GROUNDWATER EXPLORATION AT THE SOUTH-WESTHERN PART OF MAIKUNLKELE VILLAGE, NIGER STATE NIGERIA, USING ELECTRICAL METHOD

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Abstract
A conventional D.C Vertical Electrical Sounding (VES) Survey was carried out in Government Day Secondary School Site, Maikunkele Minna, Nigeria. It lies between latitudes 09^{0}40'37.17" to 09^{0}41'37. 15"N and longitudes 06^{0}29'51.66" to 06^{0}30'51.55"E in the Basement complex region of Nigeria. The survey was carried out with the aim of determining the ground water potential of the area, the technique employed in this study is the Vertical Electrical Sounding (VES) using Schlumberger configuration. A total of 30 vertical electrical sounding (VES) points were located on grid profiles separated at 100 m interval between profiles. The data obtained from the field were subjected to geophysical interpretation with the help of a computer based program called WinResist software. Result from both the iso-resistivity plots and the vertical sections indicate three geological sections which are the topsoil whose resistivity ranges from 10 Ωm to about 400 Ωmat various depths from 0 m to 1 m the second layer are laterite in some places such as profiles C, D and E and weathered /fractured basement on profiles A and B its depth extend to about 10 meters in most cases, with resistivity below 500 Ωm. The third layer which is fresh basement on profiles A and B and parts of C is majorly weathered basement on profiles D, E and some parts of C. the result of this investigation reveals that points located within profiles D and E falls within weathered basement to a depth of about 30 meters and can be recommended for any bore hole drilling for efficient fresh water production.

Keyword: *Lithology, Aquifer, Geoelectric, Basement, Vertical Electrical Sounding (VES)*

Introduction
More than 300 million people in Africa today do not have access to clean water (Water for Africa, 2010). Many communities meet their daily water need from rivers, lakes, or reservoirs, sometimes using aqueducts or canals to bring water from distant surface water sources (Plummer *et al.,* 1999; Water for Africa, 2010). Another important and more improved source is groundwater, the water that lies beneath the ground surface, filling the pore space between grains in bodies of sediment and clastic sedimentary rock, and filling cracks and crevices in all types of rock. The source of groundwater is rain and snow that falls to the ground. A portion of this precipitation percolates down into the ground to become groundwater. How much precipitation soaks into the ground is influenced by climate, land slope, soil and rock type, and vegetation. In general, approximately 15% of total precipitation ends up as groundwater, but that varies locally and regionally from 1 to 20%. Despite the fact that global water distribution shows that groundwater is about 0.61%, it is surprisingly, about 60 times as plentiful as fresh water in lakes and rivers on the surface (Plummer *et al.,* 1999; Water for Africa, 2010).

Groundwater is therefore, a tremendous major economic resource, particularly in most cities of Nigeria where portable water is scarce. Many homes and organizations pump their required quantities of water from the ground because groundwater is commonly less polluted and more economical to use than surface water (Plummer *et al*., 1999). Electrical resistivity survey is relevant to groundwater exploration (Olasehinde, 1999; Nwankwo *et al.,* 2004; Singh et al., 2006; Alile *et al*., 2008; Ariyo & Adeyemi, 2009; Anudu, *et al.,* 2011; Oyedele *et al.,* 2011). The resistivity of rocks is strongly influenced by the presence of groundwater, which acts as an electrolyte. The minerals that form the matrix of a rock are generally good resistors than groundwater, so the resistivity of sediment decreases with the amount of groundwater it contains. This depends on the fraction of the rock that consists of pore spaces and the fraction of this pore volume that is water filled (Lowrie, 1997).

Among the geoelectrical methods, vertical electrical sounding techniques have been frequently used in hydrogeophysical studies for groundwater in both porous and fissured media (Onuoha & Mbazi, 1988; Mbonu *et al*., 1991; Franjo *et al.,* 2003). This method is based on the response of the earth to the flow of regulated input dc current source. The VES method was chosen for Maikunkele study area because it has proven to be an economic, quick and effective means of solving most ground water problems in different parts of the world (Brusse, 1963, Zohdy & Jackson, 1969; Frohlich, 1974). This study is to investigate the subsurface hydrogeological conditions and to assess the ground water potentials of the area. The main objectives are to delineate probable confined and unconfined aquifers that could be developed into productive boreholes. This will entail the estimation of geoelectric parameters (layer thickness and resistvities) from field geoelecctrical measurements. The results from these would then be used to draw conclusion to locate the possible sites within the study area where ground water development could be better sited.

Statement of the Problem

Meeting the growing demand of easy access to potable water which is inadequate in the study area because due to inadequate distribution systems. The problem of obtaining adequate supply of quality water is generally becoming more acute in the study area due to ever increasing population and industrialization.

Location and Accessibility of the Study Area

The study area Government Day Secondary School site is located between latitudes $09^0$40′37.17″ to $09^0$41′37. 15″N and longitudes $06^0$29′51.66″ to $06^0$30′51.55″E (Figure 1.1). The area lies within the south western part of Minna metropolis and is accessible through Minna-Zungeru-Kontagora road. The area has a typical Guinea savannah climate with distinct wet and dry seasons: A dry season which usually last from December to March and an accompanied rainy season which last from April to October.

