# EVALUATION OF GROUNDWATER POTENTIAL OF HOSTEL AND INNOVATION AREA IN PHASE ONE OF FUOYE CAMPUS USING EM/VLF AND ELECTRICAL RESISTIVITY METHODS

**BY**

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## GRANITE

It is a common type of felsic intrusive igneous rock which is granular and phaneritic in texture. Granite can be predominantly white, pink or grey in color, depending on their mineralogy. Granite is always nearly massive, hard, and tough and it has therefore gained widespread use throughout humanity and more recently as a construction stone.

## MIGMATITE-GNEISS

The migmatite-gneiss is a highly metamorphosed rock that occurs in white and dark bands showing the alignment of the mineral. The mineral constituent in the rock is quartz, feldspar, biotite, muscovite, plagloclase, they majorly occur in hilly or low-lying form.

## GRANITE-GNEISS

The granite-gneiss rock is a metamorphosed granite rock and has a gneissic texture, the rock has light and dark colored bands that show the way the mineral are aligned and the rocks are usually massive.

## CHARNOCKITE

This rock is a coarse grained rock of approximately granitic composition containing feldspar, orthopyroxene and quartz. This rock has granulites facies assemblage characterized by anhydrous minerals. The origin of this rock is still debated; some may have formed by crystallization of anhydrous magma under plutonic conditions, others by high grade regional metamorphism of igneous rock.

# CHAPTER THREE

# METHODOLOGY

## 3.1 ELECTROMAGNETIC-VERY LOW FREQUENCY (EM-VLF) METHOD

The EM-VLF geophysical method is a quick and powerful tool, which is used to delineate shallow conducting lineament features in the near sub-surface of the earth crust. The method is based on measurement of the secondary magnetic field that is induced in local conductors, by primary electromagnetic fields generated by powerful military radio transmitter. The entire equipment (ABEM WADI) is portable and is mounted on a belt worn by the user. The system consists of three units which includes the following; Hand – held controller (with strap – type handle), Measuring unit with battery compartment, Antenna unit.

ABEM WADI utilizes the negative component of electromagnetic field generated by military radio transmitter with very low frequency (VLF), range between 15-30 kHz. It sends primary field waves into the subsurface which in returns send out a weak secondary magnetic field, which had been built around conductive geological structures aligns in concentric lines around the transmitting antenna. It measures the field strength and phase displacement around geologic structure such as fault or shear zone in the bedrock. WADI instrument registered not only the filtered real part i.e. the part of the resulting field which is in phase with the primary field from the VLF transmitter, but also the imaginary part which is 900 out of phase with the primary field. It is sensitive to transmitters around the world and it automatically picks the most suitable. In order for induction to occur, the structure must be aligned roughly towards the transmitter.

This method make use of four electrode in the acquisition of the data, two current electrode (C1 and C2) are use to send current into the subsurface while two potential electrode (P1 and P2) are use in measuring the resulting voltage difference. From the resulting current (I) and voltage (V) value, the apparent resistivity (*pa)* value is been calculated.

$$pa = k V / I$$

Where k is the geometric factor that depends on the arrangement of the electrodes. The resistivity meter give the resistivity value (R= V / I), so to get the apparent resistivity, it is given by,

$$pa = kR.$$

In electrical resistivity method, different geophysical techniques are array are been used which depends on the following;

i) Type of structure to be map.
ii) Background noise level
iii) Sensitivity of the resistivity meter

Also, the things to be considered in choosing the best array configuration are as follows;

i) Signal strength
ii) Horizontal data coverage
iii) Depth of investigation
iv) Sensitivity of the array to horizontal and vertical structures

## 3.3 FIELD PROCEDURE

## VERTICAL ELECTRICAL SOUNDING (VES)

Vertical electrical sounding measure vertical variations in electrical properties beneath the earth surface with respect to a fixed center of the array. It is done by increasing the electrode spacing linearly about a central position whose vertical resistivity variation is sought. Resistance measurements are made at each expansion and multiply by the geometric factor K to give the resistivity. The depth of investigation is dependent on the electrode spacing (expansion). It can be use to map the depth to bed rock and to delineate aquifers. Array types used include schlumberger array, wenner array and dipole-dipole array. The results are then presented as depth sounding curve.

## 3.4 ARRAY CONFIGURATION

There are different types of array configuration that can be use during geophysical investigation. These array configurations are as follows;

**Schlumberger Array**

The classical Schlumberger array is one of the most commonly used array for resistivity sounding surveys. The "n" factor for this array is the ratio of the distance between the C1-P1 (or P2-C2) electrodes to the spacing between the P1-P2 potential pair. The sensitivity pattern for the Schlumberger array is slightly different from the Wenner array with a slight vertical curvature below the centre of the array, and slightly lower sensitivity values in the regions between the C1 and P1 (and also C2 and P2) electrodes. There is a slightly greater concentration of high sensitivity values below the P1-P2 electrodes. This means that this array is moderately sensitive to both horizontal and vertical structures. In areas where both types of geological structures are expected, this array might be a good compromise between the Wenner and the dipole-dipole array. The median depth of investigation for this array is about 10% larger than that for the Wenner array for the same distance between the outer (C1 and C2) electrodes. The signal strength for this array is smaller than that for the Wenner array, but it is higher than the dipole-dipole array.

