FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 4 No. 1, March , 2020, pp 301 – 320

ELECTRICAL RESISTIVITY INVESTIGATION OF SUBSURFACE STRUCTURES AT THE N.Y.S.C. PROPOSED PERMANENT ORIENTATION CAMP, PAIKO, NIGER STATE

***Ahmed, A. L., Hfiz, B., Umar, M. and Balarabe, B.**

Department of Physics Ahmadu Bello University Zaria.

*Corresponding Author's email: aminuahmad777@gmail.com, Tel. +2348037051464

ABSTRACT

An electrical resistivity method was used in carrying out geophysical investigations at the Niger State National Youth Service Corp (N.Y.S.C.) proposed permanent orientation camp, Paiko of Paikoro Local Government Area (L.G.A.), with a view to determine the depth to the bedrock and thickness of the weathered basement. Vertical Electrical Sounding (VES) using Schlumberger electrode array was carried out along five (5) profiles having a total of fifty (50) VES stations. On each profile, were ten (10) VES stations. The inter profiles and inter VES stations were at uniform separation of 80m. The data were acquired using ABEM Terrameter, System Adjusted Signal (SAS) 1000. The field data obtained were analysed and interpreted using computer software (IPI2win and surfer 10) which gave an automatic interpretation of the apparent resistivity data. The IPI2win was used to obtain the sounding curves by plotting graphs of apparent resistivity against half the current electrode spacing log-log scale and to compute the true layered resistivity model from the soundings. Surfer 10 was used to plot the contour maps. Results from the interpretation suggest three (3) layers in most parts of the study area. However, there is a case of two (2) layers at a station (VES A6). The resistivity value for the topsoil varies from 10 to 751Ωm with thickness range from 0.98 to 4.23m (except for VES A6 where the top soil has been probably washed by erosion). The weathered basement has resistivity values ranging from 9 to 968Ωm and thickness of between 0.67 and 24.50m. The fresh basement (bedrock) has resistivity values as high as 2718Ωm. The topsoil is characterized by a top lateritic soil underlain by a silty/sandy clay soil. They have great amount of dissolved salts resulting to their low resistivity values. The weathered basements are medium to fine grain, porous or fractured rocks containing water. They are referred to as the aquiferrous zones. Highly fractured areas have low resistivity values because of their high degree of saturated water implying that their resistivity is greatly influenced by underground water. The geologic sections derived, suggest that the weathered basement entirely represents a promising aquifer which can serve as the source of water to the area throughout the year. The fresh basement rocks are coarse, close grained (plutonic or intrusive) rocks, constituting the rock forming minerals which are poor conductors resulting to their high resistivity values. The parameters of investigation have helped in determining the depth to the aquiferous zone, in identifying strategic areas (VES A4, E4, A9, B1, B6, C4, D3 and E3) for siting high-rise buildings, potential positions (VES A1, A3, A7, A8, A10, B2, B4, B5, B7, B8, B9, C3, C6, C9, D2, D7, E1, E2, E8 and E9) for the location of boreholes and possible depth of sewage system in order to avoid groundwater contamination since the area is generally a shallow fresh basement. A borehole log was provided for the borehole within the area. This survey revealed that the depth to the basement in the site was found to be about 5.00m. The depth to the aquiferrous zone was also found to be about 10.00m and therefore preferably, the sewage system should be sited at a location where the aquifer is a confined one

Keywords: Geoelectric section, Vertical Electric Sounding (VES), Groundwater Contamination and Foundation

INTRODUCTION

The statistics of failure of town planning and boreholes and even the contamination of groundwater throughout the nation has increased tremendously as a result of no or inadequate geophysical investigations (Omoyoloye *et al*., 2008). These have great effects on the environment and particularly on the inhabitants. In some areas, buildings will be choked up without provision for drainage system, proper refuse and sewage disposal e.t.c. and these can adversely affect the people in such area. A case study is the borehole at Paiko Central Market that failed after few months, also the contamination of Minna Central Mosque borehole by a nearby pit latrine. Properties worth billions of dollars have been lost in many countries due to structural disasters. Some common structural failures in Nigeria today include the failures of bridges, towers and failures of low and high rise buildings such as National Youth Service Corp (N.Y.S.C.) gymnasium where Man-O-War facilities are kept and even corp members' hostels in orientation camps. Most of these failures were caused by swelling clays (Blyth and Freitas, 1988). Therefore, the developments of new towns as well as N.Y.S.C. orientation camp sites generally require a detailed evaluation of the subsurface of the sites. Subsurface study of a new site is necessary so as to provide subsurface and aerial information that normally assists civil engineers, builders and town planners in the design, planning and siting of foundations of civil engineering structures (Omoyoloye *et al*., 2008). Water is an essential and inevitable commodity in human life. It is needed for agricultural and industrial purposes, domestic use and for human consumption. Hence, access to clean uncontaminated water in the N.Y.S.C. orientation camps must be taken into consideration. Most of the world surface water is found to be polluted either from anthropogenic activities by man or nature, such as salinity, oil spillage, industrial waste and so on. These factors have necessitated the purification of surface water before consumption or other uses incurring high costs. Hence, this has given rise to exploration of groundwater as alternative source of water supply. Groundwater is found within the pore spaces of soil or rock called the aquifer (Offodile, 1992). The nature of the aquifer is a function of subsurface geological composition that plays an important role in determining the circulation of water from the surface (infiltration) to subsurface water through recharge processes. The composition of aquifer varies between locations, as each location has a unique geological lithology giving rise to variation in groundwater depth among different places. Detailed knowledge of the aquifer as well as understanding of the aquifer composition is important for optimum groundwater exploration. Successful groundwater exploration largely depends on the pre-drilling information (survey) because most groundwater explorations fail due to inadequate pre-drilling information (Gomes, 2006; Afuwai *et al.,* 2014). As a result, credence is lent to the development of groundwater in the present study site owing to the lack of any known surface water nearby and around the site. Hence, methods used for locating viable groundwater aquifers and their hydrological conditions should be effective so as to accurately ascertain the groundwater potential at the survey site and geophysical methods particularly the Electrical Resistivity methods are playing a satisfactory role in groundwater investigations. Though the use of geophysics for planning new N.Y.S.C. site, new towns and estates is yet to be fully embraced, this study has shown that the adoption of geophysical studies can aid in appropriate allocation of spaces for residence, high-rise buildings and recreational facilities and buried utilities like underground sewage channels within N.Y.S.C camps.

Location of the Study Area

The area under study in Paiko lies between latitude 9°26'59.51"N and 9°27'17.49"N and Longitude 6°38'40.58"E and 6°38'50.01"E. Paiko hosts the secretariat of Paikoro Local Government Area, of Niger State. It has an estimated population of about 158,086 and covering a total area of 2,066km^2 with other small villages, settlements and hamlets (Figure 1). It is part of Sheet 185 N.W. and is located at about 25km along Minna-Suleja express way (Figure 2). The terrain is relatively flat and accessible by road.

Fig. 1: Map of Niger State showing Paikoro L.G.A.

Source: Adapted and modified from the administrative Map of Nigeria.

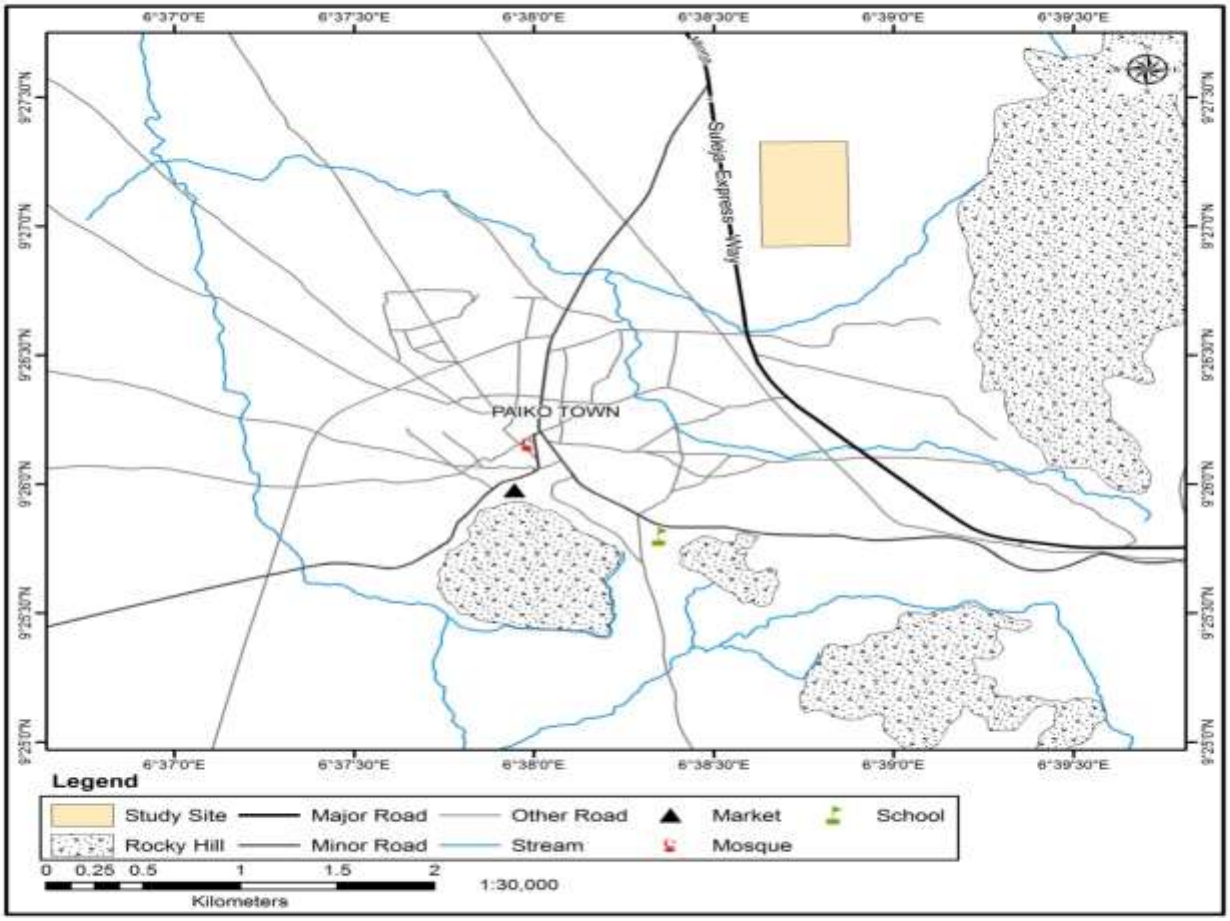


Fig. 2: Map of Paiko showing the study site.