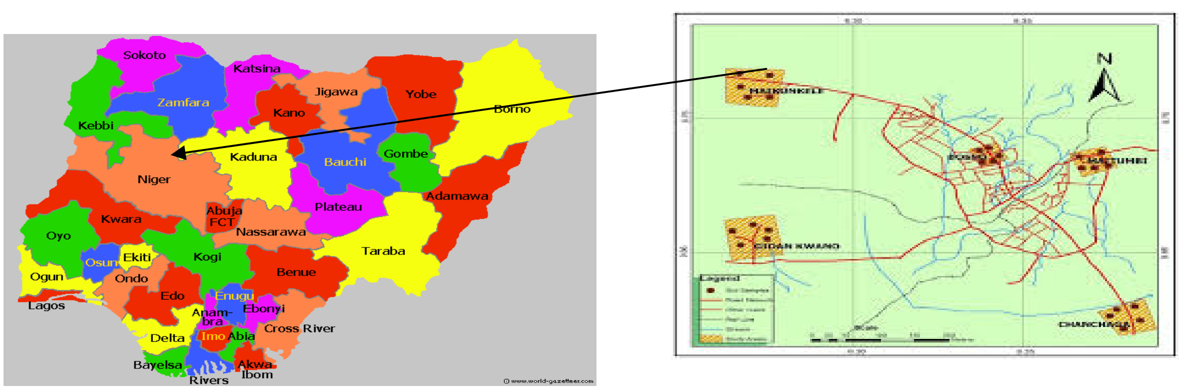


Figure 1: Location Map of the Study Area

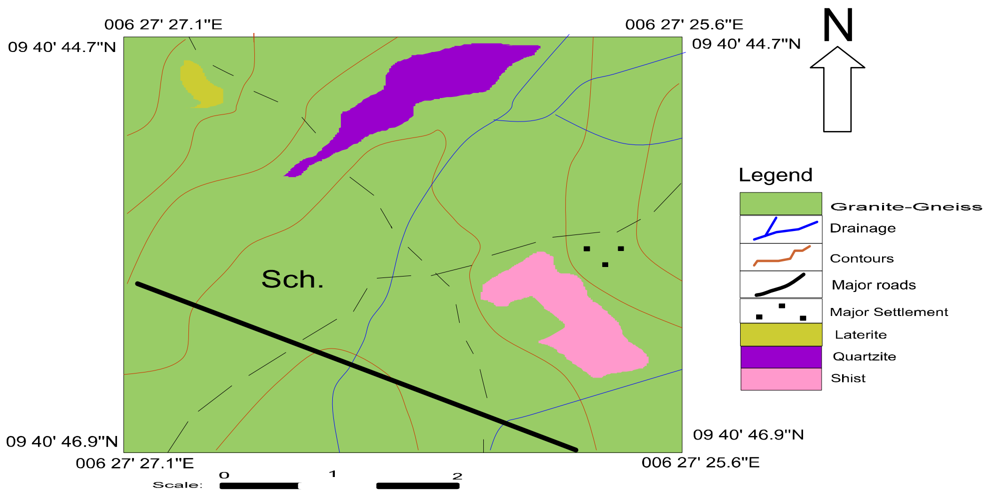


Figure 2: Geological Map of the Study Area

The geology of the study area is part of Minna Sheet 164 and falls within the Basement Complex Terrain of Nigeria. The Nigerian Basement Complex forms part of the ancient African shield, bordered to the west by West African Cratonic Plate and underlies about 61% of Nigeria's land mass. The rock types found in the study area consists redominantly of coarse-grained biotite granite and granodiorite. The granite types and the granodiorite together form part of the older Granite. The geology of the study area is part of Minna Sheet 164 and falls within the Basement Complex Terrain of Nigeria. The Nigerian Basement Complex forms part of the ancient African shield, bordered to the west by West African Cratonic Plate and underlies about 61% of Nigeria's land mass. The rock types found in the study area consists predominantly of coarse-grained biotite granite and granodiorite. The granite types and the granodiorite together form part of the older Granite. The study area is underlain by Precambrian rocks of the Nigerian basement complex and consists of crystalline rocks mainly of older granite series formed during the Pan Africa Orogeny. The older granite consisting pagmatites, quartz veins, porphrics granites, gneisses are present. The hydrogeology of the study area is controlled by the vegetation rainfall, vegetation cover and evapotranspiration and the general geology of the area. The geology of the area serves as the ground water reservoir while rainfall is the dominant source of the ground water. These factors are responsible for the number of aquifers to be encountered and the means of recharging them.

Methodology

The procedure employed in this research is as follows:

i. Profile laying
ii. data collection
iii. data analysis
iv. interpretations
v. and conclusions

Geotron terrameter with model number 41 was used throughout to collect both current and voltage readings which were later converted to resistance values with the help of Ohm's law (R =V/I). The resistance value multiplied by the geometric factor (K-factor) gives the resistivity.

VES points D1 to D6 made up of profile D and VES points E1 to E6 made up of profile E. In order to accurately locate the VES points even after the field survey, GPS was used to collect the coordinate and topography readings for each VES point.

Finally, the terrameter was set up by inserting both the current and potential electrode into the ground while ensuring tight connections of the terminal.

Data Collection

The study area was gridded as shown in Figure 3.1, the survey area was covered by five (5) profiles and each profile was 500 m long. The inter grid spacing and that of inter-profile spacing was 100 m apart respectively. The terrameter model Geotron 41 was used to collect data for about Thirty (30) VES points using the Global Positioning System (GPS) to locate the sounding points appropriately. The Schlumberger configuration method was used in taking the data. This array is the most widely used of all other configuration in vertical probing.

Data Presentation

Ohm's law ($R = \frac{V}{I}$) was used to estimate the resistance and later multiplied by the geometric factor to obtain the apparent resistivity, the apparent resistivity data obtained from the VES survey was presented as depth sounding curves by plotting the apparent resistivity along the ordinate axis and the half current electrode spacing (AB/2) along the abscissa. The plot was made on log-log graph paper. The resistivity depth sounding curves was classified based on layer resistivity, the number of layers in the subsurface and the thickness of each layer.

Theory of Electrical Resistivity Method

The fundamental equation for resistivity survey is derived from Ohm's law (Grant and West, 1965; Dobrin and Savit, 1988; Nwankwo, 2010):

$$\rho = \frac{RA}{L} \qquad (1)$$

Where ρ is resistivity, R is resistance, L is length of homogenous conducting cylinder and A is cross sectional area for the solid earth, whose material is predominantly made up of silicates and basically non-conductors, the presence of water in the pore spaces of the soil and in the rock fractures enhances the conductivity of the earth when an electrical current I is passed through it, thus making the rock a semi-conductor. Since the earth is not like a straight wire and it is anisotropic, then equation (1) is thus customized to:

$$\rho = \frac{\Delta V}{I} . 2\pi r \qquad (2)$$

Where 2rπ is then defined as a geometrical factor (G) fixed for a given electrode configuration.

The Schlumberger configuration was used in this work. The geometric factor G is thus given as

$$\rho_a = \frac{\Delta V}{I} . 2\pi r \qquad (3)$$

Wenner array. Electrical resistivity profiling is usually carried out when variation in apparent resistivity in horizontal direction is to be determined (Telford *et al.,* 1980), if boundaries or discontinuities are vertical rather than horizontal. However, the length of the electrode configuration or electrode spacing is very important because it determines the depth of penetration. For each position of the electrode, an apparent resistivity is obtained and the resulting data is contoured that is joining area of equal apparent resistivity with a line. The method is particularly applicable to location of high and low resistivity surface materials. This technique can be used for fractures, topographic peaks, ore bodies, gravel deposits and water. Wenner array. Electrical resistivity profiling is usually carried out when variation in apparent resistivity in horizontal direction is to be determined (Telford *et al.,* 1980). However, the length of the electrode configuration or electrode spacing is very important because it determines the depth of penetration. For each position of the electrode, an apparent resistivity is obtained and the resulting data is contoured.

Vertical Electrical Sounding

Electrical resistivity sounding is used when an investigation of resistivity variation with depth is being carried out. This method helps in determining apparent variation in resistivity with depth that is, vertical changes in apparent resistivity in the earth when the subsurface of different geo-electrical layers are detected horizontally. It may be different vertically. Apparent resistivity method furnishes details on the vertical succession of the conducting zones and the individual thickness and true resistivity. The technique is based upon the fact that the fraction of the electric current put into the ground, penetrating below any particular depth, increase with increased penetration of the current. The electrode configuration commonly used for vertical electrical sounding (VES) is the Schlumberger array. For this survey, the Schlumberger array method was employed. The value of the apparent resistivity depends on the geometry of the electrode array used (G factor).