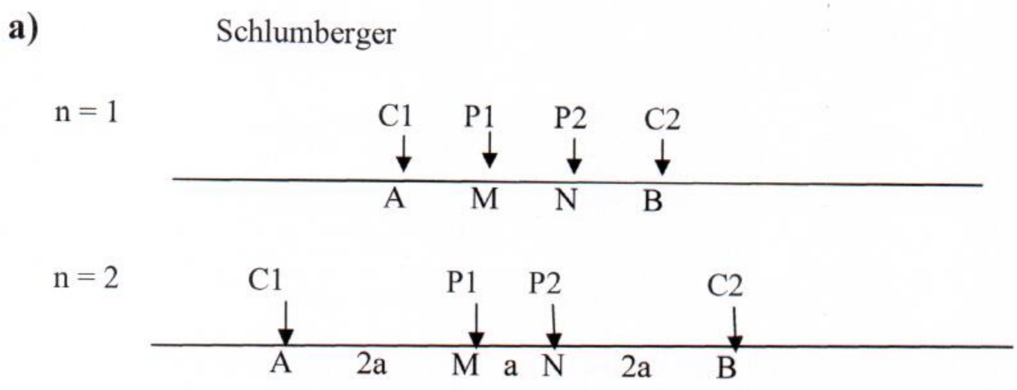


**FIGURE 3.2: SCHLUMBERGER ELECTRODE ARRAY (LOKE 1999)**

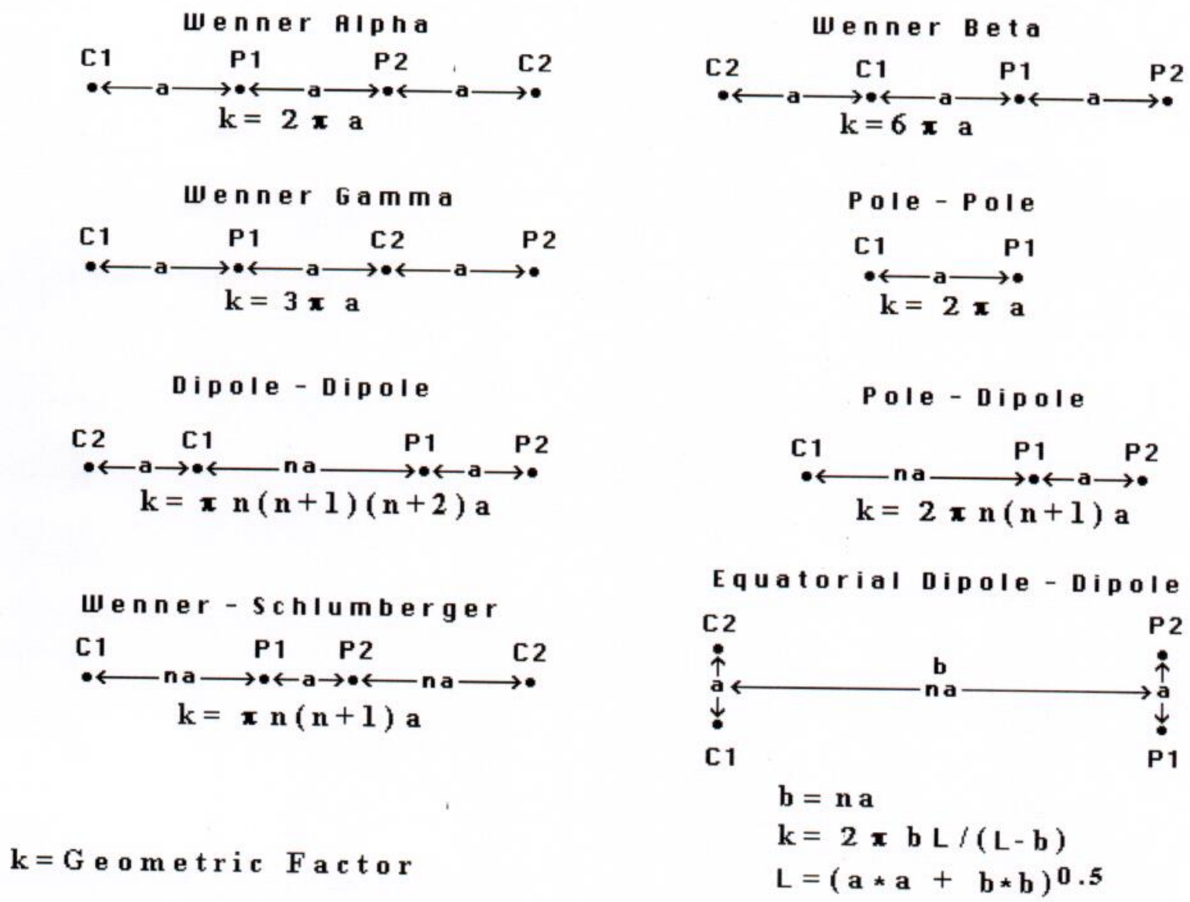


**FIGURE 3.3: COMMON ARRAYS USED IN RESISTIVITY SURVEYS AND THEIR GEOMETRIC FACTORS (LOKE 1999)**

## APPLICATIONS OF THE ELECTRICAL RESISITIVITY METHOD

i. Groundwater Exploration
ii. Engineering Studies
iii. Environment Studies
iv. Geological Mapping
v. Mineral Exploration

## FACTORS AFFECTING ELECTRICAL RESISTIVITY METHOD

There are several factors affecting the electrical resistivity method which can bring about variance in

i Rock Type

ii Temperature

iii Rock texture

iv Conductivity of the soil body

v Porosity of the rock body

## 3.5 INSTRUMENTATION

### VLF-EM instrument (receiver)

The VLF-EM receiver is widely used in geophysical surveying. ABEM WADI utilizes the negative component of electromagnetic field generated by military radio transmitter, with very low frequency (VLF) range between 15-30 kHz. It sends primary field waves into the subsurface which in returns send out a weak secondary magnetic field, which had been built around conductive geological structures aligns in concentric lines around the transmitting antenna.