Source: Adapted and modified from Topo Sheet 185 N.W.

Climate, Relief and Vegetation

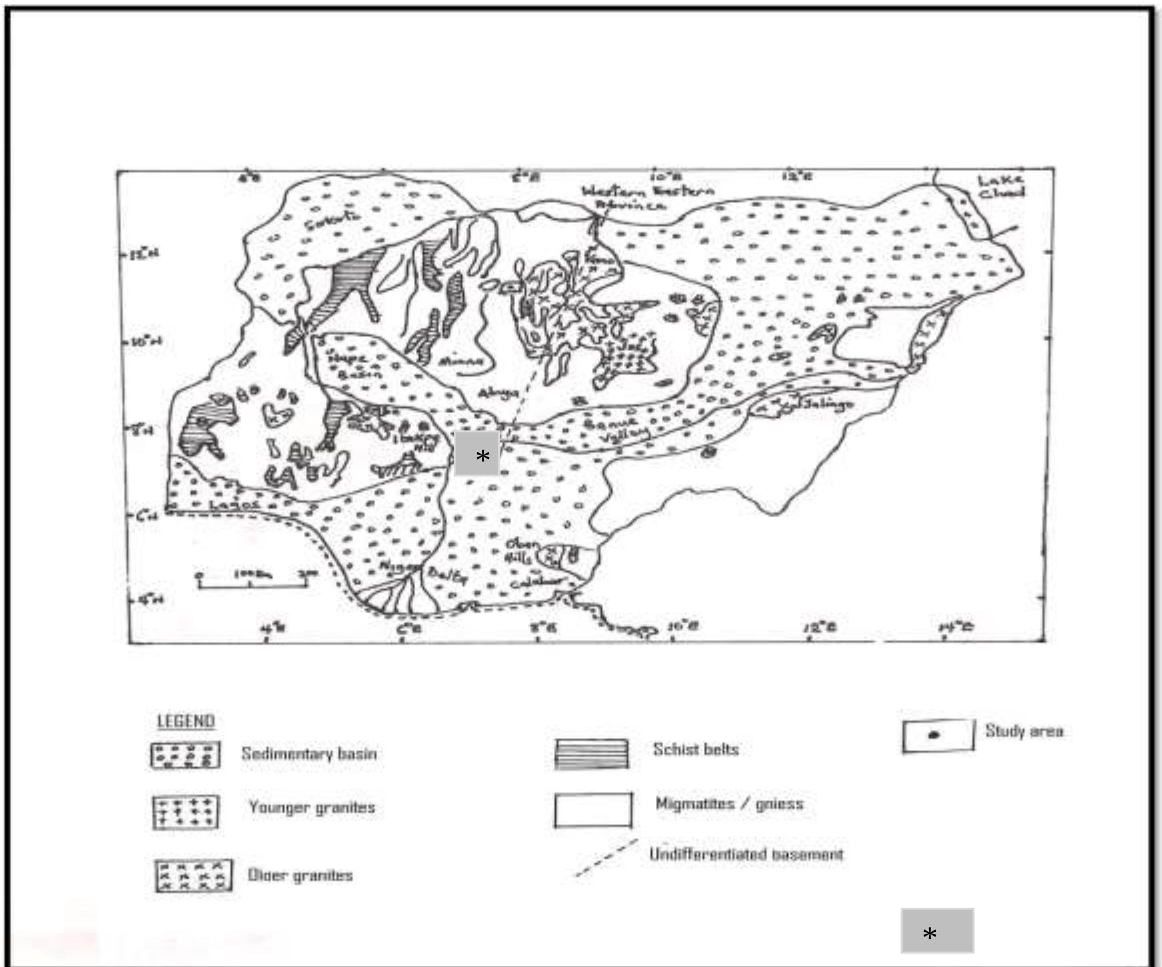
The vegetation of the study area belongs to the central Savannah which is a transitional type between the forest zone of southern Nigeria and the Guinea Savannah types of the Northern Nigeria (Ajibade and Woakes, 1976). This area is characterized by tall grasses with light forest, sparsely distributed trees in the dry season and evenly distributed trees in the wet (rainy) season. The area lies within the middle belt of Nigeria. The annual rainfall distribution pattern shows a maximum of 1300mm rainfall and minimum of 900–1000mm (McCurry, 1976). The rainy season is between April and October covering a period of six months. Temperature is highest in March at about 30^0C and lowest in August at about 25^0C (Ajibade, 1982). The topography of the study area is marked by high and flat terrain, with most of the highlands visible around the vicinity of the area. Generally, the fertile soil and hydrology of the area permit the cultivation of most Nigeria's staple crops and still allows sufficient opportunities for grazing, fresh water fishing and forestry development.

iv.

General Geology of the Study Area

The study area is within the north-central portion of the Nigerian Basement Complex rocks (Figure 3). This Basement Complex is characterized by three lithofacies (Olarewaju *et al*., 1996; Olasehinde, 1999):

i. Migmatite-Gneiss Complex
ii. the Schist Belt
iii. the Older Granites



Falls within the Basement Complex

Fig. 3: Geological Map of Nigeria showing the Study Area.

Source: Adapted and modified from the Nigerian Geological Map.

The Migmatite-Gneiss Complex

This group is the oldest basement rock and the commonest rock type in the Nigerian Basement complex. It comprises two main types of gneisses: the biotite gneiss and the banded gneiss. Very widespread, the biotite gneisses are normally fine-grained with strong foliation caused by the parallel arrangement of alternating dark and light minerals. The banded gneisses show alternating light-coloured and dark bands and exhibit intricate folding of their bands.

The Schist Belts

Rocks of the schist belts occur predominantly in the Western half of Nigeria. Their lithologic composition ranges from schists through phyllites to pelitic, semi-pelitic, and psammatic rocks as well as marble, quartzite and amphibolite (Obaje et al., 2006). The Schist belts fall into two age groups: The earlier group contains assemblages of mafic igneous rocks, pelitic schists and phyllites, banded iron formation and, locally, coarse grained clastics and carbonate rocks. These belts show complex structural styles and are extensively invaded by granitic plutons belonging to the widely distributed Pan-African magmatic suite. The latter group of schist belts is characterized by coarsed to fine grained clastics, insignificant mafic igneous rocks, a simple, straight structural style and an absence of internal granite plutons

The Older Granites

The Older Granites are widespread throughout the Basement Complex and occur as large circular masses within the schists and the migmatite - gneiss complex. The older granite series comprises mainly granite, granodiorites, diorites, charnokitic rocks and gabbros which intruded during the Pan-African Orogenic Cycle and formed part of the Precambian Basement Complex. The study area, Paiko, consists predominantly of medium to coarse-grained biotite - granite and granodiorites which varies from light coloured to medium dark coloured (Kogbe, 1976) as shown in (Figure 4). The granite types and the granodiorite together form part of the older granite (Rahaman, 1988). Peculiar to the area, is outcropping at different sizes, shapes and locations with noticeable fractures and joints.

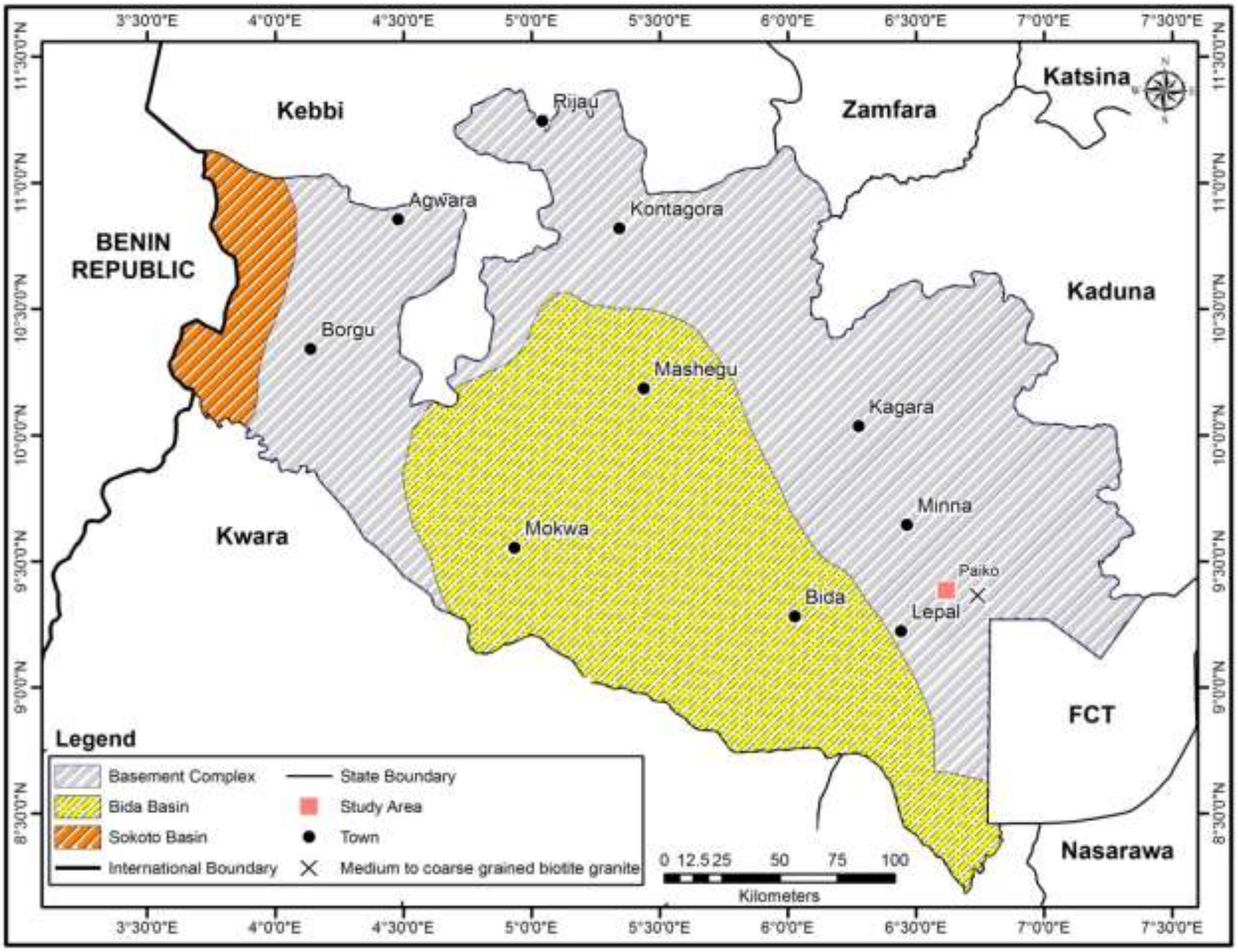


Fig. 4: Geological Map of Niger State showing the Study Area.