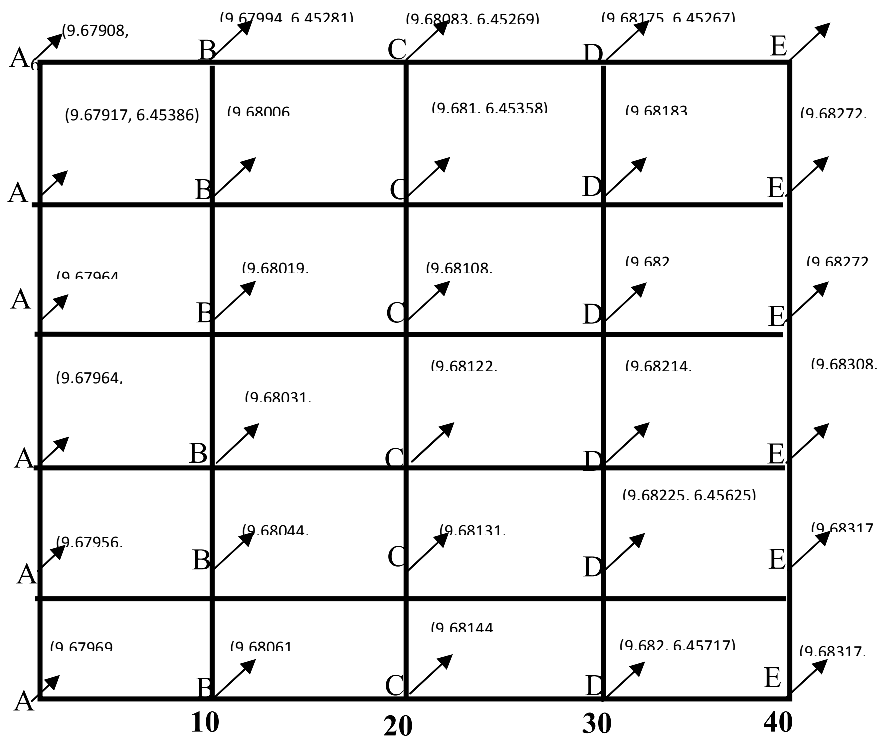


Figure 3: The Profile Layout for VES Data Collection N-S (North-South

$$AB \geq 5 \qquad MN\rho_a = \pi X\frac{V}{I} \; X \left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right]$$

This array is less sensitive to lateral variations and faster to use as only the current electrodes are moved.

Data Analysis and Interpretation

Ohm's law $V = IR$ was used to estimate the resistance value and later multiplied by the geometric factor to obtain the apparent resistivity.

The VES interpretation was carried out using a computer program, called WinResist software 2010 edition. The curve gives the equivalent n-layered model from the apparent resistivity of each sounding point. Surfer 10 computer software was used to produce iso-resistivity and geoelectric vertical section contour maps of data deduced from the WinResist. This gives more information about the sub-surface structure.

Interpretation of Iso-resistivity

From the results obtained from WinResist software curves, which is continuous variation of resistivity with depth, the following interpretations were deduced.

i. The Iso-resistivity Maps at varying depths: 0 m, 5 m, 10 m, 15 m, 20 m, were produced.
ii. contour map of Geo-electric section through the profiles and

The geo-electric section and geologic interpretation was based on all available geologic information found within the study area. The resistivity values were later compared with standard values of resistivity associated with rock types in the basement complex and this is to ascertain the composition and the geo-sections in the study area.

Interpretation of Iso-resistivity Contour Map at Surface

The Iso-resistivity Map at surface is as shown in Figure 4, produced from values on table 1a. The map is contoured at interval of 20 Ωm. The resistivity varies from 20 Ωm to 460 Ωm. The high resistivity observed around VES D2 can be attributed to human activity as evidence on the site, which shows outcrops concrete during construction of the school compound. It can be observed that at the extreme Northern corner of the study area that there exists an outcrop of weathered granitic-gneiss rock. A low resistivity region observed at the central portion of the study area is a region where the top soil has washed away revealing a sandy region which has high permeability. Other region generally shows low to high resistivity of top soil.

Interpretation of Iso-resistivity Contour Map at 5m

The Iso-resistivity Map at surface is as shown in Figure 5, produced from values on table 1a. The map is contoured at interval of 50 Ωm. The resistivity varies from 20 Ωm to 460 Ωm. The resistivity value of 50 Ωm to 200 Ωm could be observed at central, north eastern, south-eastern and north- western part, this zone may likely show clay saturated with surface water. The fractured or fairly weathered basement could be found prominently at south-eastern part of the map (i.e. VES C4 and D5) with resistivity value ranging between 50 Ωm and 150 Ωm. A high resistivity value of 600 Ωm was found prominent at south-western corner of the study area (i.e.VES B1) which is also found at the surface. This signifies a weathered basement rock.

Interpretation of Iso-resistivity Contour Map at 10 m

The Iso-resistivity Map at 10 m depth is as shown in figure (6) produced from values on table 1b. The map is contoured at interval of 30 Ωm. The resistivity varies from 60 Ωm to

960 Ωm across the field. The relatively high resistivity value observed at the south western part of the study area is due to the lateritic content, a low resistivity region at the North-eastern part of the study area. This region has resistivity value ranging between 30 Ωm to 150 Ωm which could be attributed to weathered basement table1b. The fractured or fairly weathered basement could be found prominently at south-western part of the map (i.e. VES B1) with resistivity value ranging between 240 Ωm and 460 Ωm.

Interpretation of Iso-resistivity Contour Map at 20 m

The map of iso_resistivity at 20 m (figure 7) produced from values on table 1b is contoured at interval of 50 Ωm. The resistivity varies from 50 Ωm to 750 Ωm. It can be observed here that the relatively high resistance found at the south western part, also continued at the central part of (Figure 7) and South-Western part of the iso- resistivity map at 20 m. This is an indication that the laterite extends down at a much longer depth and at the Northern corner of the study area (VES D3). This region has resistivity value ranging between 200 Ωm to 500 Ωm and it can be seen that the region has a low resistivity at the northern part of the study area with resistivity value ranging between 30 Ωm to 150 Ωm. This is attributed to presence of ground water.

	surface		**5 meters**	
X	Y	RES	Y	RES
0	0	38.3	0	
100	0	3.4	0	1058
200	0	1.6	0	
300	0	56.6	0	56.6
400	0	3.8	0	
500	0	365.9	0	365.9
0	100	179.7	100	179.7
100	100	45	100	45
200	100	281.3	100	281.3
300	100	161.2	100	
400	100	94.8	100	16
500	100	127.7	100	
0	200	54.9	200	354.5
100	200	92.5	200	
200	200	47.2	200	
300	200	10	200	
400	200	91.1	200	91.1
500	200	10.3	200	
0	300	216.4	300	70
100	300	101.8	300	101.8
200	300	230.1	300	323.1
300	300	2.1	300	
400	300	457.2	300	24.9
500	300	18.6	300	18.6
0	400	393.1	400	393.1
100	400	147.3	400	147.2
200	400	124.3	400	124.3
300	400	38.5	400	
400	400	1.5	400	3.3
500	400	157.6	400	