**Omhega Terrameter**

This is used in measuring the electrical resistance of the different layers in the subsurface. The instrument is tested and trusted over the years, it is highly sophisticated, compact, lightweight with inbuilt power source, transmitter or signal sender, receiver and microprocessor. The instrument takes consecutive resistivity value in several cycles and averages the value obtained at each cycle to give the final resistivity readings. The transmitter signals current, the receiver moves and measures the voltage correlated with the transmitted current signal in the resistivity survey mode while the microprocessor monitors and control the terminal which includes the ON/OFF switch, circuit selector, range selector, power indicator and display screen, all these units are housed in a single casing which is mounted on a dry cell battery. It gives the resistance value as the electrodes are moved on the field.

**Electrode**

Four electrodes made of steel rod are used. The steel rods are driven into the earth with the aid of a hammer and about one quarter of the total length of the electrode in the topsoil for a good contact. Two electrode, current electrode (C1 and C2) are use to send current into the subsurface while the other two electrode, potential electrode (P1 and P2) are use in measuring the resulting voltage difference.

**Reels of long cable**

There are four reels used on the field, two of which are big reels with cable of about 1000m in length which are mainly used in connecting current electrodes (C1 and C2) to the terrameter, while the other two smaller reels with cables of about 500m in length are used in connecting potential electrode (P1 and P2) to the terrameter.

**Measuring tape**

The measuring tapes which are of various lengths are used to mark off the electrode spread, and the hammer is used in driving the electrode into the ground for good contact.

**Global Positioning System (GPS)**

The GPS is a geologic instrument which is used to mark the position of one's location on the field with respect to the globe, i.e the Latitude, Longitude and Elevation above sea level which is known as the altitude at that point.

## PRECAUCTION TAKING DURING RESISTIVITY SURVEY

During electrical resistivity survey, some precautionary measures were taken on the field so as to have a high precision and accuracy in the resulting data. These include;

i) It was ensure that connection and disconnection of current cables were done only when the switch was off, else the current electrode will be dangerous to human health

ii) The cable was insulated to avoid being electrocuted when current is released

iii) Error of misconnection of the crocodile clips to the corresponding potential and current electrode was avoided by often indication by an arrow on the terrameter pointing to the direction of the error side.

iv) It was ensure that the electrode was hammered well into the ground to ensure good electrode contact with the ground.

v) The possibility of leakage from current circuit to potential circuit during measurement was avoided by connecting the circuit in series.

## LIMITATION OF ELECTRICAL RESISTIVITY METHOD

Resistivity method is an efficient method for delineating shallow vertical discontinuities and shallow layered sequence involving changes in resistivities. However, it has quite a number of limitations, which includes;

i) Depth of penetration is limited by the maximum amount of electric power that is introduced into the ground.

ii) It cannot be carried out on an outcrop.