Source: Adapted and modified from Niger State Geological Map.

MATERIALS AND METHOD

The principal instrument used for this survey was the ABEM terrameter Signal Averaging System (SAS) 1000 as shown in (Figure 5). No booster was used because the expected depth-to-basement in the area is within the range of penetration of instrument. The resistance reading at every point was automatically displayed on the digital read-out screen and was written down. The Terrameter and other equipment used for this survey are shown in (Figure 3.4). The GARMIN 12 channel personal navigation geographic positioning (GPS) receiver unit was used to take the coordinate of the location of the electrical sounding points and the boundary of the survey area. The site plan of the survey area showing the survey profiles and sounding points is as shown in (Figure 6).

The Vertical Electrical Sounding (VES) using Schlumberger array was used at fifty (50) stations.

Fig. 5: ABEM Terrameter (SAS 1000) and other equipment to carry out the research.

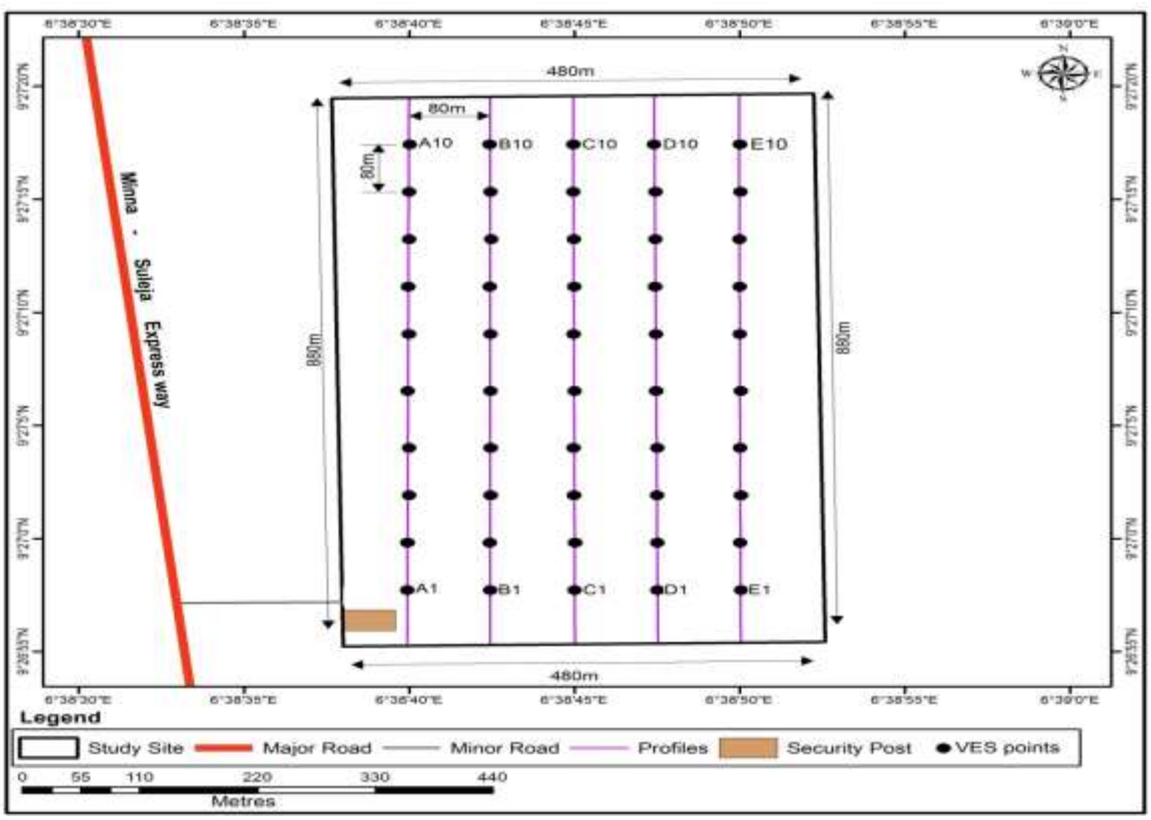


Fig 6: Study Site showing Profiles and VES points.

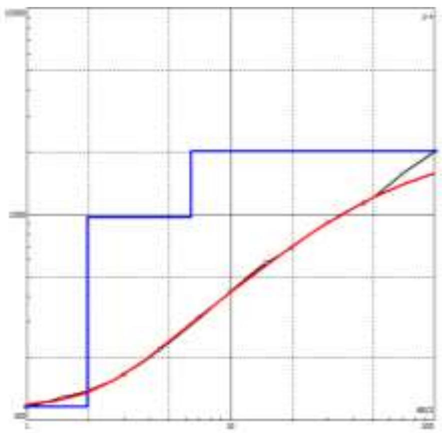
RESULTS AND DISCUSSION

For an analytical discussion of the results of the VES, the geologic equivalent of the geoelectric section for the points were drawn (Figures 8-12), since the interpretation of the collected geoelectrical sounding data is meaningless without some reliable geological control or some data relating to the intrinsic resistivities of the various geoelectric areas (Worthington, 1977).

The field data obtained have been analysed using computer software (IPI2win) which gives an automatic interpretation of the apparent resistivity data. Figures 4.1 is example of curve type and model obtained from VES station A4 as shown in (Figure 7).

The interpretation of this curve was based on the principle that all points of maxima and minima are indicators of different lithologies. Similarly, where the resistivity values tend to infinity is an indication of the fresh basement rock (Telford et al., 1976).

In addition, in order to help see at a glance the resistivity distributions over the whole area, comprehensive subsurface isoresistivity contours at various points at preferred depth were produced. Conversely, depth contours were plotted at various predetermined resistivity values using computer software (Sufer 10.0 model). These plots are presented later on.



N	ρ	h	d
1	117	1.97	1.97
2	968	4.4	6.37
3	2023		

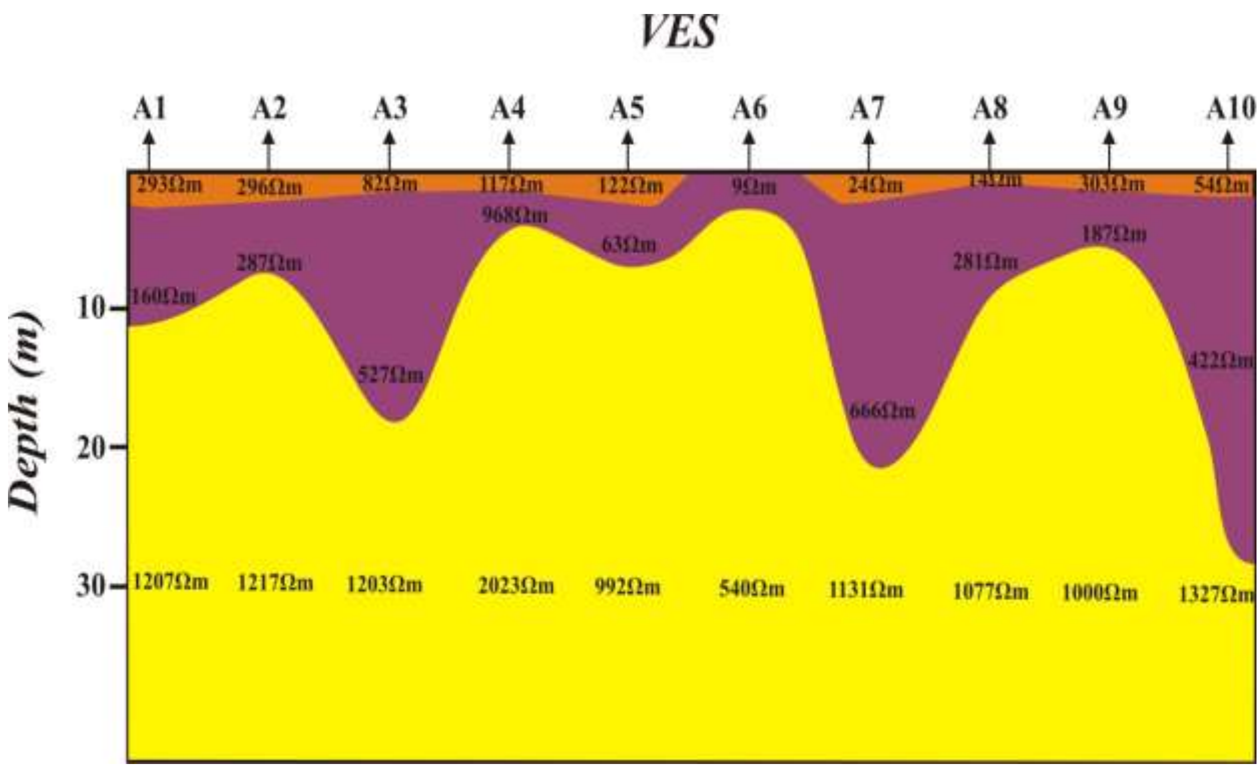
Fig. 7: Curve at VES A4 (TYPE A)

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.

PROFILE "A"

The geoelectric section along this profile, suggests three (3) geoelectric layer cases and a two (2) layer case at VES A6 (Figure 8). The top layer whose resistivity value ranges from 14 to 303Ωm and thickness from 1.39 to 2.55m (except for VES A6 where the top soil has been probably washed by erosion) with the thickest portion at VES A1 (2.55m) is a lateritic and a silty/sandy clay soil. The second layer whose resistivity value ranges from 9 to 968Ωm and thickness from 2.47 to 24.50m with the thickest portion at VES A10 (24.50m) is an indicator of the weathered basement. The third layer which is the fresh basement rock cuts across the entire length of the profile, and is shallowest at VES A6 (2.47m) and deepest at VES A10 (26.8m). The resistivity of this area ranges from 540 to 2023Ωm.