Table 1b: iso-resistivity values for 10 and 15m

10 meters			20 meters		
X	**Y**	**RES**	**X**	**Y**	**RES**
0	0		0	0	89.1072
100	0	40.241	100	0	25.169
200	0	552.57	200	0	78.131
300	0	91.284	300	0	92.042
400	0	49.189	400	0	45.21
500	0		500	0	65.607
0	100		0	100	175.404
100	100	108.46	100	100	112.455
200	100		200	100	40.2
300	100		300	100	52.472
400	100	10.472	400	100	74.682
500	100	7.14	500	100	43.633
0	200		0	200	723.69
100	200	163.36	100	200	185.377
200	200	685.92	200	200	435.336
300	200		300	200	227.528
400	200		400	200	269.28
500	200	76.507	500	200	84.2996
0	300		0	300	225.968
100	300	176.45	100	300	136.45
200	300		200	300	465.349
300	300	19.074	300	300	6.542
400	300	247.63	400	300	558.756
500	300		500	300	79.036
0	400		0	400	33.505
100	400		100	400	249.046
200	400	182.04	200	400	220.34
300	400		300	400	99.199
400	400	140.16	400	400	199.08
500	400		500	400	120.76

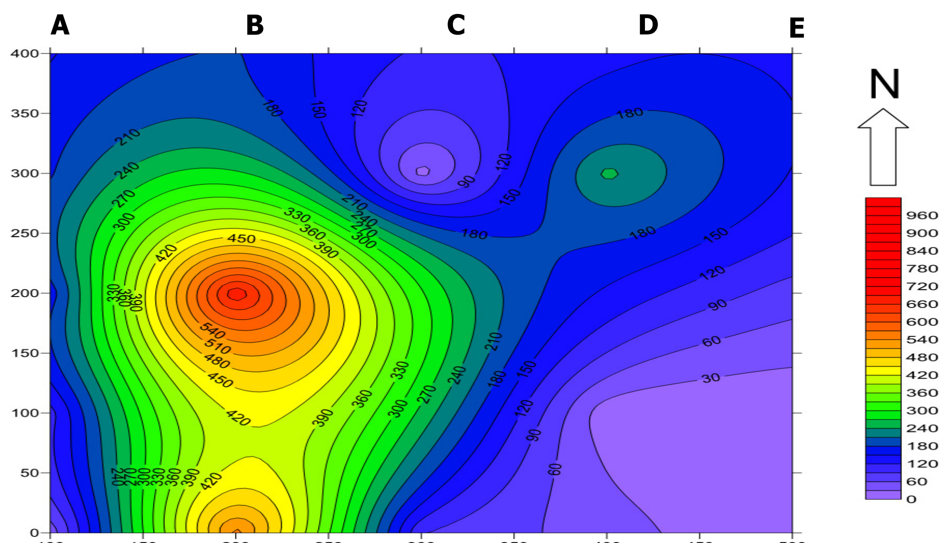


Figure 4: Iso-resistivity contour Map at Surface Contour Interval is 20 Ωm

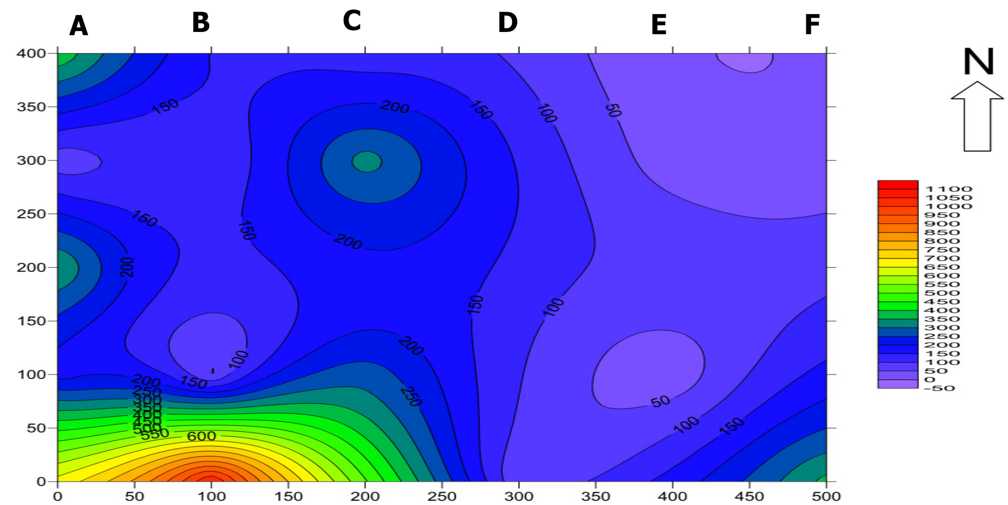


Figure 5: Iso-resistivity contour map at 5 m Contour Interval is 50 Ωm

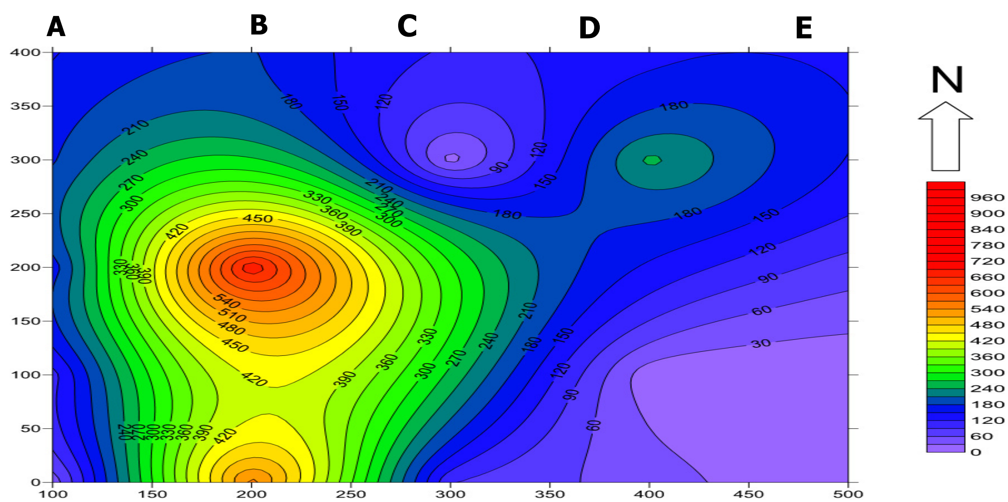


Figure 6: Iso-resistivity contour Map at 10 m Contour Interval is 30 Ωm

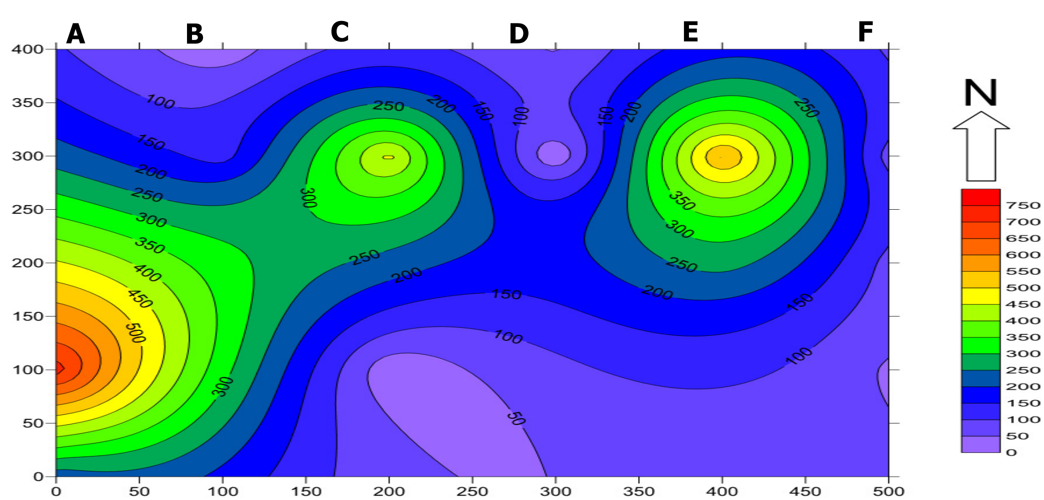


Figure 7: Iso-resistivity contour Map at 20 m Contour Interval is 50 Ωm

Interpretation of Geo-electric Vertical Section along Profile

The vertical geo-electric section of profile A to E and their corresponding geologic sections are shown in figure 8 to 12. The maps ware obtained using the values on tables 2a and 2b

Interpretation of Geo-electric Vertical Section along Profile A

The vertical geo-electric section of profile A is as shown in figure (8a) while its corresponding geologic section is shown in figure (8_b). The map is contoured at an interval of 70 Ωm. This map can be divided into three layers. Profile A has top soil with resistivity ranging from 140 Ωm to about 900 Ωm. This high resistivity is due to concrete from the construction work. It is followed by a layer of clay saturated with ground water with resistivity ranging from 30 Ωm to 150 Ωm

Interpretation of Geo-electric Vertical Section along Profile B

The vertical geo-electric section of profile B is as shown in figure (9a) while its corresponding geologic section is shown in figure (9b). The map is contoured at an interval of 300 Ωm. This map can be divided into three layers.

The top soil with resistivity ranges from 300 Ωm-600 Ωm. The isolated point B3 with high resistivity is a concrete from construction of school building. The second layer of clay saturated with ground water with low resistivity ranging from 300 Ωm downward dominate the area to about 30 metres.

Interpretation of Geo-electric Vertical Section along Profile C

The vertical geo-electric section of profile C is as shown in figure (10a) while its corresponding geologic section is shown in figure (10b). The map is contoured at an interval of 200 Ωm. This map can be divided into three layers.

