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Determination of Groundwater Potential in the Permanent site of University of Abuja, FCT, Nigeria

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ABSTRACT: This study was carried out with the aim of demonstrating the application of vertical electrical sounding (VES) method of investigation in the exploration for groundwater in University of Abuja, Permanent Site and Environs. A total of 12 VES points were probed in the area with AB/2 of 1 – 250m and covering a total area of 6.75km^2. ABEM SAS 300c tarrameter was used to generate the data using schlumberger array method. The data was interpreted using computer iteration methods (IPI2Win). Isoresistivity of topsoil, isoresistivity of weathered layer, isoresistivity of basement, weathered layer thickness and a 3-D of weathered layer thickness were also generated using surfer software. The result reveals five curve types (A, H, HA, HK and QH) and it shows variation in the layers available in the study area, some with four geo – electric layers: top soil, lateritic clay, weathered basement and fractured/fresh basement while some with three geo-electric layer: topsoil, weathered and fractured/fresh basements. It also shows variation in the groundwater potentiality of the study area i.e. good (VES 1, 5, 7, 9), moderate (VES 2, 4, 6, 8, 11, 12) and low (VES 3, 10). The good potential area is suggested for drilling of boreholes.

KEYWORDS: Groundwater potential, vertical electrical sounding, University of Abuja.

INTRODUCTION

Next to air, the most critical natural resource for life on earth is water. Fortunately, this water has been gifted by nature in bounteous proportion with its quality of transformation through perennial hydro geological evaporation, condensation, and precipitation. With the population explosion, increasing tempo of industrialization, and agricultural growth, the demands on the potable water supply have increased beyond our perception. It is within our comprehension that surface water is unable to cope with the ever increasing demands and the only alternative source of perennial water supply is groundwater. In order to pursue large scale development of groundwater it is essential to have a reliable estimate of groundwater potential [7].

In many developed and developing countries there is not only a heavy reliance on ground water as a primary drinking supply but also as a supply of water for both agriculture and industrial use. The reliance on groundwater is such that it is necessary to ensure that there are significant quantities of water and that the water is of a high quality. The use of geophysics for both groundwater resource mapping and for water quality evaluations has increased dramatically over the last 10 years in large part due to the rapid advances in microprocessors and associated numerical modeling solutions. The principal source of groundwater is meteoric water, that is, precipitation. However, two other sources are occasionally of some consequence.

These are juvenile water and connate water. The former is derived from magmatic sources, whereas the latter represents the water in which sediments are deposited. Connate water is trapped in the pore spaces of sedimentary rocks as they are formed and has not been expelled.

The amount of water that infiltrates into the ground depends on how precipitation is dispersed, namely, on the proportions that are assigned to immediate run-off and to evapotranspiration, the remainder constituting the proportion allotted to infiltration/percolation. Infiltration refers to the seepage of surface water into the ground, percolation being its subsequent movement, under the influence of gravity, to the zone of saturation. In reality, one cannot be separated from the other. The infiltration capacity is influenced by the rate at which rainfall occurs (which also affects the quantity of water available), the vegetation cover, the porosity of the soils and rocks, their initial moisture content and the position of the zone of saturation. The retention of water in soil depends on the capillary force and the molecular attraction of the particles. As the pores in the soil become thoroughly wetted, the capillary force declines, so that gravity becomes more effective. In this way, downward percolation can continue after infiltration has ceased but the capillarity increases in importance as the soil dries. No further percolation occurs after the capillary and gravity forces are balanced. Thus, water percolates into the zone of saturation when the retention capacity is satisfied. This means that the rains that occur after the deficiency of soil moisture has been catered for are those that count as far as supplementing groundwater is concerned. The water in the zone of aeration is referred to as vadose water. This zone is divided into three subzones, those of soil water, the intermediate belt and the capillary fringe. The uppermost or soil water belt discharges water into the atmosphere in perceptible quantities by evapotranspiration. In the capillary fringe, this occurs immediately above the water table, water is held in the pores by capillary action.An immediate belt occurs when the water table is far enough below the surface for the soil water belt not to extend down to the capillary fringe. The degree of saturation decreases from the water table upwards. An aquifer is the term given to a rock or soil mass that not only contains water but from which water can be abstracted readily in significant quantities. The ability of an aquifer to transmit water is governed by its permeability.By contrast, a formation with permeability of less than 10-9 ms^{-1} is one that, in engineering terms, is regarded as impermeable and is referred to as an aquiclude.