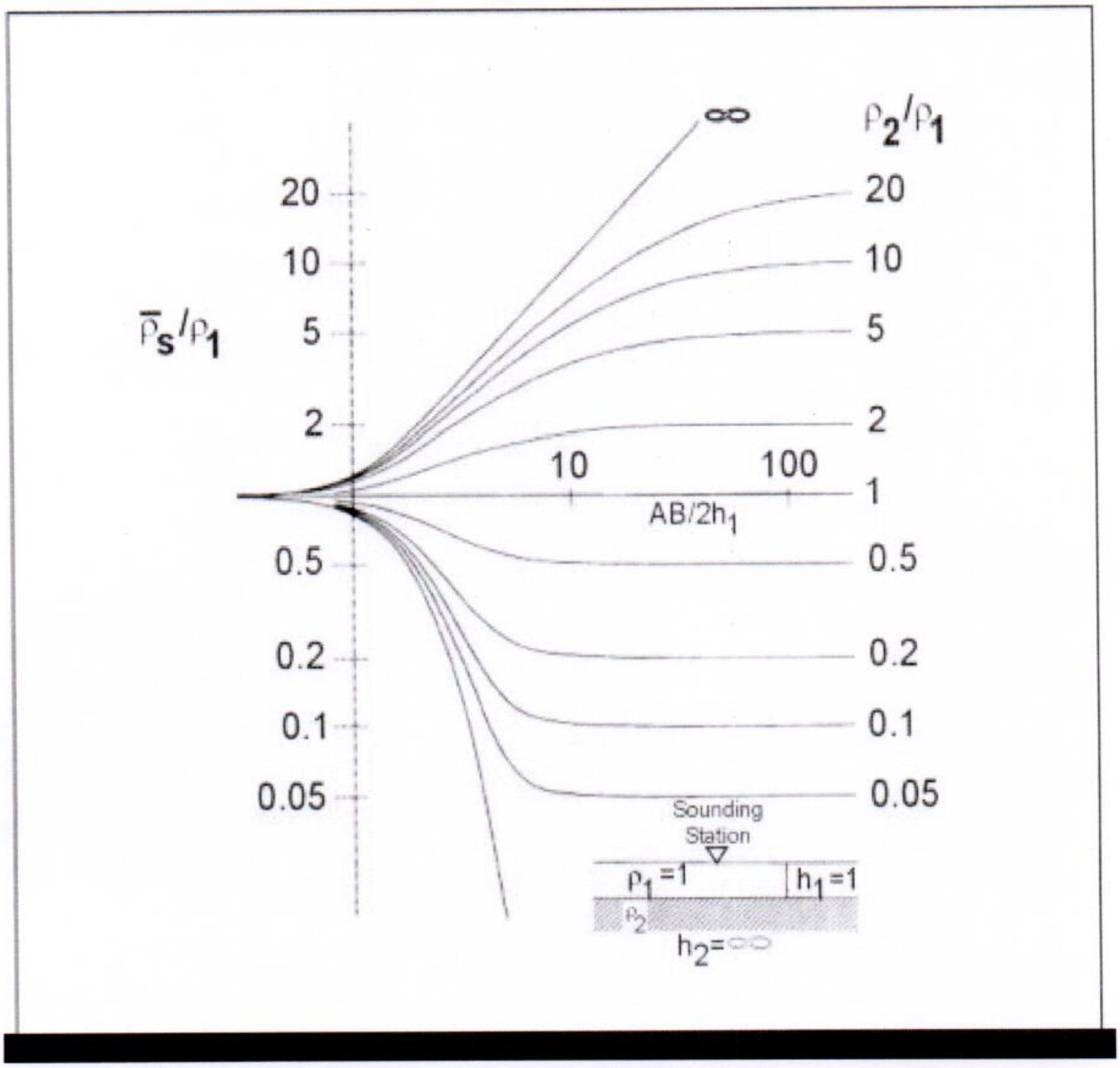


**FIGURE 3.4: TWO-LAYER MASTER SET OF SOUNDING CURVES FOR THE SCHLUMBERGER (LOKE 1999)**

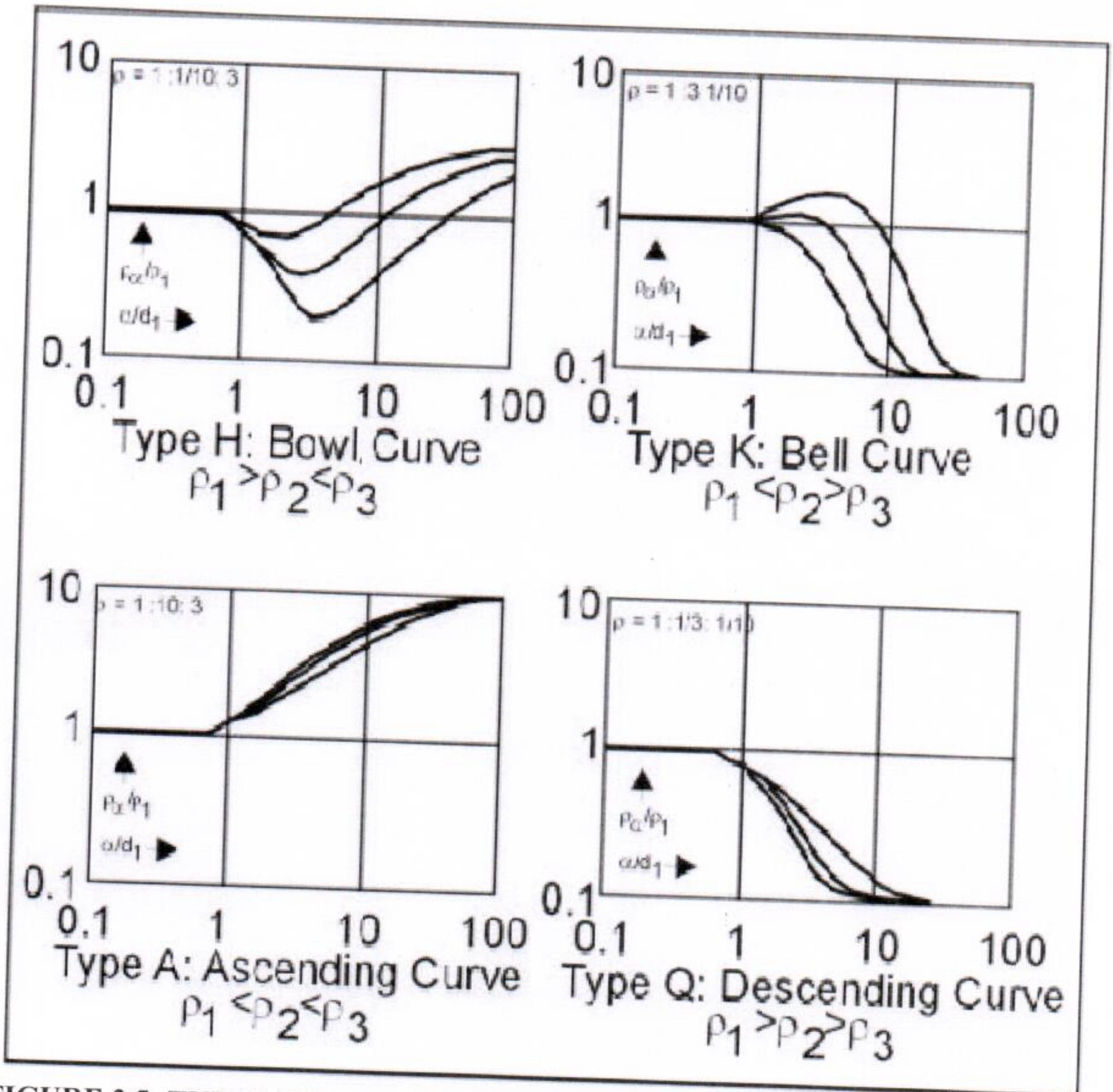


**FIGURE 3.5: TYPES OF VES CURVE (LOKE 1999)**

### 3.6.2 COMPUTER ITERATION METHOD

This is done with the use of computer system, and with the help of geophysical software such as Winresist. Computer iteration method involves two main stages which are;