SCALE

HORIZONTAL 2cm: 80m

VERTICAL 2cm: 10m

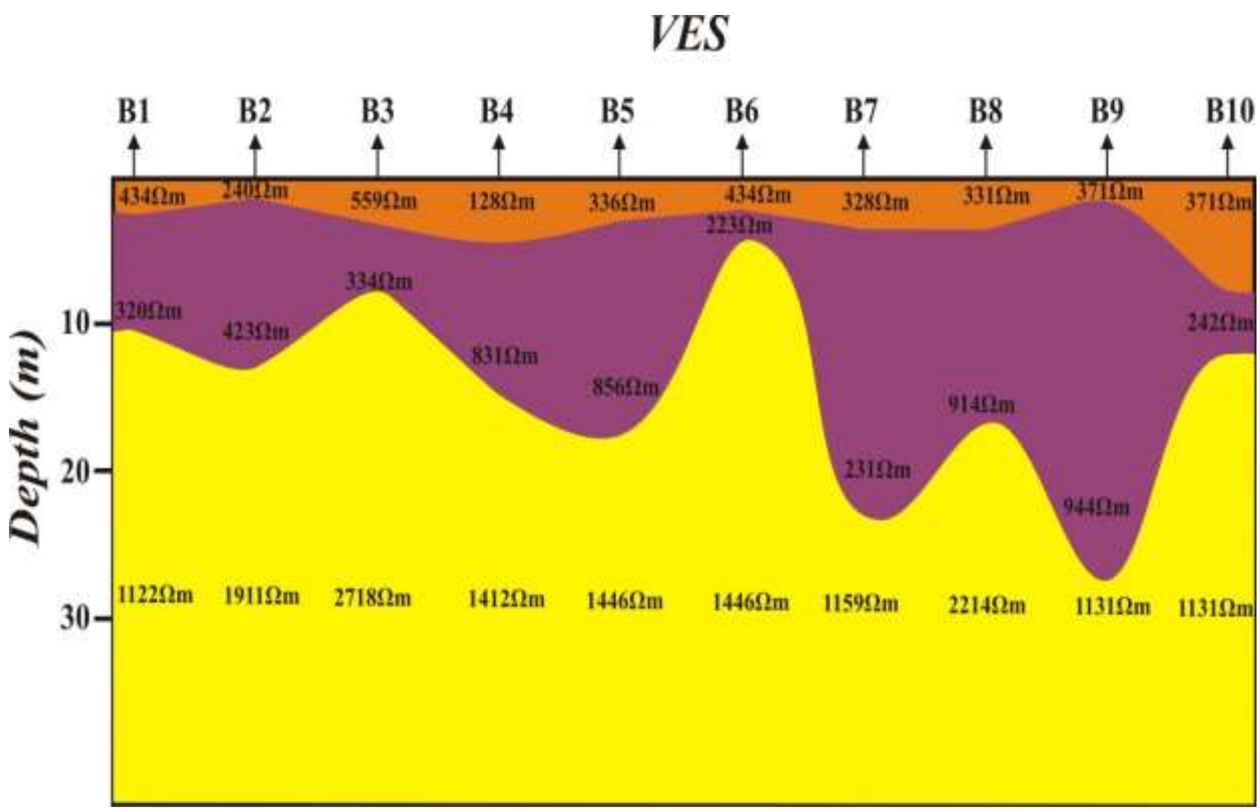
KEY

	TOP SOIL (14Ωm to 303Ωm)
	WEATHERED BASEMENT (9Ωm to 968Ωm)
	FRESH BASEMENT (540Ωm to 2023 Ωm)
↑	VES POINT ON THE PROFILE

Fig. 8: Geoelectric Section along Profile A.

PROFILE "B"

The geoelectric section along this profile, suggests that the subsurface is made up of three (3) layers (Figure 9). The top soil resistivity value ranges from 128 to 559Ωm and thickness ranging from 1.15m at VES B2 to 3.39m at VES B10. The second layer, appearing to be a weathered basement has resistivity ranging from 223 to 944Ωm and thickness ranging from 4.38 to 18.60m. The resistivity of the third layer ranges from 1122 to 2718Ωm. The fresh basement is closer to the surface around VES B6 with resistivity value of 1446Ωm and its highest resistivity value appears at VES B3 with a value of 2718Ωm.



KEY

	TOP SOIL (39Ωm to 564Ωm)
	WEATHERED BASEMENT (130Ωm to 929Ωm)
	FRESH BASEMENT (1068Ωm to 2108 Ωm)
↑	VES POINT ON THE PROFILE

SCALE

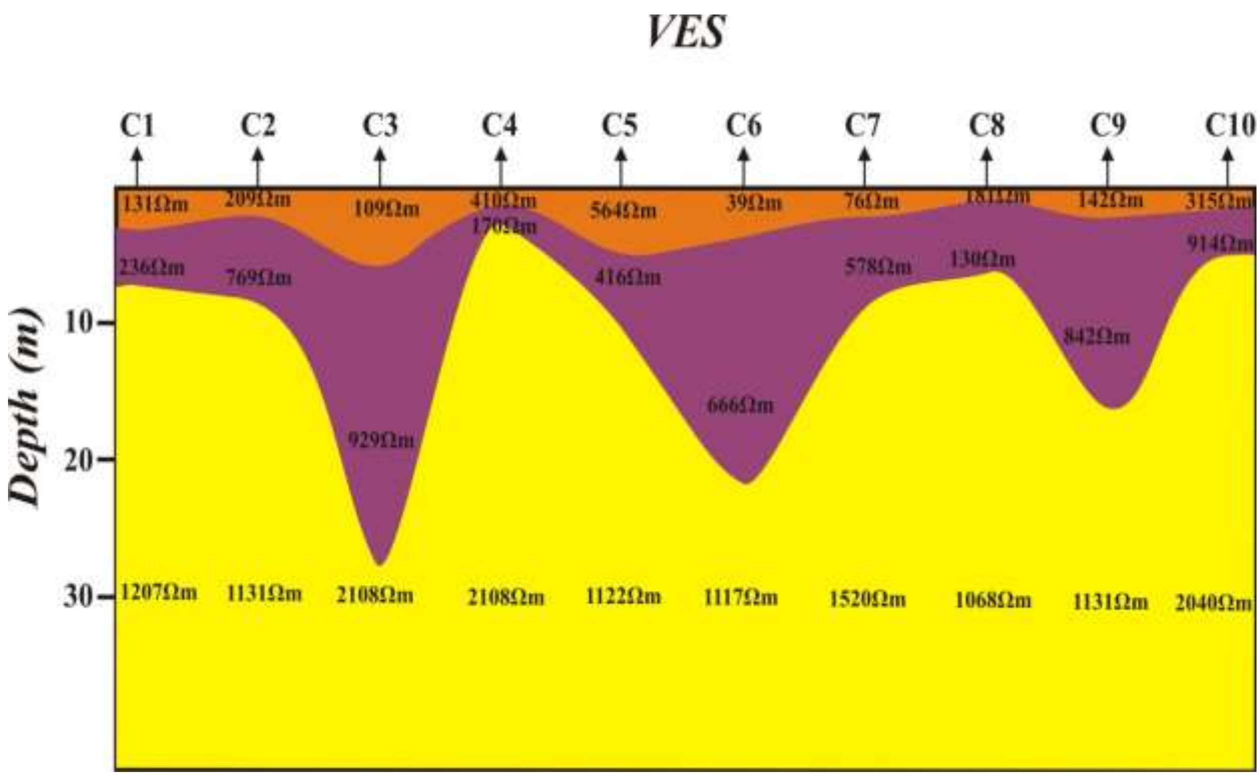
HORIZONTAL 2cm: 80m

VERTICAL 2cm: 10m

Fig. 9: Geoelectric Section along Profile B.

PROFILE "C"

The geoelectric section for this profile shows the presence of three (3) layers (Figure 10). The top layer is thinnest at VES C8 which is 0.98m thick and thickest at VES C3 with a thickness of 3.34m. Its resistivity ranges from 39 to 564Ωm. The thickness of the second layer ranges from 5.08 to 22.70m and its resistivity is between 130 to 929Ωm. The range type here is generally weathered. The third layer is the fresh basement with the resistivity value ranging from 1068 to 2108Ωm. It is shallowest at 6.36m at VES C4 and deepest at 26.04m at VES C3.



SCALE

HORIZONTAL 2cm: 80m

VERTICAL 2cm: 10m

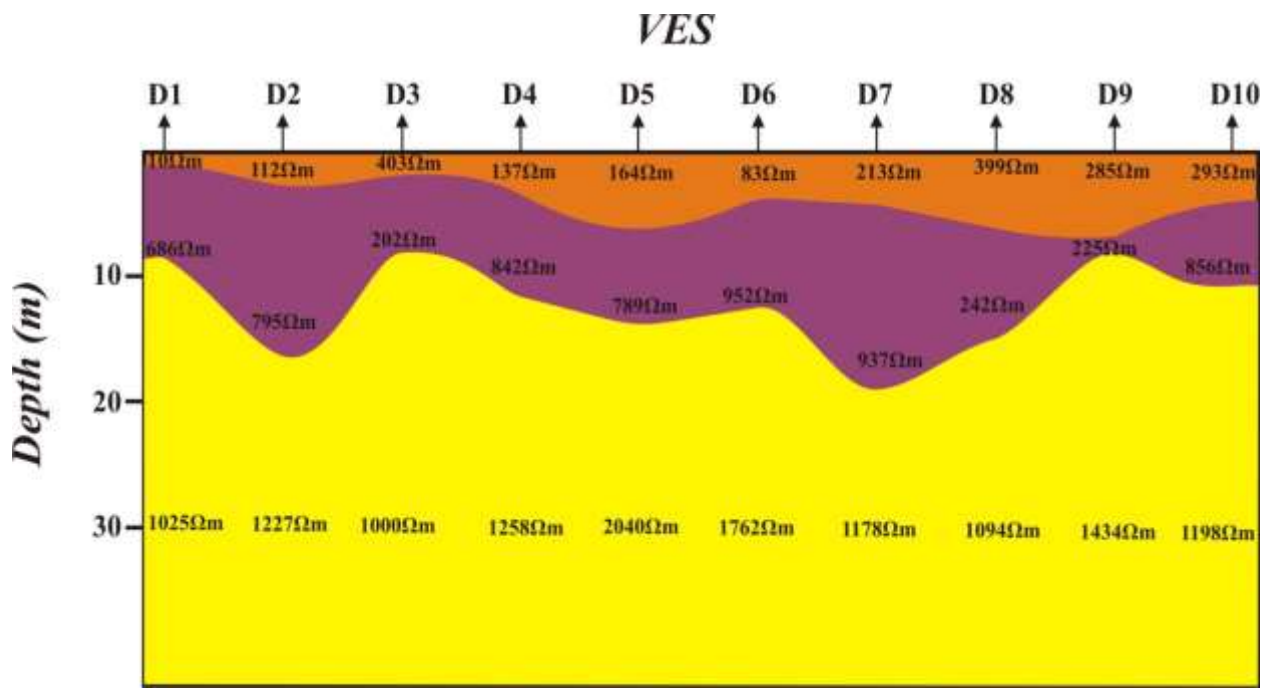
KEY

	TOP SOIL (39Ωm to 564Ωm)
	WEATHERED BASEMENT (130Ωm to 929Ωm)
	FRESH BASEMENT (1068Ωm to 2108 Ωm)
↑	VES POINT ON THE PROFILE

Fig. 10: Geoelectric Section along Profile C.