The first layer has resistivity values ranging between 10.00 Ωm to 92.00 Ωm as shown in table 4.3. This spread through the entire profile and at different depths. The highest resistivity value of (92.00 Ωm is found at VES C_2 and the lowest value of 10.00 Ωm is at VES C_4), which is an outcrop due to erosion. The thickness of this layer ranges between 0.3 m to 8.0 m. The highest thickness of about 20.0 m occurs at VES B4, while the least thickness of about 0.8 m occurs at VES B5. The lithology around this area suggests that this layer could be sand and gravels. The second layer could be fresh basement with very negligible aquifer potential. The layer has resistivity values ranging between 200.00 Ωm to 1800.00 Ωm. The layer covers the entire profile.

Interpretation of Geo-electric Vertical Section along Profile D

The vertical geo-electric section of profile D is as shown in figure (11a) while its corresponding geologic section is shown in figure (11b). The map is contoured at an interval of 300 Ωm. This map can be divided into two (2) layers.

Profile D has lateritic top soil observed at D1, D2, D5 and D6 with resistivity ranging from 40 Ωm to 120 Ωm. There is an outcrop of granite at D3 which correspond to high resistivity greater than 700 Ωm outward to about 30 metres. The weathered basement stretches up to 30 metres across the profile.

Interpretation of Geo-electric Vertical Section along Profile E

The vertical geo-electric section of profile E is as shown in figure (12a) while its corresponding geologic section is shown in figure (12b). The map is contoured at an interval of 120 Ωm. This map can be divided into two layers. Profile E has top soil from E2-E6 with low resistivity ranging from 40 Ωm to about 760 Ωm. A high resistivity outcrop of weathered basement is found at E1 which extends 30 metres from E2-E6.

Table 2a: Resistivity values for VES on profile A & B

Prifile A			Prifile B		
X	Y*-1	RES	X	Y	RES
0	-300	38.5	0	-300	179.7
0	-200		0	-200	1670.45
0	-150		0	-150	3400.67
0	-100		0	-100	900.34
0	-50	38.3	0	-50	470.6
0	0	1977	0	0	749.3
100	-300	3.4	100	-300	1020.4
100	-200	1058	100	-200	700.45
100	-150	720.1	100	-150	1600.56
100	-100		100	-100	350.4
100	-50		100	-50	2000.35
100	0		100	0	3500
200	-300	1.6	200	-300	2300.35
200	-200		200	-200	500.79
200	-150	504.5	200	-150	1700.12
200	-100	1229	200	-100	870.78
200	-50	257.2	200	-50	6223
200	0		200	0	900.23
300	-300	56.6	300	-300	161.2
300	-200	56.6	300	-200	350
300	-150	208.5	300	-150	120.45
300	-100		300	-100	1450.6
300	-50	44	300	-50	890.54
300	0	2264	300	0	340.89
400	-300	3.8	400	-300	94.8
400	-200		400	-200	16
400	-150	11.3	400	-150	479
400	-100		400	-100	
400	-50		400	-50	
400	0		400	0	
500	-300	365.9	500	-300	127.7
500	-200	365.9	500	-200	
500	-150		500	-150	
500	-100	16.5	500	-100	30.2
500	-50		500	-50	157.2
500	0		500	0	39.5

Table 2a: Resistivity values for VES on profile A&B

profile C			profile D		
X	Y*-1	RES	X	Y*-1	RES
0	-300	54.9	0	-300	216.4
0	-200	354.5	0	-200	70
0	-150		0	-150	
0	-100		0	-100	
0	-50	3100	0	-50	
0	0		0	0	

100	-300	92.5	100	-300	101.8
100	-200		100	-200	101.8
100	-150	541.1	100	-150	117.4
100	-100		100	-100	
100	-50		100	-50	
100	0	749.3	100	0	
200	-300	47.2	200	-300	230.1
200	-200		200	-200	323.1
200	-150	197.7	200	-150	
200	-100		200	-100	702.9
200	-50		200	-50	
200	0		200	0	
300	-300	10	300	-300	2.1
300	-200		300	-200	
300	-150		300	-150	150.4
300	-100	963.1	300	-100	
300	-50		300	-50	
300	0	274.6	300	0	
400	-300	91.1	400	-300	457.2
400	-200	91.1	400	-200	24.9
400	-150		400	-150	44
400	-100		400	-100	
400	-50	3.7	400	-50	
400	0		400	0	
500	-300	10.3	500	-300	18.6
500	-200		500	-200	21.6
500	-150	9	500	-150	446.9
500	-100		500	-100	
500	-50		500	-50	
500	0		500	0	