For example, clays and shales are aquicludes. Even when such rocks are saturated, they tend to impede the flow of water through stratal sequences. An aquitard is a formation that transmits water at a very slow rate but that, over a large area of contact, may permit the passage of large amounts of water between adjacent aquifers that it separates.

1.1 Objective Of The Present Study

The primary objective of the present study is to apply electrical resistivity method in the quantitative assessment of groundwater potential. From the combination of the resistivity techniques used in the field, processing and interpretation of the field data using computer software, this study aims to investigate the following aspects:

1. Locating and identifying potential water bearing zones in the area.

2. Investigating the hydrogeology of the area by geophysical determination of the thickness of the aquifer.

1.2 Geological Setting Of The Study Area

The study area, the Permanent site of University of Abuja is located in FCT, Abuja, Nigeria. It is lies within latitudes 8.95780°N to 8.98752°N and longitudes 7.1758°E to 7.2365°E [26].

The geology of the area is generally the crystalline basement rocks. Older granite mainly porphyroblastic granite and migmatite, porphyritic granite, granite gneiss, biotite gneiss and pockets of medium-grained biotite and biotite hornblende granite constitute the dominants rocks in the area. Generally, only small amount of water can be obtained in freshly unweathered bedrock below the weathered layers.

Groundwater is found mainly in the variable weathered/transition zone and in fractures, joints and cracks of crystalline basement. Fissure systems in Nigeria rarely extend beyond 50m, as evident by available drilling data. The local water table is controlled by textural and compositional changes within the regolith vertical profile and the bedrock topography [39]

2 Field Procedures

Field investigation was conducted for each of sounding points. Each of the VES has 1 – 250m spread out as its sounding points and the interval distance between the VES points varies from 500m to 1500m depending on the geological outcrops. The entire field work was carried out between 11th and 14th of February 2012, before the beginning of the rainy season.

3 DATA COLLECTIONS AND INTERPRETATIONS

ABEM Tarrameter SAS 300c was used for data gathering at the field. It is made in such a way that it uses the potential difference as well as the current sent into the ground to automatically compute the resistance of the subsurface at any given point, for a particular set of electrode configurations. The instrument is programmed in such that it filters self potentials and noise from incoming signals, so that the output is actually the true resistance of subsurface, which can be used, with appropriate formulae, in the calculation of the apparent resistivity of the subsurface in ohmmeter. ABEM Tarameter SAS 300c usually comes with self rechargeable battery, four electrodes, cables, hammer, crocodile clips and measuring tapes.

Schlumberger configuration was employed in the data gathering process which is called VES (vertical electrical sounding) [18],[23],[28],[35],[38]. Twelve VES was acquired from the study area (6.75km^2) and with aid of computer software (IPI2Win), the below graphs were obtained (fig 3.1 – 3.12).