i. An initial model needs to be determined from the field data which is done by partial curve matching

ii. Computer modeling which give the final accepted geo-electric structure

The geophysical software gives directive on how to operate it. Parameters needed from obtained field data and data from curve matching were inputted. Prior the interpretation, it is ensure that the VES curve smoothened. The curve matching get cumbersome where there are many layers, hence the computer iteration makes the interpretation of such problems easier. A fast observation is done based on the iteration nature of the program.

The layer parameters are altered until a good fit is achieved between the observed and calculated values. The iteration process of a curve can go as far as more than 10 times of achieving an effective match, after which the computer displays the final result of the iteration in form of curve and layer parameter. This method is the most effective of all the interpretation methods in terms of efficiency, speed and accuracy.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 DATA PRESENTATION AND INTERPRETATION

### 4.1.1 ELECTROMAGNETIC-VERY LOW FREQUENCY (EM-VLF) RESULT

A total number of six (6) EM-VLF profiles were generated and twelve conductive zones were identified on the profile (appendix I). Six (6) traverses were established within the study area that runs from north to south and also west to east. The inter-station spacing along the traverses were 5m expect traverse 1 that has a spacing of 10m within the study area. The points where we have positive peak of the filtered real were interpreted as conductive zones (Alvin et al., 1997), with values ranging from 12 to 55. This might be as a result of the presence of geologic features such as fractures, fault or weathered basement.

### 4.1.2 ELECTRICAL RESISTIVITY (VES) RESULT

Twelve (12) Vertical Electrical Sounding (VES) were occupied and interpreted at the identified conductive zones. VES curve were generated for these soundings (appendix II). Three curve types were identify from the interpreted VES data namely; H, K and A. The number of layer inferred from the 12 VES point are 3 layers comprising of the topsoil, clayey sand /sandy clay and the fresh basement. This is shown in table 4.1 below.

**TABLE 4.1: GEOELECTRIC PARAMETERS**

| VES NO | NO OF LAYERS | RESISTIVITY | THICKNESS | DEPTH | REMARK | CURVE TYPE |
|---|---|---|---|---|---|---|
| 1 | 1 | 102.6 | 1.6 | 1.6 | Topsoil | K |
| | 2 | 492.0 | 1.4 | 3.0 | Sand | |
| | 3 | 242.7 | - | - | Weathered layer | |
| 2 | 1 | 235.1 | 4.6 | 4.6 | Topsoil | H |
| | 2 | 115.5 | 15.8 | 20.3 | Sandy clay | |
| | 3 | 939.6 | - | - | Fresh basement | |
| 3 | 1 | 118.8 | 5.0 | 5.0 | Topsoil | H |
| | 2 | 10.6 | 2.4 | 7.4 | Clay | |
| | 3 | 4492.1 | - | - | Fresh basement | |
| 4 | 1 | 115.4 | 3.5 | 3.5 | Topsoil | H |
| | 2 | 50.8 | 14.3 | 17.7 | Clay | |
| | 3 | 6526.8 | - | - | Fresh basement | |
| 5 | 1 | 373.3 | 0.9 | 0.9 | Topsoil | H |
| | 2 | 78.3 | 19.5 | 20.4 | Clay | |
| | 3 | 8185.5 | - | - | Fresh basement | |
| 6 | 1 | 206.9 | 1.1 | 1.1 | Topsoil | H |
| | 2 | 64.7 | 19.5 | 20.6 | Clay | |
| | 3 | 825.4 | | | Fresh basement | |
| 7 | 1 | 140.4 | 1.9 | 1.9 | Topsoil | H |
| | 2 | 62.4 | 10.5 | 12.4 | Clay | |
| | 3 | 1440.8 | - | - | Fresh basement | |
| 8 | 1 | 153.5 | 1.9 | 1.9 | Topsoil | A |
| | 2 | 250.7 | 0.2 | 2.1 | Sand | |
| | 3 | 337.9 | - | - | Weathered layer | |
| 9 | 1 | 141.2 | 2.1 | 2.1 | Topsoil | K |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 317.6 | 0.4 | 2.5 | Sand | |
| | 3 | 307.0 | - | - | Weathered layer | |
| 10 | 1 | 193.8 | 1.0 | 1.0 | Topsoil | H |
| | 2 | 68.1 | 9.7 | 10.7 | Clay | |
| | 3 | 1535.4 | - | - | Fresh basement | |
| 11 | 1 | 151.9 | 1.4 | 1.4 | Topsoil | H |
| | 2 | 53.3 | 8.9 | 10.2 | Clay | |
| | 3 | 2304.2 | - | - | Fresh basement | |
| 12 | 1 | 74.8 | 1.0 | 1.0 | Top soil | H |
| | 2 | 22.0 | 2.8 | 3.9 | Clay | |
| | 3 | 583.3 | - | - | Fresh basement | |

## 4.2 INTERPRETATION OF THE GEO-ELECTRIC SECTION

The figure 4.1 below shows the geoelectric section across VES 3 and 4. There are 3 geoelectric layers identified and categorized. The first layer is the topsoil with resistivity value ranging between 115.4Ωm to 118.8Ωm and depth between 3.5 and 5.0. The second is the weathered layer and the resistivity of this layer ranges from 10.6Ωm to 492.6Ωm and thickness ranging between 2.5m and 14.3m. The third layer is the fresh basement with resistivity values ranging from 4492.1Ωm and 6526.8Ωm.