	Profile E			**Profile E**	
X	**Y*-1**	**RES**	**X**	**Y*-1**	**RES**
0	-300	393.1	300	-300	38.5
0	-200	198.1	300	-200	
0	-150		300	-150	
0	-100	61.7	300	-100	38.5
0	-50	229.8	300	-50	4.5
0	0		300	0	59.9
100	-300	147.3	400	-300	1.5
100	-200	147.2	400	-200	3.3
100	-150		400	-150	37
100	-100		400	-100	
100	-50	159.3	400	-50	
100	0	71.4	400	0	186.3
200	-300	124.3	500	-300	157.6
200	-200	12.3	500	-200	
200	-150	53.9	500	-150	
200	-100		500	-100	77
200	-50		500	-50	
200	0		500	0	1510

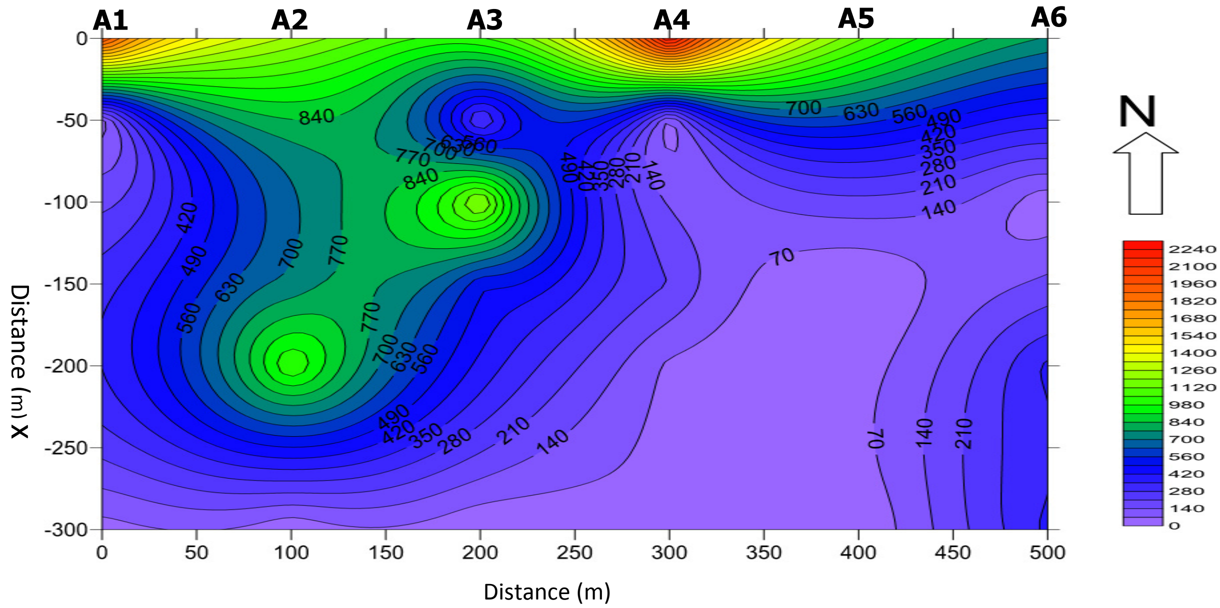


Figure 8a: Geoelectric Vertical section along Profile A (Contour Interval is 70Ωm)

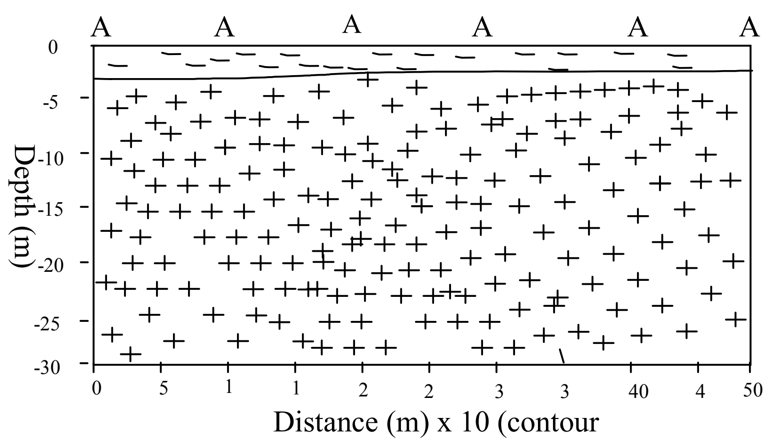
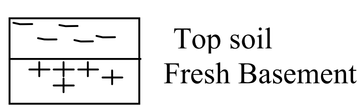


Figure 8b: Vertical Section through Profile A

Legend



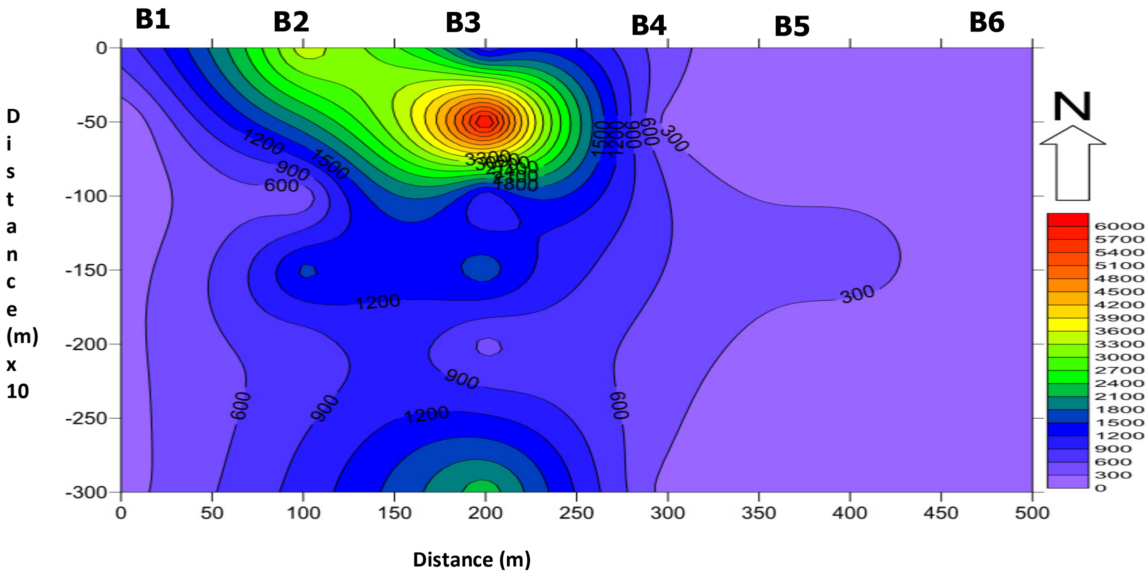


Figure 9a: Geoelectric Vertical section along Profile A (Contour Interval is 70 Ωm