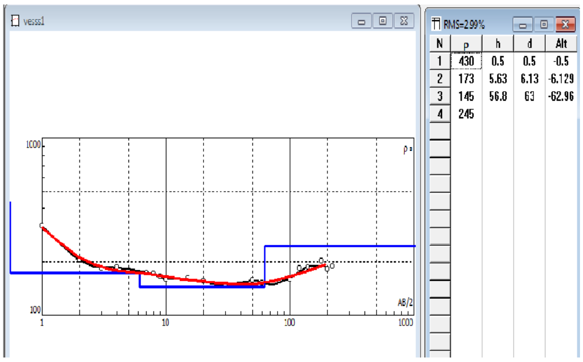

Fig. 3.1 Ves one

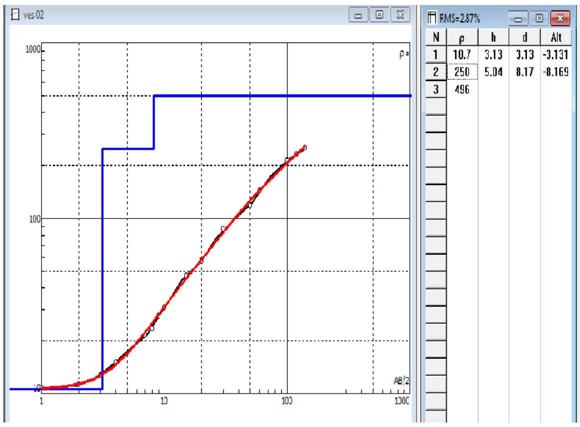

Fig. 3.2 VES two

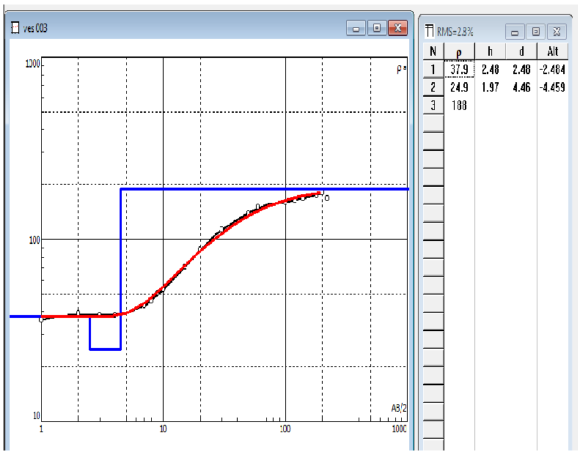

Fig.3.3 VES three

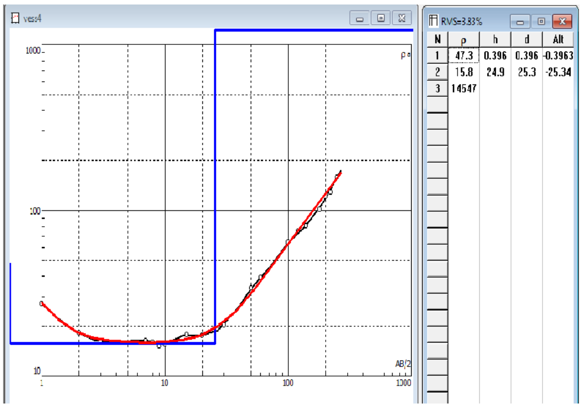

Fig. 3.4 VES four

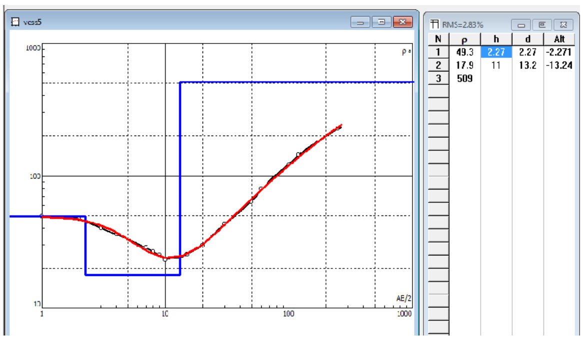

Fig. 3.5 VES five

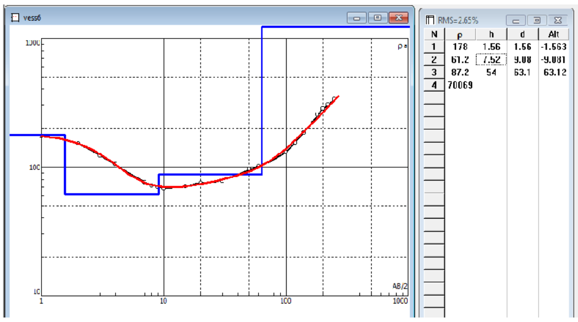

Fig. 3.6 VES six

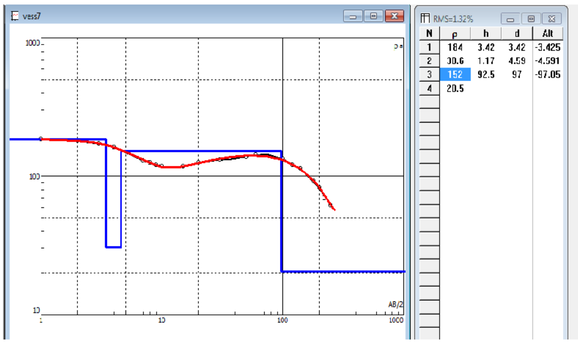

Fig. 3.7 VES seven

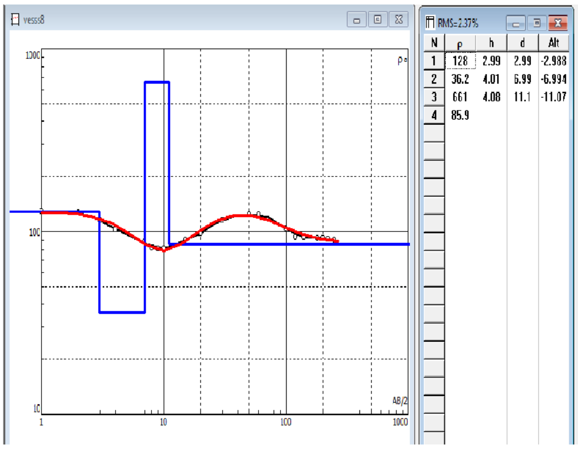

Fig. 3.8 VES eight

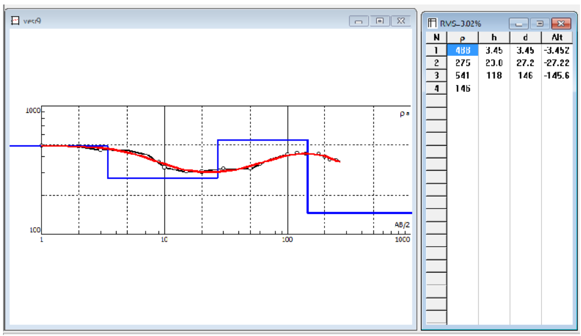

Fig.3.9 VES nine

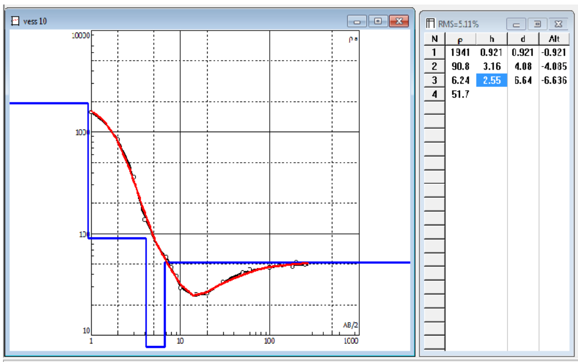

Fig. 3.10 VES ten

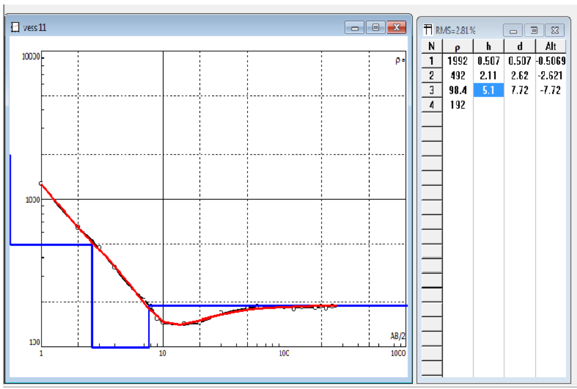

Fig. 3.11 VES eleven

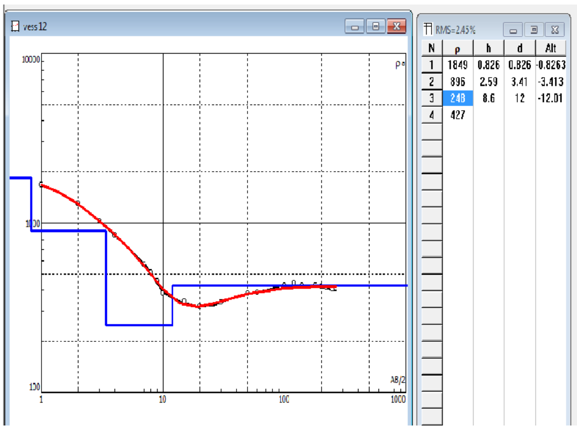

Fig. 3.12 VES twelve

Table 3.1 summary of curves

VES	Layer	Resistivity (Ωm)	Thickness(m)	Depth(m)	Probable Lithology	Curve types	Coordinates
1	1	430	0.5	0.5	Topsoil	QH	Latitudes
	2	173	5.63	6.13	Lateritic clay		8.98752N
	3	145	56.8	63	Weathered basement		
	4	245	-	-	Fractured basement		Longitudes 7.18518E
2	1	10.7	3.13	3.13	Topsoil	A	Latitudes
	2	250	5.04	8.17	Weathered basement		8.98033N
	3	496	-	-	Fractured basement		Longitudes 718332E
3	1	37.9	2.48	2.48	Topsoil	A	Latitudes
	2	24.9	1.94	4.46	Weathered basement		8.97653N
	3	188	-	-	Fractured basement		Longitudes 7.1758E
4	1	47.3	0.396	0.396	Topsoil	H	Latitudes
	2	15.8	24.9	25.3	Weathered basement		8.98059N
	3	14547	-	-	Fresh basement		Longitudes 7.1970E