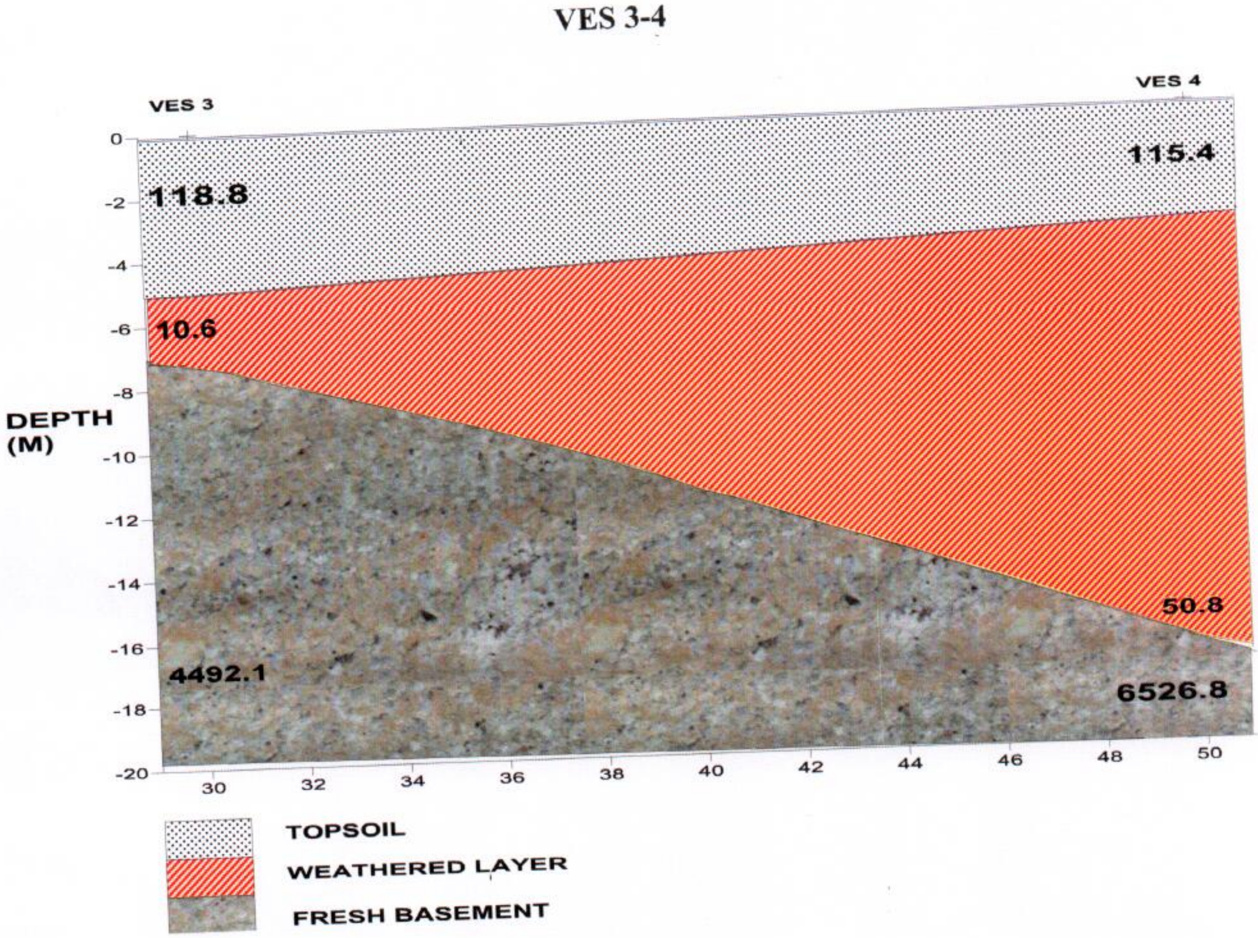


FIGURE 4.1: GEOELCTRIC SECTION ALONG VES 1-3

The figure 4.2 below shows the geoelectric section across VES 5 and 6. There are 3 major layer identified and categorized. The first layer is the topsoil with resistivity value ranging between 206.8Ωm to 373.3Ωm and thickness between 0.9m and 1.1m. The second is the weathered layer which has resistivity value ranging from 64.7Ωm to 78.3Ωm and thickness ranges between 20.4m and 20.6m. The third layer is the fresh basement with resistivity value ranging from 8185.5Ωm and 8254.6Ωm