PROFILE "D"

The geoelectric section for this profile shows three (3) layers extending all along its length (Figure 11). The topsoil has resistivity ranging from 10 to 403Ωm and thickness ranging from 1.26 to 4.23m. The second layer of the geoelectric section also suggests that the thickest portion is at VES D7 with a thickness of 16.20m and thinnest at VES D9 with a thickness of 3.28m. The resistivity ranges between 202 and 952Ωm. The third (3) layer with resistivity value as low as 1000Ωm and as high as 2040Ωm appears to be the fresh basement. The shallowest depth of the fresh basement was found to be about 7.51m at VES D9 and deepest at depth 18.16m at VES D7 along the chosen profile of the study area.



SCALE

HORIZONTAL 2cm: 80m

VERTICAL 2cm: 10m

KEY

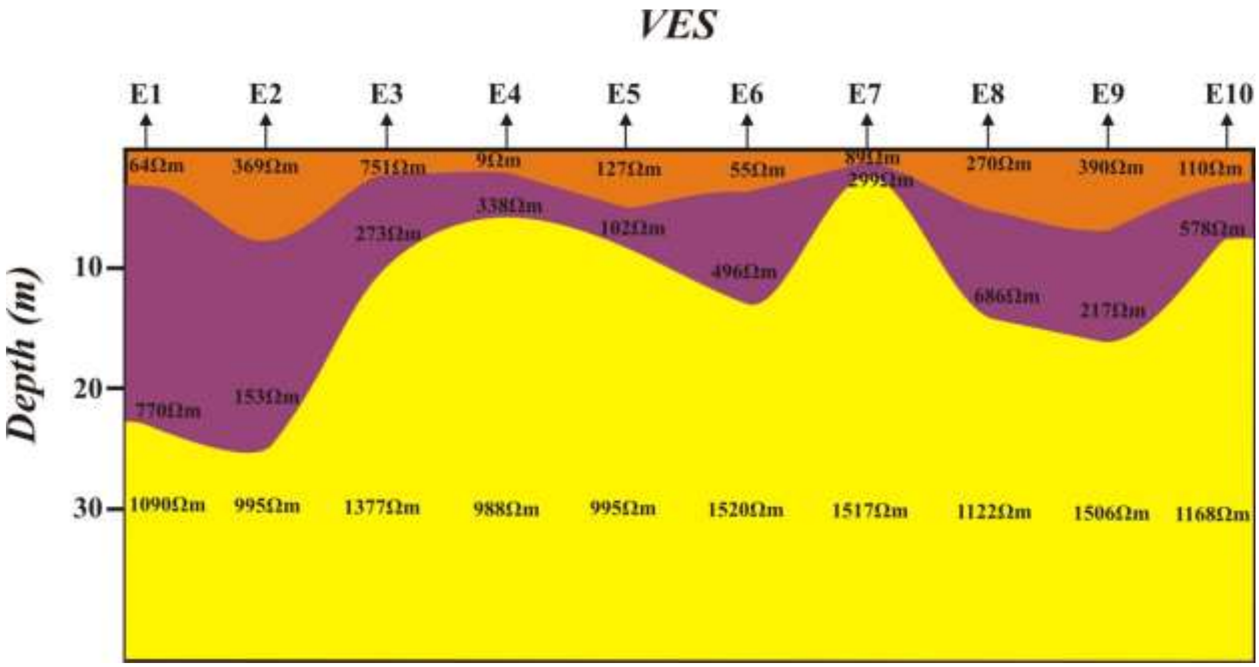
	TOP SOIL (39Ωm to 564Ωm)
	WEATHERED BASEMENT (130Ωm to 929Ωm)
	FRESH BASEMENT (1068Ωm to 2108 Ωm)
↑	VES POINT ON THE PROFILE

Fig. 11: Geoelectric Section along Profile D

PROFILE "E"

The geoelectric section along this profile suggests three (3) layers extending all over the profile, (Figure 12). The topsoil has resistivity ranging from 9 to 751Ωm and thickness ranging from 1.34m at VES E7 to 3.96m at VES E2. The geoelectric section also suggests that the second layer (weathered basement) is thickest at VES E1 with a thickness of 20.80m and thinnest at VES E7 with thickness of about 0.67m. The resistivity value ranges from 102 to 772Ωm.

The third layer which is the fresh basement has resistivity value as low 988Ωm and as high as 1520Ωm. The shallowest depth to the fresh basement (bedrock) was found to be 2.01m at VES E7 and the deepest is 24.26m at VES E2.



SCALE

HORIZONTAL 2cm: 80m

VERTICAL 2cm: 10m

KEY

	TOP SOIL (39Ωm to 564Ωm)
	WEATHERED BASEMENT (130Ωm to 929Ωm)
	FRESH BASEMENT (1068Ωm to 2108 Ωm)
↑	VES POINT ON THE PROFILE

Fig. 12: Geoelectric Section along Profile E.

Isoresistivity Contour Maps

The Isoresistivity contour maps have helped to show at a glance the resistivity distributions over the whole area at preferred depths. This work shows the isoresistivity map at 5.00m, 15.00m, and 27.00m depth respectively as shown in Figures 13 to 15 below.
Figure 13 show that the regions around VES E3, C5 and B3 have the highest resistivity values at depth 5.00m, while most of the other areas such as VES E4, A6 and A8 have low values due to the layer of silt and clay at the top layer (topsoil). However, the highly resistive area may indicate high content of sand and silt mixed with the lateritic topsoil at this depth.
Figure 14 shows a high resistivity value around VES A4, D6 and C10 and D10 which is an indication of outcrop of fresh basement; while other areas such as VES A5, C8 and A1 have very low resistivity values, which is an indication that the topsoil has been exceeded and another layer (weathered basement) that is water bearing has been reached.
In Figure 15, areas such as VES B9, D7, and C3 have very high resistivity values (low conductivity) this is because the rock in those areas are still very fresh compared to areas such as VES E2 and B7 with very low resistivity values because the rock in those areas are highly weathered.

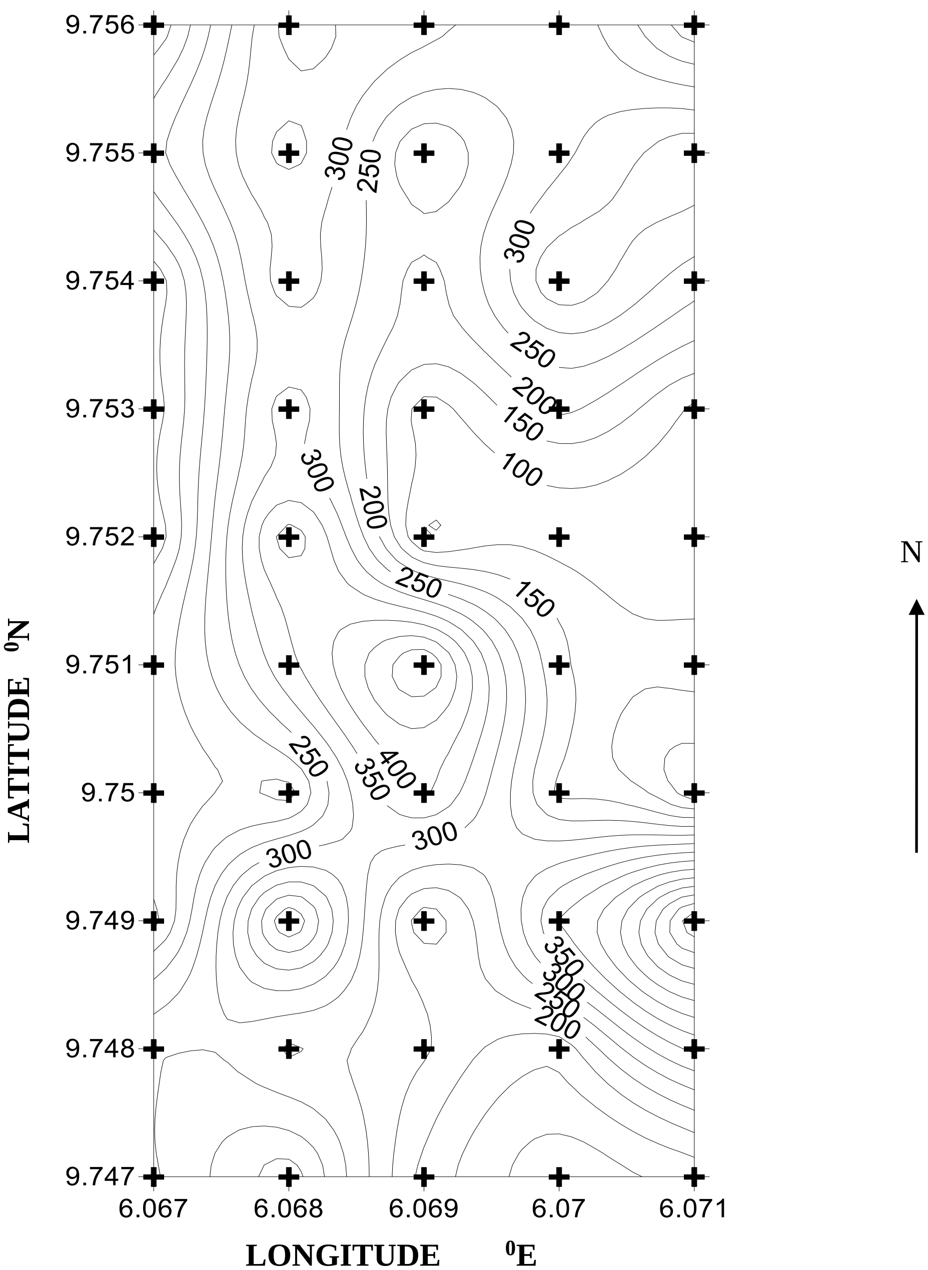


Fig. 13: Isoresistivity map at 5.00m depth. Cont. Int. 50Ωm.