5	1	49.3	2.27	2.27	Topsoil	H	Latitudes
	2	17.9	11	13.2	Weathered basement		8.97926N
	3	509	-	-	Fractured basement		Longitudes 7.1970E
6	1	178	1.56	1.56	Topsoil	HA	Latitudes
	2	61.2	7.52	13.2	Lateritic clay		8.97456N
	3	87.2	54	63.1	Weathered basement		
	4	70069	-	-	Fresh basement		Longitudes 7.21042E
7	1	184	3.42	3.42	Topsoil	HK	Latitudes
	2	30.6	1.17	4.59	Lateritic clay		8.97107N
	3	152	92.5	97	Weathered basement		
	4	20.5	-	-	Fractured basement		Longitudes 7.21009E
8	1	128	2.99	2.99	Topsoil	HK	Latitudes
	2	36.2	4.01	6.99	Lateritic clay		8.96905N
	3	661	4.08	11.1	Weathered basement		
	4	85.9	-	-	Fractured basement		Longitudes 7.20941E
9	1	488	3.45	3.45	Topsoil	HK	Latitudes
	2	275	23.8	27.2	Lateritic clay		8.96248N
	3	541	118	146	Weathered basement		Longitudes
	4	146	-	-	Fractured basement		7.2365E
10	1	1941	0.921	0.921	Topsoil	QH	Latitudes 8.96021N
	2	90.8	3.16	4.08	Lateritic clay		
	3	6.24	2.55	6.64	Weathered basement		

							Longitudes
	4	51.7	-	-	Fractured basement		
							7.23471E
11	1	1992	0.51	0.51	Topsoil	QH	Latitudes
	2	492	2.11	2.62	Lateritic clay		8.95951N
	3	98.4	5.1	7.72	Weathered basement		
	4	192	-	-	Fractured basement		Longitudes
							7.23211E
12	1	1849	0.83	0.83	Top Soil	QH	Latitudes
	2	896	2.59	3.44	Lateritic Layer		8.95780N
	3	248	8.6	12	Weathered Layer		
	4	427	-	-	Fractured basement		
							Longitudes
							7.23053E

3.1 RESULT AND DISCUSSION