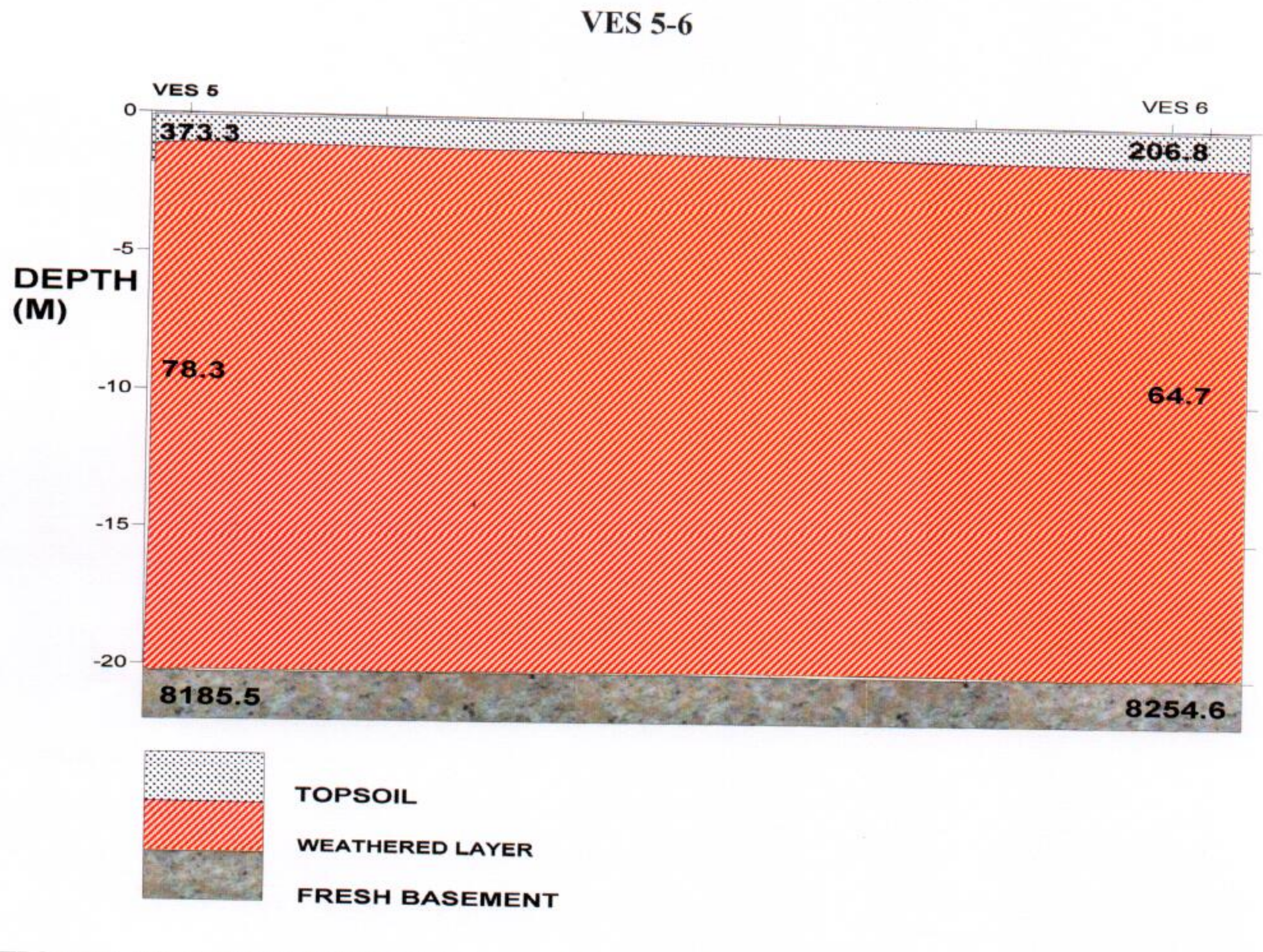


**FIGURE 4.2: GEOELECTRIC SECTION OF VES 5-6**

The figure 4.3 below shows the geoelectric section across VES 10 and 11 and 12. There are 3 geoelectric layers identified and categorized. The first layer is the topsoil with resistivity values ranging from74.8Ωm to 193.8Ωm and thickness between 1.0m and 1.4m. The second is the weathered layer which has resistivity value ranging from 22.0Ωm to 68.1Ωm and thickness ranges between 2.8m and 9.7m. The third layer is the fresh basement with resistivity value ranging from 583.3Ωm and 2304.Ωm.

