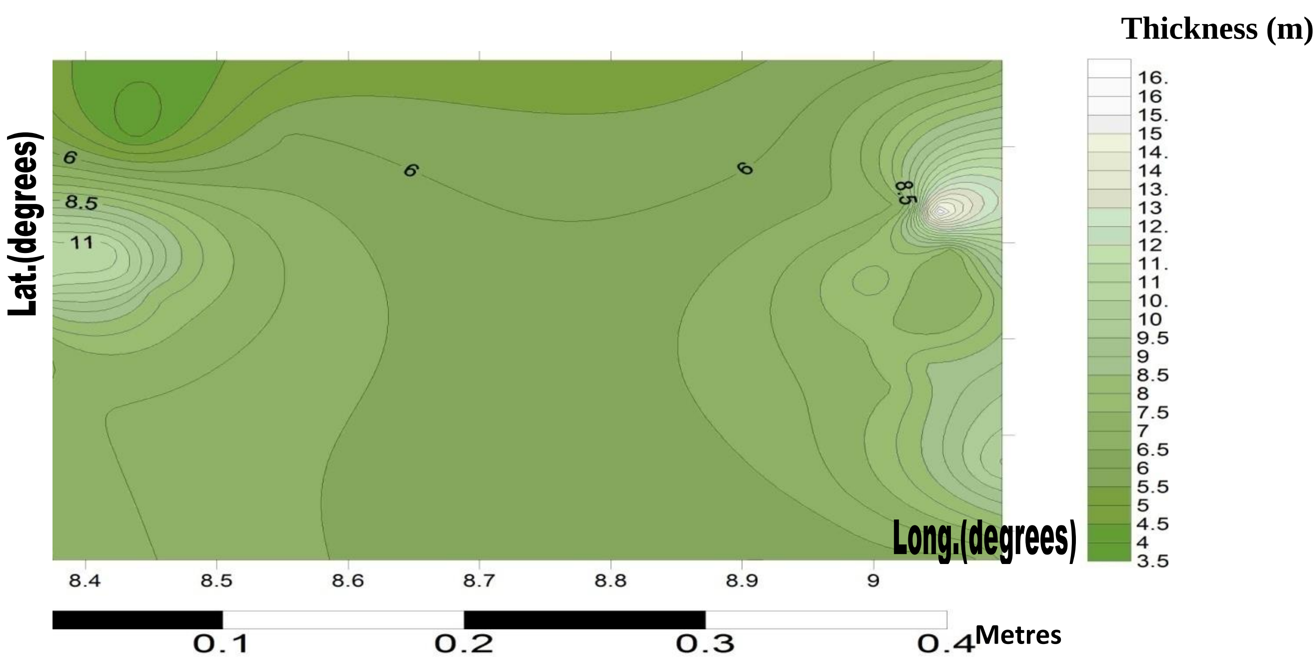

Figure 8: The Overburden Thickness Contour Map

The Topsoil Resistivity Contour Map

The map reveals the heterogeneity in the composition` of the topsoil, whose composition varies from sandy clay to laterite. The topsoil resistivity varies from 500Ωm to 7500Ωm (fig 9).

From fig (9), it can be observed that the region with topsoil resistivity values ranging from 3000 Ωm to 7000 Ωm with thickness value ranging from 6.8m to 7.2m i.e. the northwest region with a constant resistivity value of 3000 Ωm, which shows that the topsoil is characterized by high resistivity value.

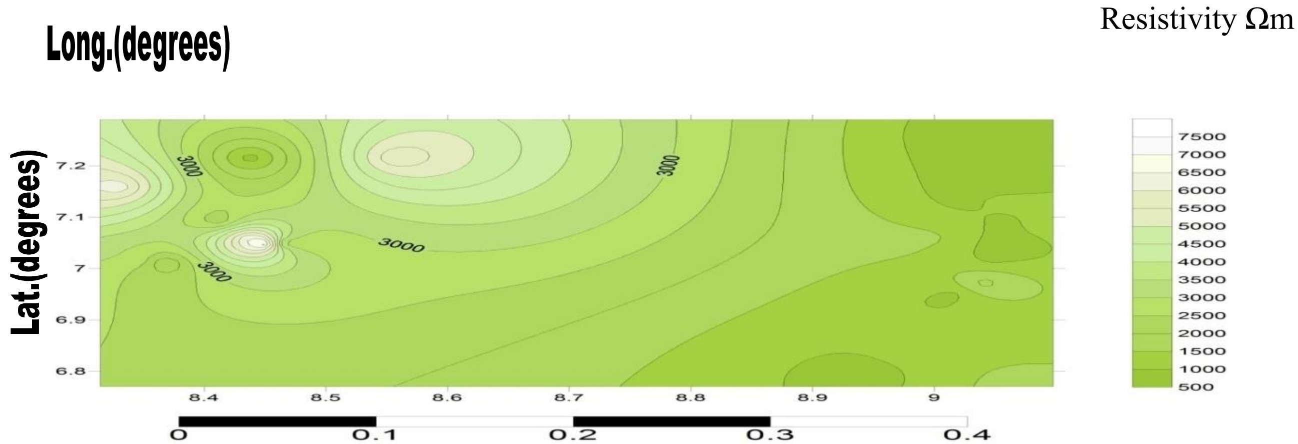

Figure 9: the Topsoil Resistivity Contour

CONCLUSION

The result presented in this work has attempted to define the subsurfaces lithology and geo-electrical structure underlying a part of the Gwagwalada area council, Abuja, Nigeria. The area is underlain by three to four layers of different lithological units such as topsoil, weathered layer, fractured layer and fresh basement; the aquifer thickness varies from 3.5m to 16.5m. The resistivity value of the weathered basement varies from 57.9Ωm to 471.1 Ωm. The depth to the bedrock varies from 3.5m to 16.5m, and the average depth to the bedrock is 10m. It has also been established from this study, the overburden thickness contour map was suited for estimating thickness of the subsurface layering (Fig.8).The presence and development of a weathered layer underlain by a fractured basement are components of aquifer system and the zone of groundwater accumulation in the study area. It can therefore be concluded that low resistivity and significantly thick weathered rock and fractured basement constitute the aquifer in this area. It can be concluded based on all findings made in the interpretation of the VES data, 12 VES Points 5,6,7,8,9,10,11,12,13,14,19,and 25 are strongly recommended as the most viable locations for the development of groundwater resources in the study area.

Recommendation

The research has shown that the geological structure of an area can be detected by adopting Vertical Electrical Sounding. However, there are few recommendations to be made for the improvement of the research work. They are as follows:

1. The electrode spreading for the Vertical Electrical Sounding (VES) should be improved by using the depth of groundwater resolution.

2. Further work should be directed at employing multiple geophysical techniques such as Wenner array, magnetic, seismic, and microgravity methods to enhance precision in the acquired results; it is expected that the use of multiple techniques will infer that the faults will be well mapped and the geometry of the zone of interest will be well delineated.

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