The geoelectric section revealed four subsurface geo-electrical layers in VES 1, 6, 7, 8, 9, 10, 11 and 12, and three subsurface geo-electrical layers in VES 2, 3, 4 and 5.

The top layer which is the topsoil has resistivity value ranges from 10.7 to 1992 ohm-m, with mean resistivity of 611.267 ohm-m. Its highest value was observed at VES 11 and the lowest at VES 2 (as seen in fig. 3.13). The top layer thickness ranges from 0.396 to 3.45m, with mean thickness of 1.872m. It highest value was observe at VES 9 and the lowest at VES 4.

The top soil contributes to the development of ground water, because it is the passage for the flow of surface water to the fractured layer. It is known as aeration area and water in this layer is called sub-surface water. The top soil generally consists of three parts: the belt of the soil water at the top, the intermediate vadose zone, and the capillary fringe at the bottom. The difference in compaction of the clayed sand is responsible for the variation in the resistivity values.

For VES 1, 6, 7, 8, 9, 10, 11 and 12 which have four layers, the second layer constitute the Lateritic clay and its has resistivity value ranges from 30.6 to 896ohm-m, with mean resistivity of 256.85ohm-m. Its highest value was observed at VES 12 and the lowest at VES 7. Its thickness ranges from 1.17 to 23.8m, with mean thickness of 6.249m. It highest value was observe at VES 9 and the lowest at VES 7.