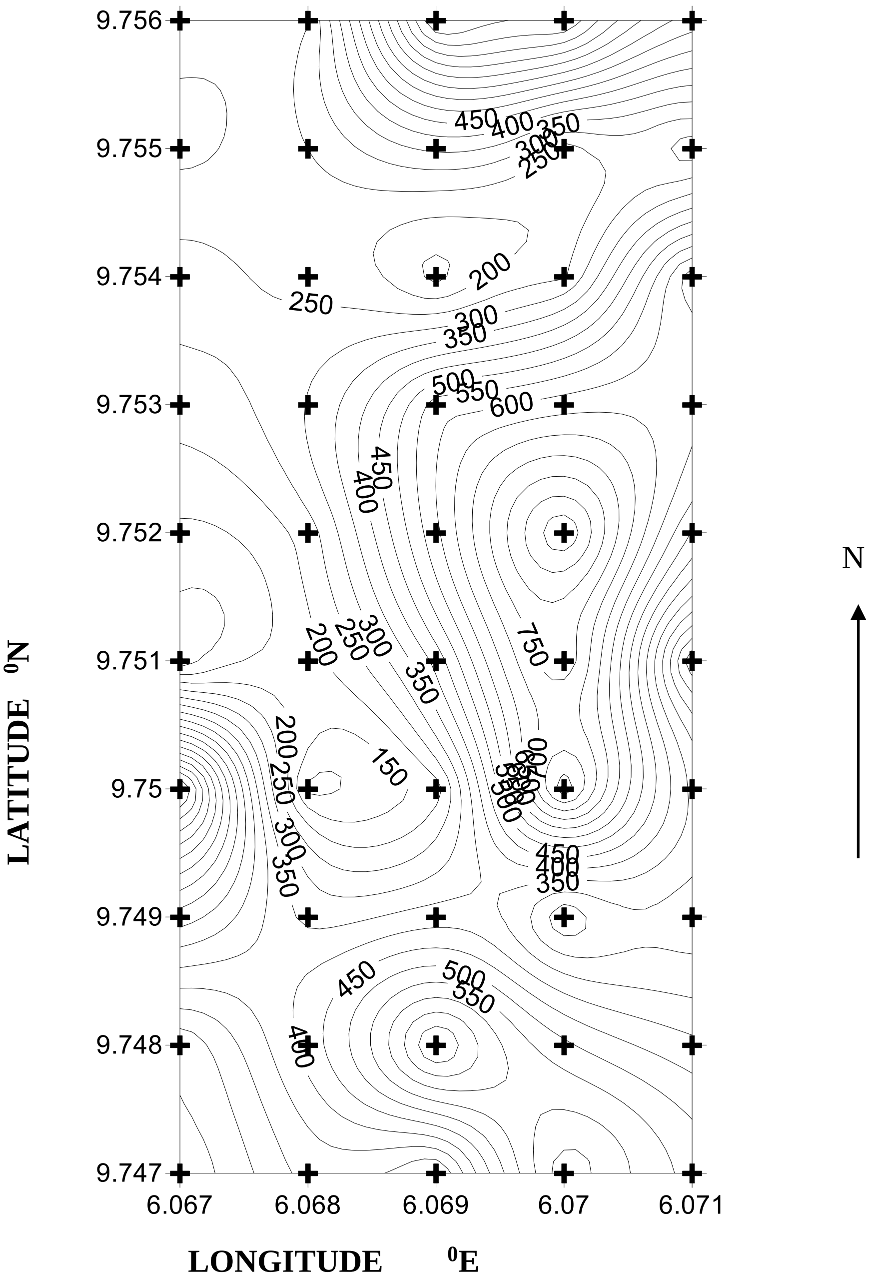


Fig. 14: Isoresistivity Map at 15.00m depth. Cont. Int. 50Ωm.

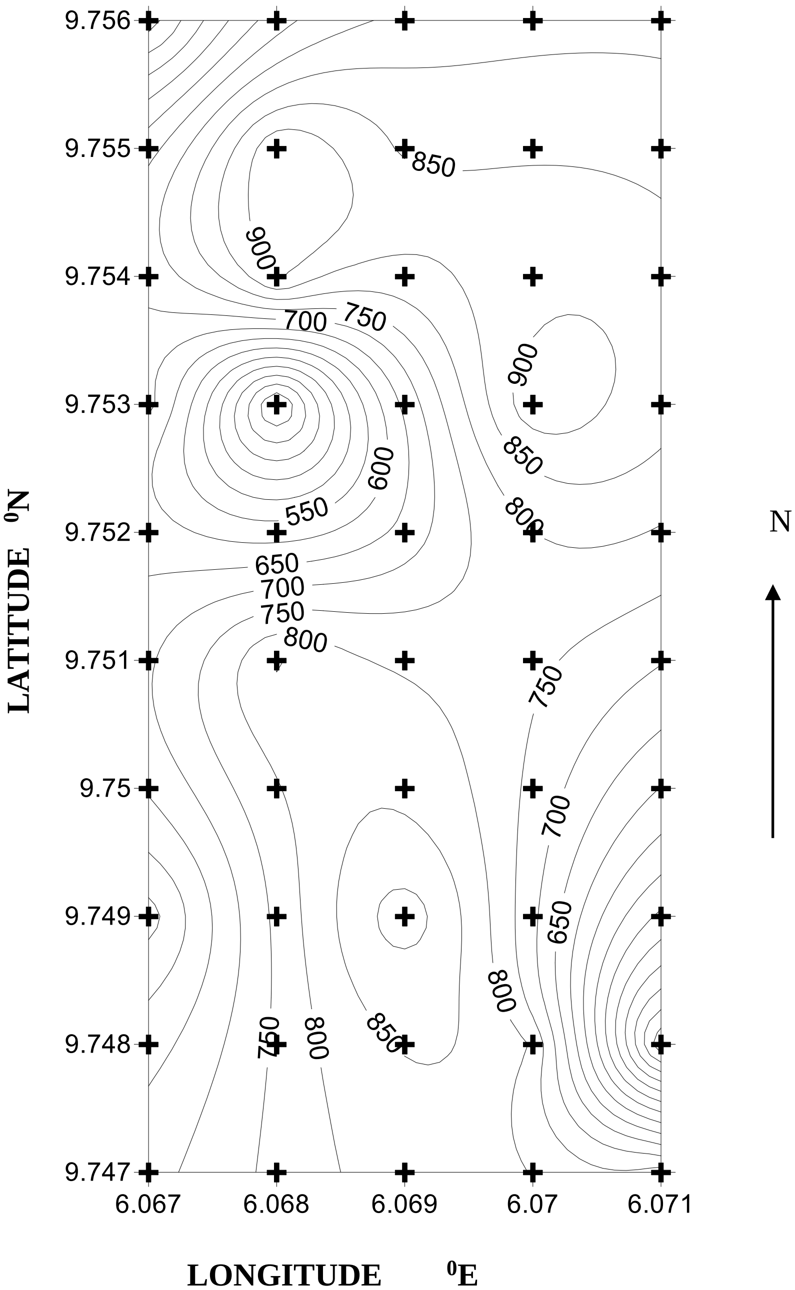


Fig. 15: Isoresistivity Map at 27.00m depth. Cont. Int. 50Ωm.

Depth-to- Bedrock map.

The IPI2win software used for the interpretation of this work generates sets of depths with the corresponding resistivity values for each layer.

The depth estimates (sum of thicknesses from topsoil to fresh basement) gives the depth to the fresh basement (or bedrock depth) which is the last depth.

These data are used to plot the depth-to-bedrock contour map and their corresponding fresh basement resistivity values (Figure 16) by picking all depth data corresponding to the resistivity assumed for bedrock at all VES points.

Figure 16 is an overlay of the depth to fresh basement and resistivity distribution within the survey area. The contour map represents the depth to basement distribution, while the image map shows the resistivity distribution within the area of study. It can be seen that the bedrock is shallowest at VES E7 with a depth of about 2.01m and deepest at A10 with a depth of about 26.81m, both VES points fall within intermediate resistivity range as shown in figure 16. A surface plot for the bedrock is shown in Figure 17 which is a representative of the bedrock topography.