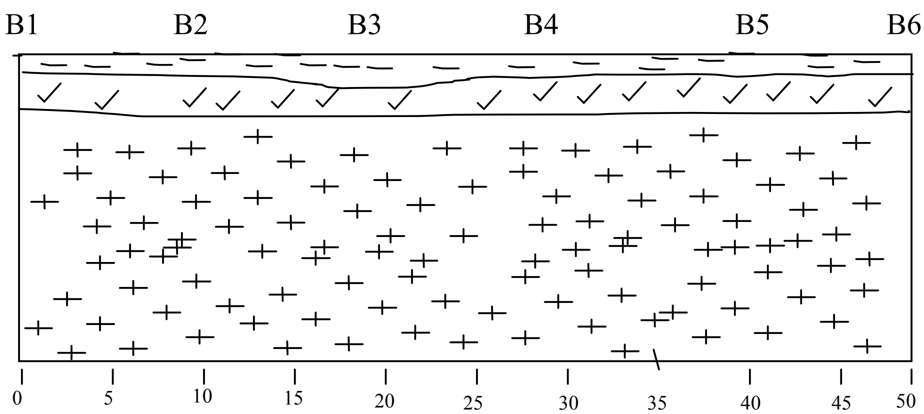
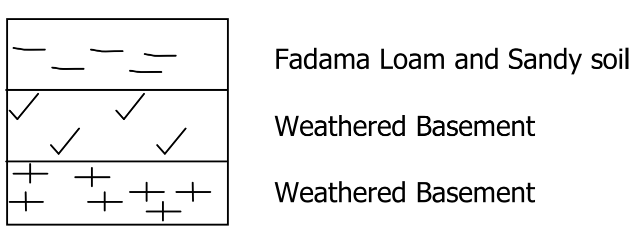


Figure 9b: Vertical Section through Profile B

Legend



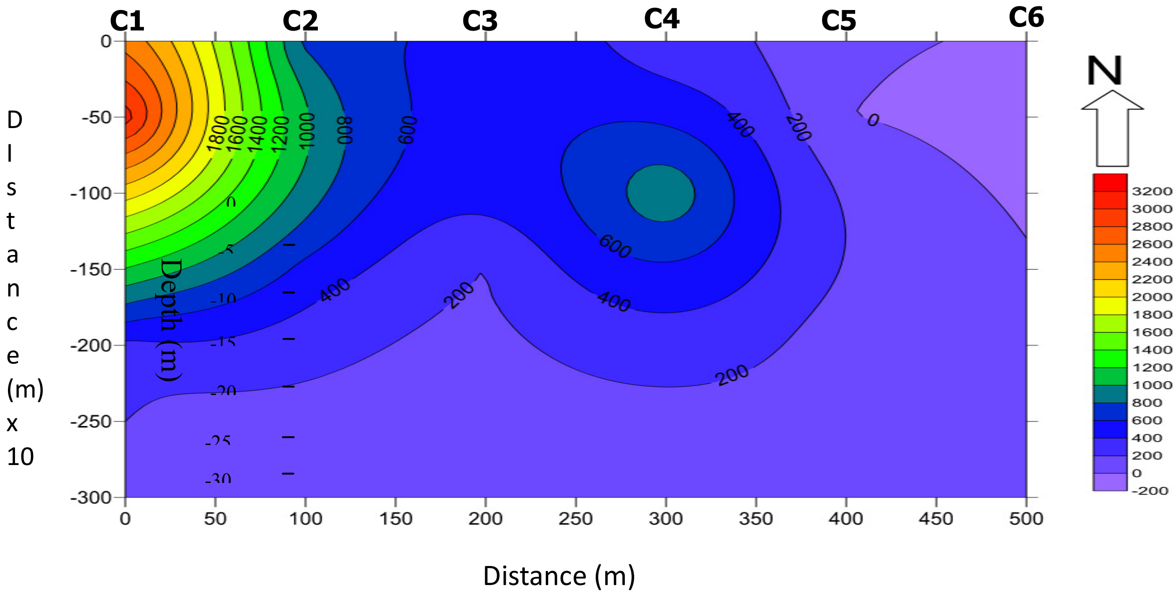


Figure 10a: Geoelectric Vertical section along

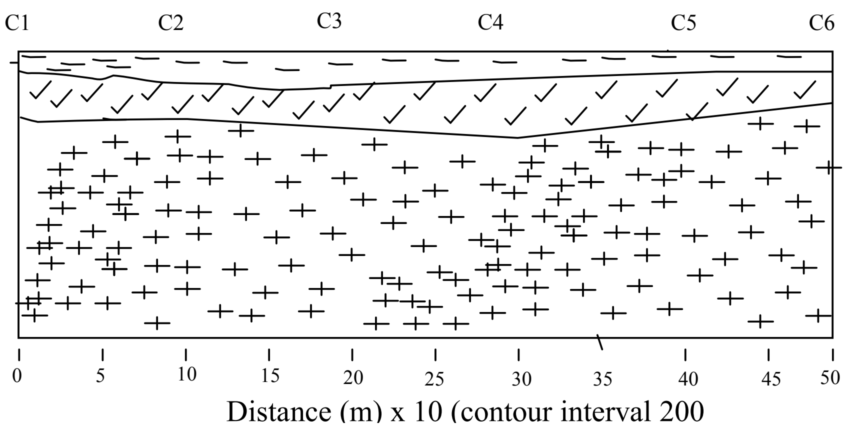
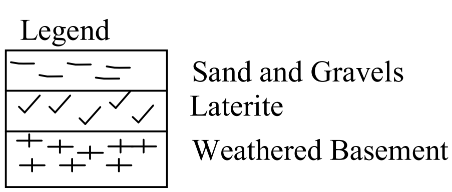