The second layer of VES 2, 3, 4 and 5, and the third layer of VES 1, 6, 7, 8, 9, 10, 11 and 12 which is the Weathered zone has resistivity that ranges from 6.24 to 661 ohm-m, with mean resistivity of 187.287 ohm-m. Its highest value was observe at VES 8 and the lowest at VES 10 (as seen in fig. 3.14). The Weathered zone thickness ranges from 1.94 to 118m, with mean thickness of 32.0425m. It highest value was observe at VES 9 and the lowest at VES 3.

The third layer of VES 2, 3 and 5, and the fourth layer of VES 1, 7, 8, 9, 10, 11 and 12 constitute the Fractured basement which has resistivity that ranges from 20.5 to 509 ohm-m, with mean resistivity of 236.11 ohm-m. Its highest value was observe at VES 4 and the lowest at VES 7.

The third layer in VES 4 and the fourth layer in VES 6 constitute the Fresh basement and its resistivity is 14547Ωm in VES 4 and it is 70069Ωm in VES 6, while the mean resistivity 42308Ωm.

The isoresistivity maps for topsoil, weathered basement and fractured basement as well as the isopach of weathered basement and 3-D Isopach of weathered basement are as shown in figures 3.13 – 3.17 respectively.

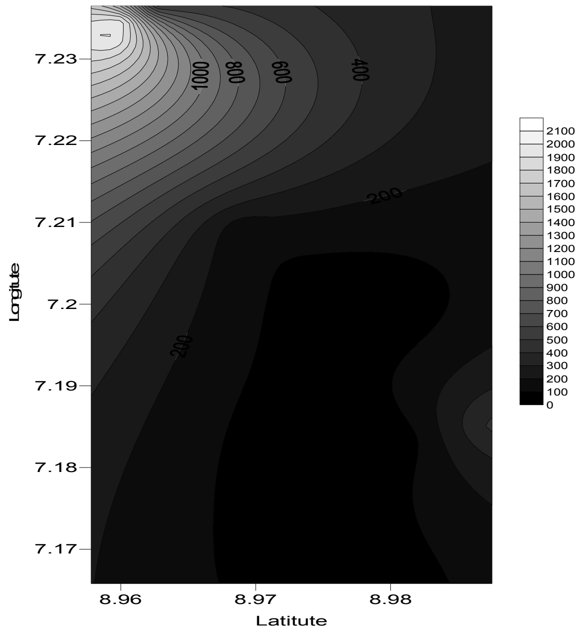

Fig. 3.13 isoresistivity of topsoil

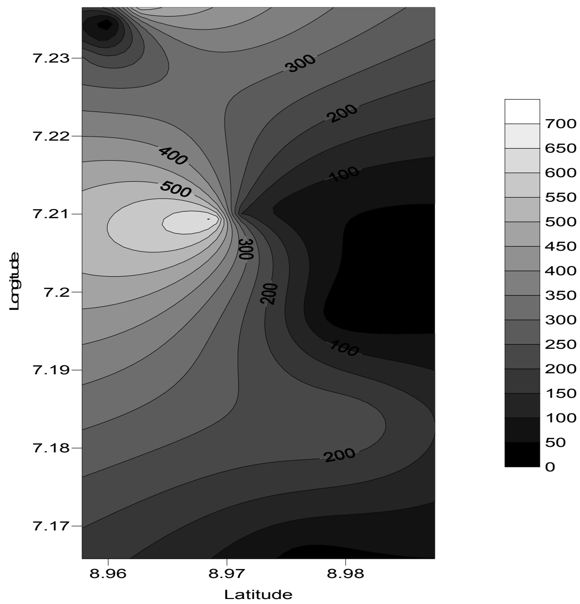

Fig. 3.14 isoresistivity of weathered basement

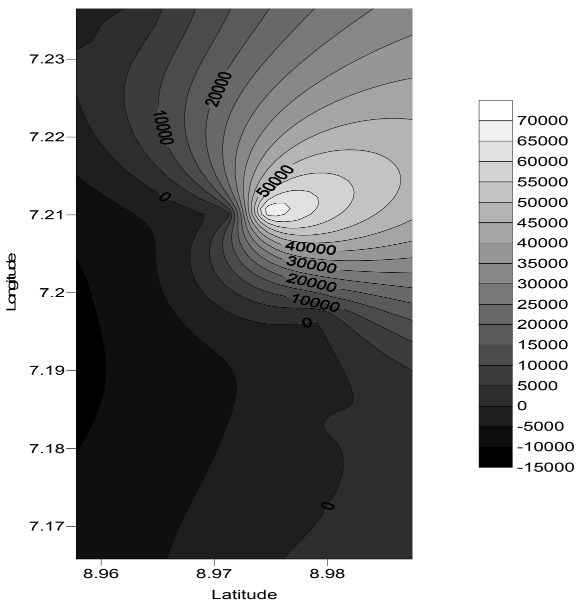

Fig. 3.15 isoresistivity of basement

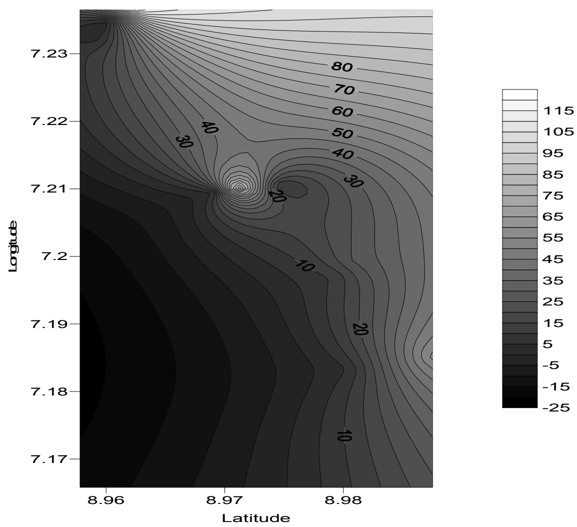

Fig. 3.16 isopach of weathered basement

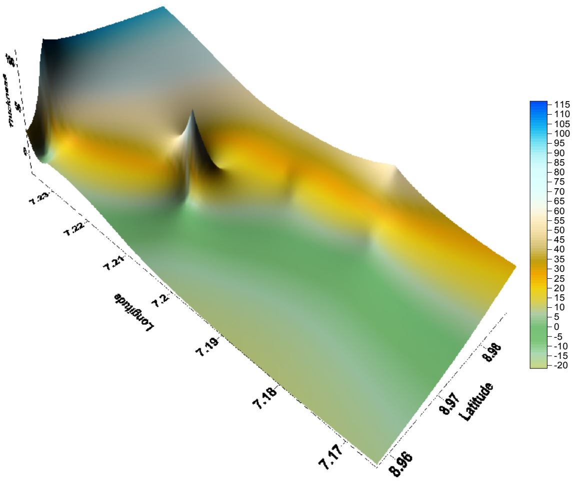

Fig. 3.17 3-D Isopach of weathered basement

3.2 Conclusion