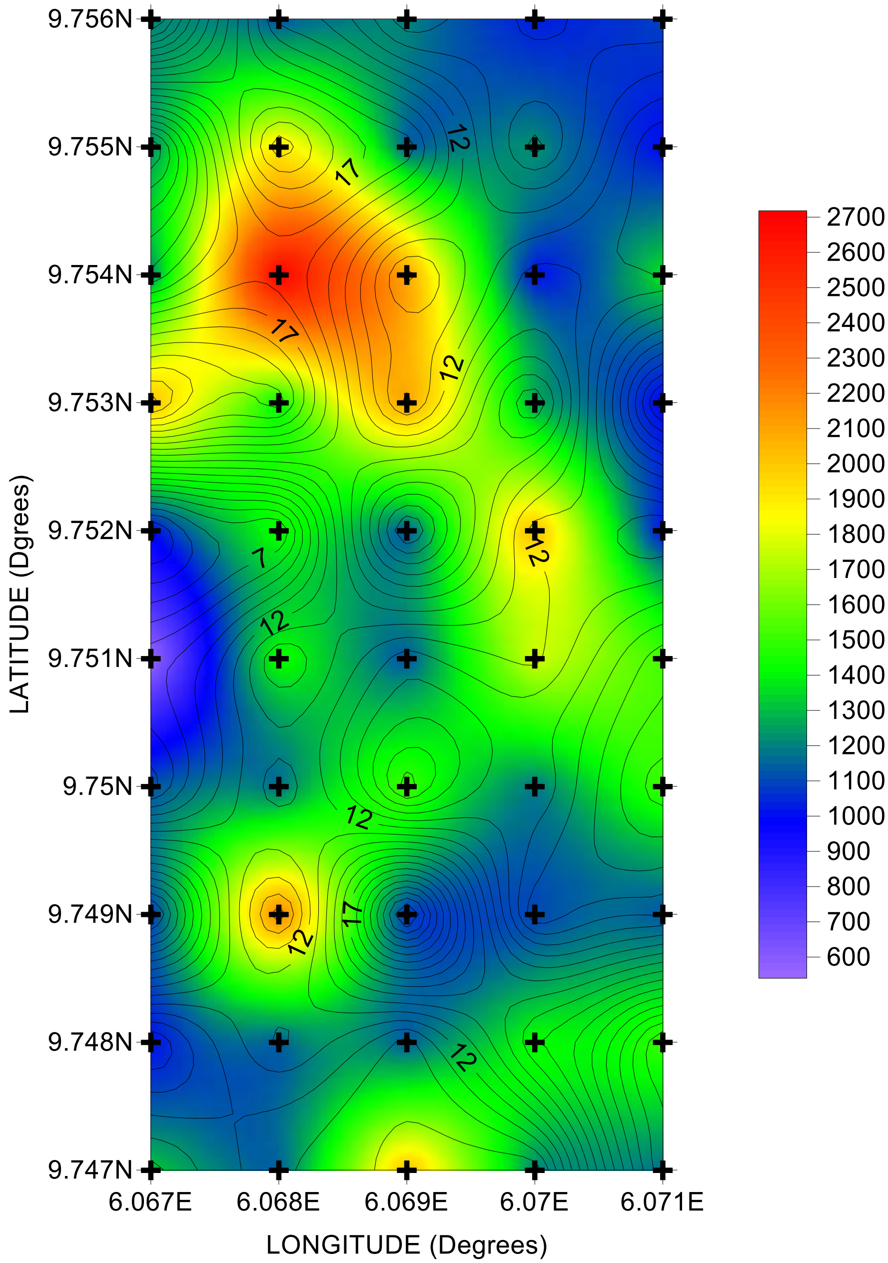


Fig. 17: Depth-to-Bedrock Contour map and Fresh Basement resistivity distribution. Cont. Int. 1.00m.

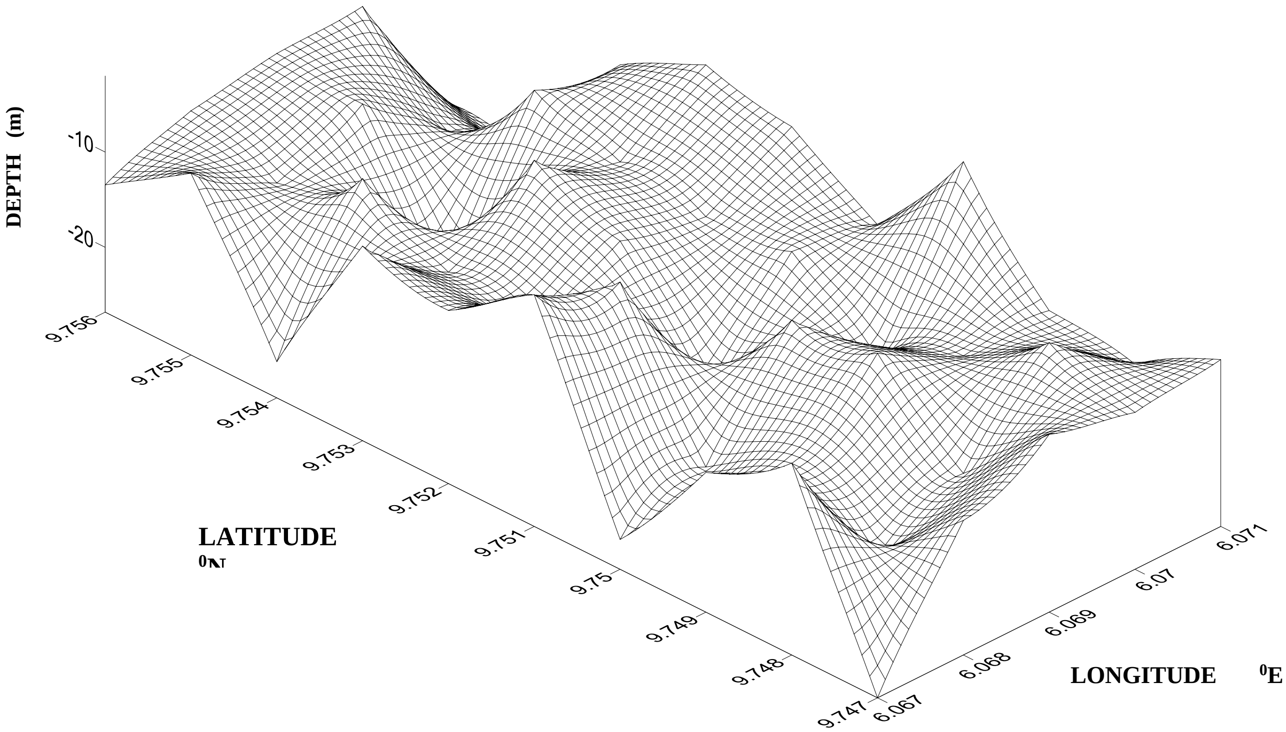


Fig. 17: Surface Plot of the Bedrock.

Depth-to-and thickness of Weathered Basement maps

In achieving depth to the weathered basement and thickness of the weathered basement, data of depths to the weathered basement (thickness of the topsoil) with the corresponding resistivity values at each VES stations were used (Figure 18). The same process was followed using the resistivity values for the weathered basement at each VES stations and their corresponding thicknesses distribution to plot the map of the weathered basement thickness with their resistivity (Figures 19). Figure 19 shows that weathered basement is deepest at VES D9 with a depth of about 4.23m. The thickest portion of the weathered basement indicated by Figure 4.18 is about 24.50m which is at VES point A4 and the thinnest portion is at VES point E7(0.67m) with resistivity value as 299Ωm.

The VES carried out at fifty (50) stations aided in deriving geoelectric sections along five (5) profiles. These revealed that there are mostly three geoelectric layers (3 - layer cases) beneath each VES station, and a two layer geoelectric case at VES A6. The predominant layers are: the topsoil consisting of lateritic and silty/sandy clay soil. The resistivity of this layer is as low as 10Ωm and as high as 751Ωm, while the thickness ranges from 0.98m at VES C8 to 4.23m at VES D9 (except for VES A6 where the top soil has been probably washed by erosion). The weathered basement formed the second layer on each profiles (except for profile A, VES A6 where the top soil has been probably washed by erosion and the weathered basement became the first layer) with the resistivity value as low as 9Ωm and as high as 968Ωm on some profiles. The weathered basement is considered as the aquifer and the thickness ranges from 0.67m at VES E7 to 24.50m at VES A10. The shallowest depth to bedrock is 2.01m at VES E7 and the deepest is 26.81m at VES A10. The third layer is the fresh basement whose resistivity is as high as 2718Ωm. The aquifer in the area is deepest at 10.00m.

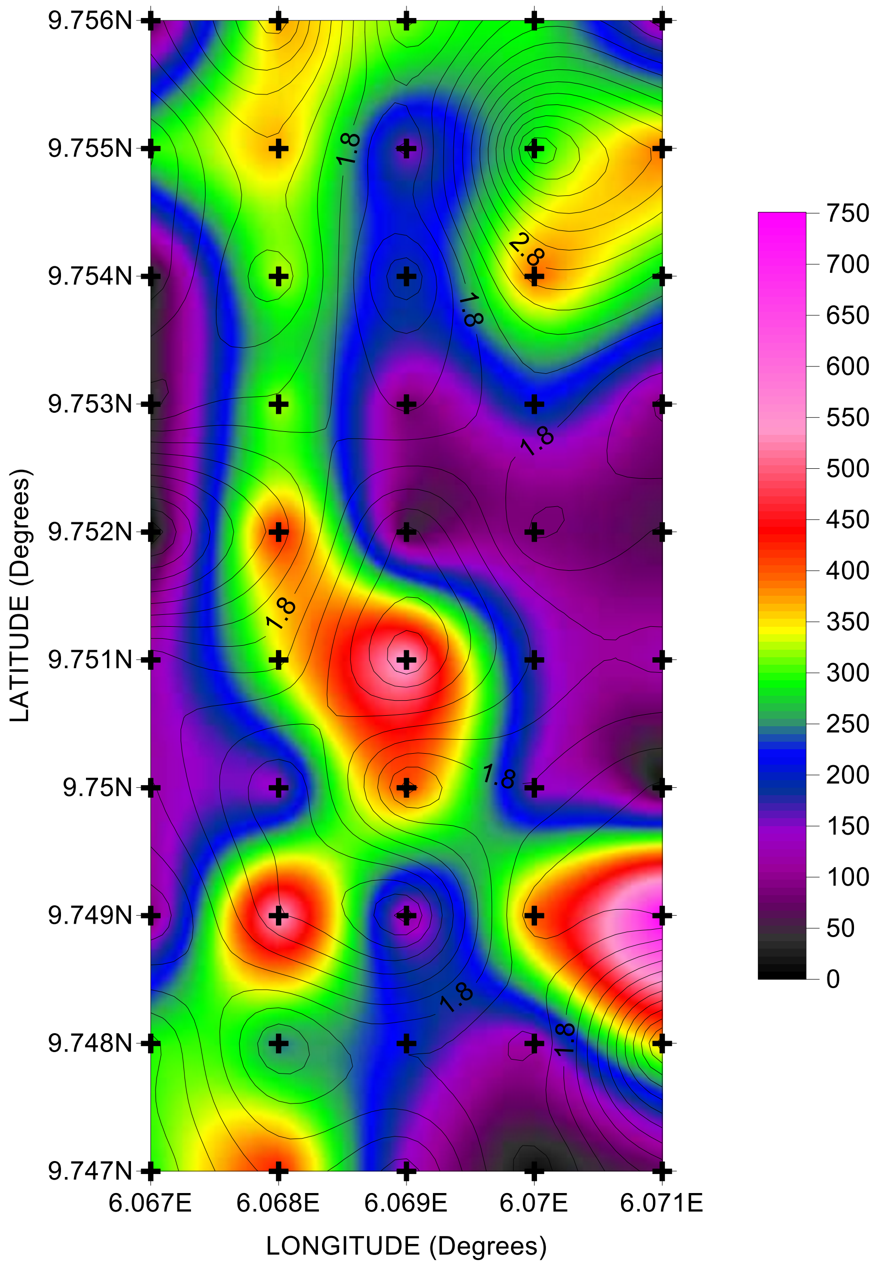


Fig. 18: Depth-to-Weathered Basement Contour map and Weathered Basement resistivity distribution. Cont. Int. 0.20m.