Figure 10b: Vertical Section through Profile C



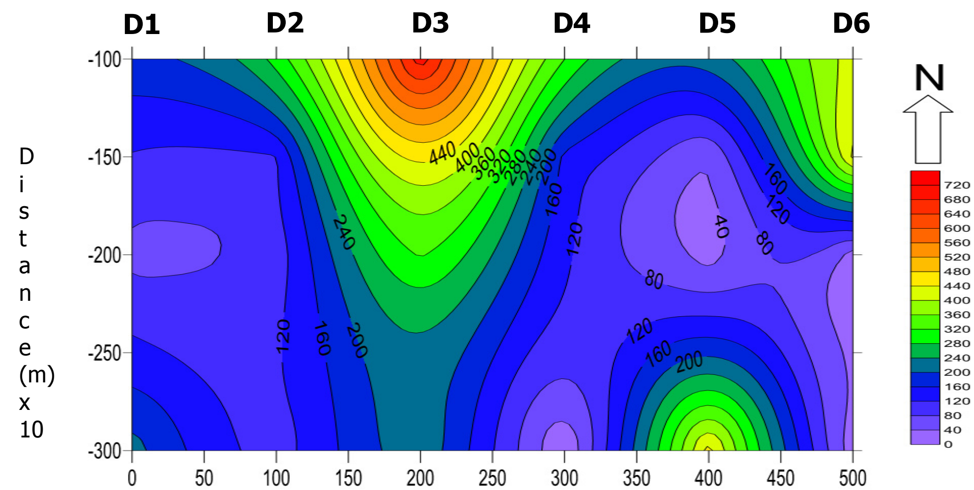
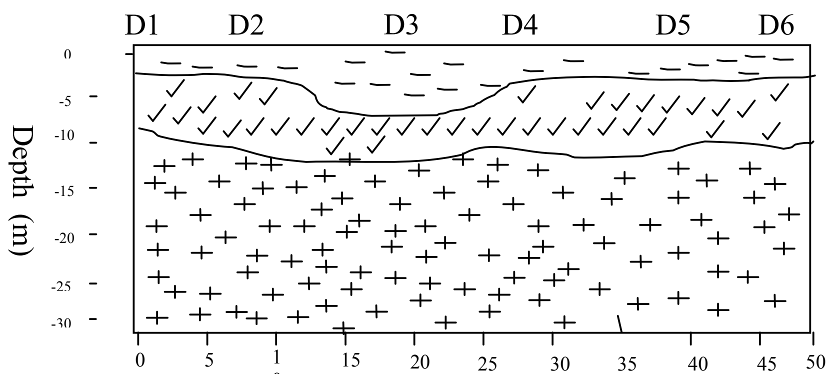
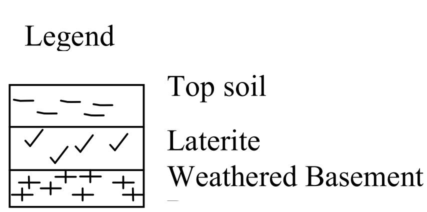


Figure 11a: Geoelectric Vertical section along Profile D (Contour Interval is 300 Ωm)



Distance (m) x 10 (contour interval 200 Ωm)

Figure 11b: Vertical Section through Profile D



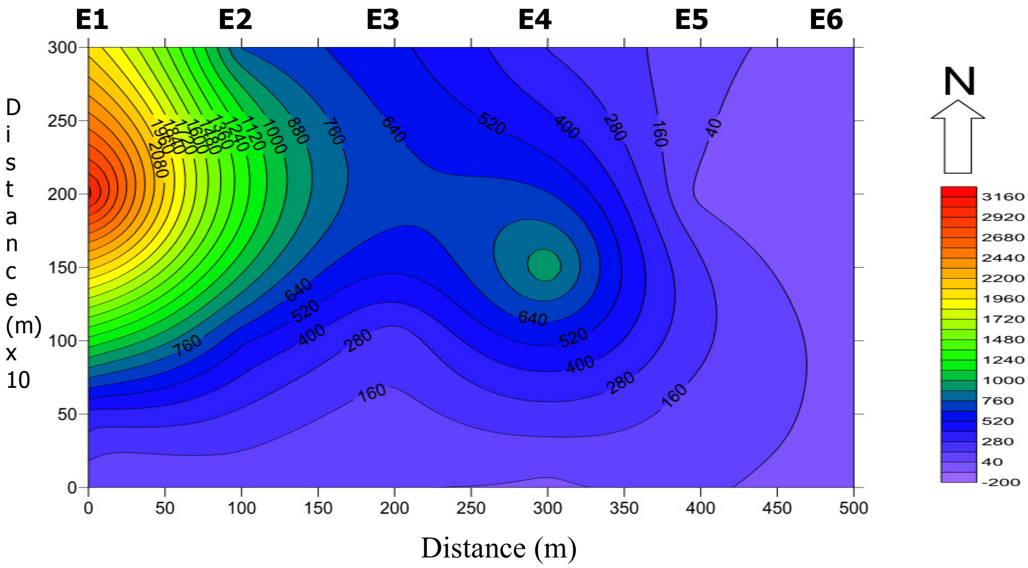


Figure 12a: Geoelectric Vertical Section along Profile E (Contour Interval is 120 Ωm)

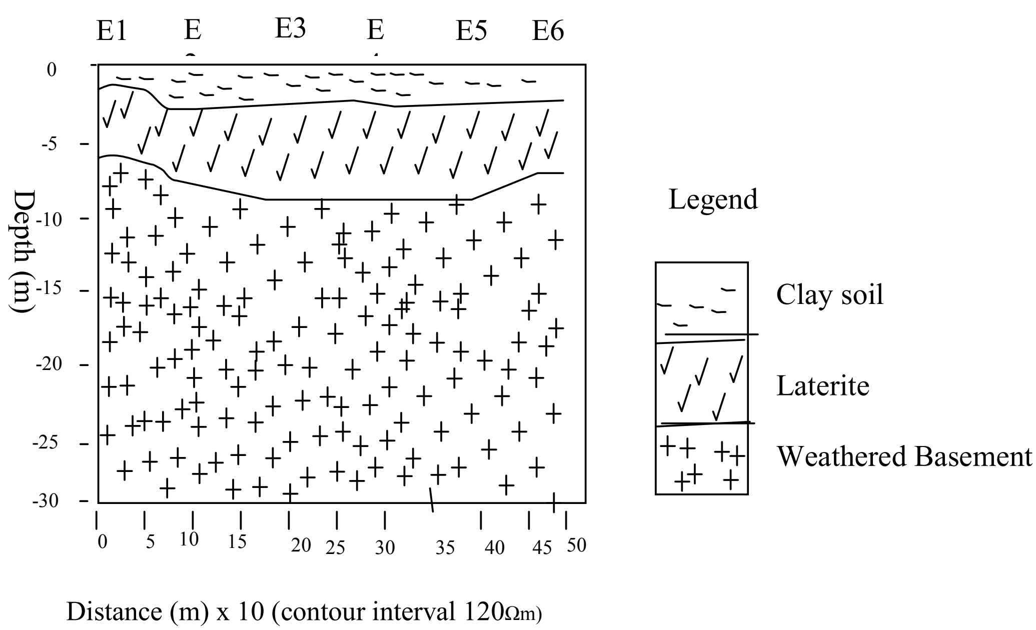


Figure 12b: Vertical Section through Profile

on VES points A1-A3. The low resistivity values observed on A4-A6 which is as low as 70 Ωm could ba a clear indication of weathered basement up to a depth of 30 metres (see table).

Conclusion

In this study, electrical resistivity method using vertical electrical sounding (VES) was carried out on 30 VES points sounded using the Schlumberger electrode array with a view to understand the subsurface geologic settings that could guide the successful exploration of groundwater.

Details of the result show that VES C3, D5, E3, E4 are viable for ground water exploration. VES E2 shows presence of ground water in weathered basement at a depth of equally 20 metres. The entire area can be classified into three geological units. The top soil which varies in thickness from 0 to 1 metres followed by clay layer that varies in thickness from 1 m to about 5 metres, weathered basement that ranges from 5 to about 20 metres and finally, fresh basement which varies from 20 metres to infinity.

Recommendations

Electrical resistivity method has been successfully adopted in this search for subsurface water exploration. It is therefore recommended that a borehole be drilled at any VES points located on profiles D and E, from a depth of about 40 meters to 50 meters.

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