The results from geoelectric sounding for groundwater exploration in the University of Abuja Permanent Site, Northcentral Nigeria have been presented. The interpretation results obtained from the study area shows the sequence and relationships between the subsurface lithologies. VES test revealed four subsurface geoelectric layers (top soil, lateritic clay, weathered basement, fracture/fresh basement) in VES stations (1, 6, 7, 8, 9, 10, 11, 12) and three subsurface geoelectric layers (topsoil, weathered basement and fracture basement) in VES station (2, 3, 4, 5).

The weathered basement and the fractured basement have been identified as the aquiferous zone in the area. [25] [39] The geoelectric parameters determined from the VES data interpretation were employed to generate different hydro-resistivity maps such as isoresistivity of top soil map, isoresistivity of weathered layer map, isoresistivity of fractured basement map, isopach of weathered basement map and 3-D representations of weathered basement (figures 3.13 to 3.17 are relevant). Integrating all the geoelectric parameters determined, the best suggested sites for sitting wells or boreholes (between 20m to 40m depth is suggested for drilling of borehole) are VES stations 1, 5, 7 and 9, because these VES stations have a good overbudden thickness ranging from 1.94m to 118m (table 3.1, fig. 3.16 and fig. 3.17). The research has shown that in basement environment, Vertical Electrical Sounding (VES) have proved to be very reliable for underground water studies and therefore the method can excellently be used for shallow and deep underground water geophysical investigation.

It is envisaged that the findings of this work will provide reliable background information for an elaborate groundwater development in University of Abuja Permanent Site.

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