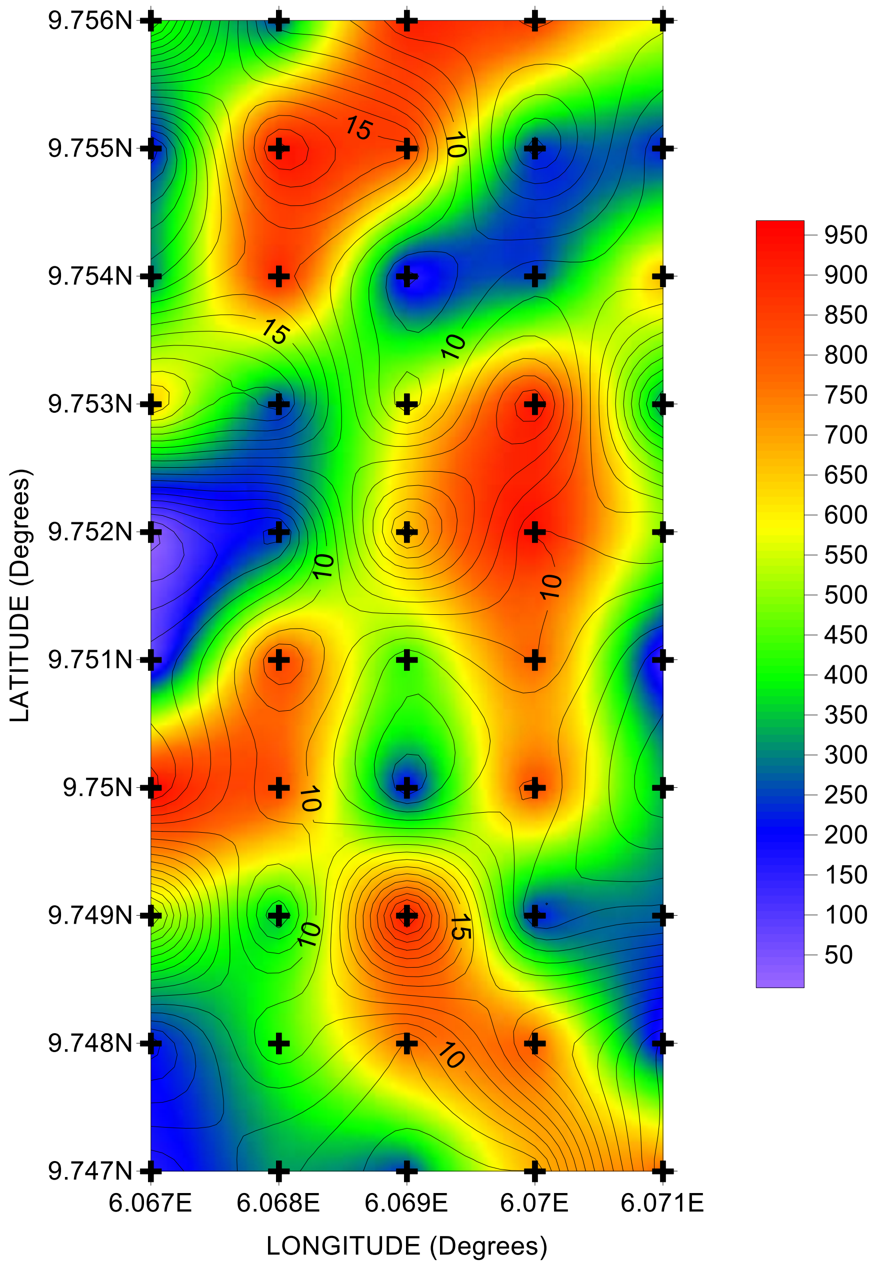


Fig. 19: Thickness of Weathered Basement Contour map and Weathered Basement resistivity distribution. Cont. Int. 1.00m.

CONCLUSION

In this work, the electrical d.c. resistivity method was employed to establish fifty (50) VES points which offered complimentary solution to the problem of this investigation. The study area is mostly characterized by three (3) layered geoelectric sections which include the topsoil, weathered basement and fresh basement. The topsoil has resistivity ranging from 10 to 751Ωm. The weathered basement has resistivity ranging from 9 to 968Ωm with depth to it ranging from 0.98 to 4.23m. The topsoil is lateritic and silty/sandy clay, associated with the weathering of sulphide minerals from the underlying granitic rocks. They have great amount of dissolved salts resulting in low resistivity values. The weathered basement is deepest around VES D9 with a depth to it of 4.23m. The thickest portion of the weathered basement is 24.50m at VES A10. The weathered basements are medium to fine grain porous or fractured rocks containing water. They are referred to as the aquiferrous zone. Highly fractured areas have low resistivity because of its high degree of saturated water implying that their resistivity is greatly influenced by underground water. The fresh basement has its deepest part at VES A10 of 26.81m located along profile A. The fresh basement rocks are coarse, close grained (plutonic or intrusive) rocks, constituting the rock forming minerals which are poor conductors.

The study area is found to have shallow depth to the fresh basement (about 5.00m). The following areas can be used for siting boreholes: VES A1, A3, A7, A8, A10, B2, B4, B5, B7, B8, B9, C3, C6, C9, D2, D7, E1, E2, E8 and E9. These points have considerable thickness of weathered basement (fractured zone thickness > 10.00m) which can be a good water aquifer i.e. have identified elements for groundwater storage such as high porosity, permeability and less consolidation.

Strategic areas for siting high-rise buildings may include: VES A4, A9, B1, B6, C4, D3, E3 and E4. These are areas with shallow depths to the bedrock (5.00 to 10.00m) and also thin topsoil (thickness < 5.00m) because of the lateritic and silty/sandy clayey nature of the topsoil. The consolidated basement (bedrock) can serve as pillar supports for buildings. Since the study area has shallow depths to the bedrock and water aquifer, the depth of sewage system should be less than 10.00m to the aquiferrous zone (weathered basement) in order to avoid groundwater contamination.

There is no known geophysical survey that has been carried out in the site. However, this survey revealed that the depth to the basement was found to be about 5.00m. The depth to the aquiferrous zone was also found to be about 10.00m and therefore the depth of sewage system should be less than 10.00m in order to avoid groundwater contamination.

REFERENCES

Ajibade, A.C. (1982): The origin of the Older Granites of Nigeria, some evidence from the Zungeru region. Nigerian Journal of Mineralization Geology, 19(1), 223–230.

Ajibade, A.C. and Woakes, M. (1976): Proterozoic crustal development in the Pan-African Regime of Nigeria, In: C.A. Kogbe (Editor) Geology of Nigeria; Published by Rock View (Nigeria.) Ltd., 57–63.

Blyth, K.T. and Freitas, G.P. (1988): Behaviour of Foundation and Structures', in proceedings of the 9th International Conference of Soil Mechanics, Tokyo, Session 2, 8-10.

Gomes, N. (2006): Access to Water, Pastoral Resource Management and Pastoralists' Livelihoods; Lessons Learned From Water Development in Selected Areas of Eastern Africa (Kenya, Ethiopia and Somalia); In NATIONS, Food And Agriculture Organization Of The United Nations (F. A. A. O. O. T. U. N). Livelihood Support Programme Working Paper 26, Access to Natural Resources Sub-Programme.

Kogbe, C. A., (1976): Geology of Nigeria (2nd Revised Edition). Rockview Publishing Company, Jos, Nigeria, 531–538.

McCurry, P. (1976): The Geology of the Precambrian to Lower Palaeozoic rocks of Northern

Nigeria-a review in: C.A. Kogbe (Editor), Geology of Nigeria. Elizebethan Publishing Company, Lagos, 15–39.

Obaje, N.G., Lar, U.A., Nzegbuna, A.I., Moumouni, A., Chaanda, M.S. and Goki, N.G. (2006): Geology and Mineral Resources of Nasarawa State, an investor Guide. Elizabethan Publishers, Lagos, 21-34.

Offodile, M.E. (1992): An Approach to Groundwater Study and Development in Nigeria. Mecon Services Ltd., Jos, Nigeria, 224-236.

Olarewaju, V.O., Olorunfemi, M.O. and Alade, O., (1996): Chemical Charateristicts of Groundwater from some Parts of the Basement Complex of Central Nigeria. Journal of Mineralization Geology, 33 (2), 135-139.

Olasehinde, P. I., (1999): An Integrated Geological and Geophysical Exploration Technique for Groundwater in the Basement Complex of West Central Part of Nigeria. Journal of National Association of Hydrogeologist (Water Resources), 10 (1), 46-49.

Omoyoloye, N.A., Oladipo, M.I. and Adeoye, O.O. (2008): 'Engineering Geophysical Study of Adagbakuja Newton Development, Southwestern Nigeria. Medwell Online Journal of Earth Science, 2(2), 55-63.

Rahaman, M.A. (1988): Recent Advance in the study of the Basement Complex of Nigeria, Symposium on the geology of the Basement Complex of Nigeria, Obafemi Awolowo University, Ile-Ife, Nigeria (doi:1016/0899-5362(91)90102-5), 7(2), 223-228.

Telford,W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., (1976): *Applied Geophysics*. Cambridge University Press, London, 620 - 623.

Worthington, P.F., (1977): Geophysical Investigation of Groundwater Resources in the Kalahari Basin, Geophysics, 42, 838 – 849.