**VES 10-12**

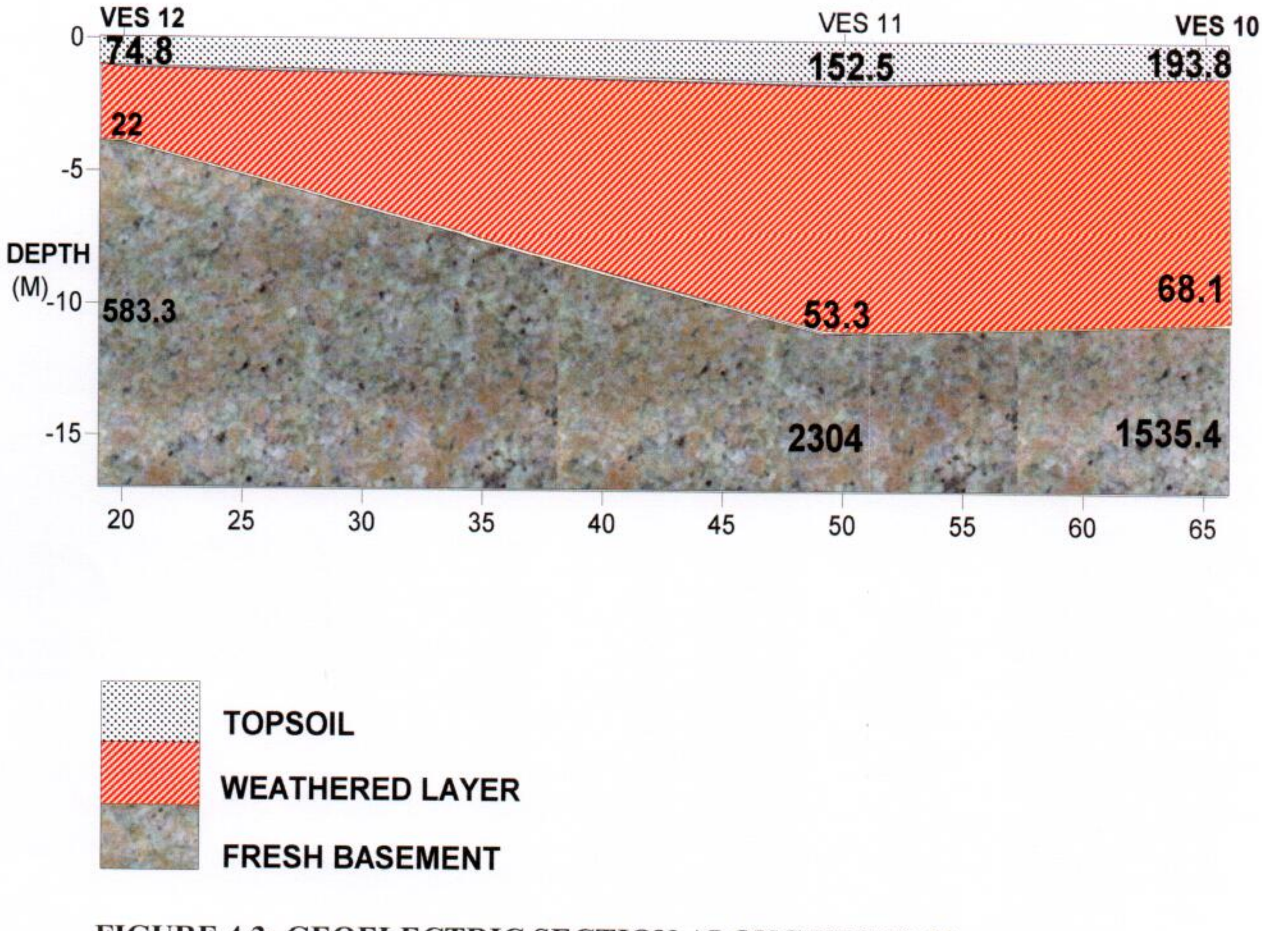


**FIGURE 4.3: GEOELECTRIC SECTION ALONG VES 10-12**

## 4.3 DISCUSSION OF RESULTS

Electromagnetic-Very Low frequency (EM-VLF) and Electrical resistivity methods were adopted for the investigation. A total number of six (6) EM-VLF profiles were generated and twelve conductive zones were identified on the profile (appendix I). Six (6) traverses were established within the study area that runs from north to south and also west to east. The inter-station spacing along the traverses were 5m expect traverse 1 that has a spacing of 10m within the study area. The points where we have positive peak of the filtered real were interpreted as conductive zones with values ranging from 12 to 55. This might be as a result of the presence of geologic features such as fractures, fault or weathered basement.

Twelve (12) Vertical Electric Soundings (VES) were occupied at these identified conductive zones to determine apparent resistivities of the subsurface layer of each respective point. The VES results were interpreted using partial curve matching and computer iteration technique. Three curve types were identified namely; K, H and A. The resistivity curve type differ with VES 1 and 9 having an K curve type, VES 8 an A curve type, VES 2,3,4,5,6,7,10,11 and 12 have the H curve type (Appendix II). The geoelectric section generated from the VES results reveals three layers comprising of topsoil, clayey sand /sandy clay and fresh basement. The topsoil has resistivity values ranging from 74.8ohm-m to 373.3ohm-m and thickness value ranging from 0.9m to 5.0m. The weathered layer has resistivity values ranging from 10.6ohm-m to 492ohm-m and the thickness ranging from 1.4 to 19.5m across the study. Figure 4.1, 4.2 and 4.3 above show the geoelectric sections drawn from the VES stations. The geo electric section delineate three geoelectric layers namely; Topsoil, Weathered layer and the Fresh Basement.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 CONCLUSION

The application of VLF-EM method and electrical resistivity method for groundwater exploration has been used to evaluate groundwater potential of Hostel and Innovation area in phase one, Federal University Oye-Ekiti. A total number of six (6) EM-VLF profiles were generated and twelve conductive zones were identified on the profile. Twelve (12) VES station were occupied and interpreted in the study area. The geoelectric section generated from the VES results reveal three geoelectric layers comprising of topsoil, sandy clay/Clayey sand and fresh basement. Three resistivity curve types were identified as A in VES 8, K in VES 1 and 9 and H in VES 2,3,4,5,6,7,10,11 and 12. The topsoil has resistivity values ranging from 74.8ohm-m to 373.3ohm-m and thickness value ranging from 0.9m to 5.0m. The weathered layer has resistivity values ranging from 10.6ohm-m to 492ohm-m and the thickness ranging from 1.4 to 19.5m across the study. The results of the study area show that there is no fracture and the overburden is of variable thickness across the area.

The groundwater potential is very poor because of high proportion of clay in the weathered layer, which ranges in resistivity between 10.6 and 78.3Ωm. However, VES 2 shows a prominent groundwater potential with weathered layer resistivity value of 115.5Ωm and thickness of 15.8m.

## 5.3 RECOMMENDATION

Base on the result from the investigation, VES 2 is recommended for drilling because it shows a high potential for groundwater development in the study area with the weathered layer thickness of 15.8m and resistivity value of 115.5Ωm.

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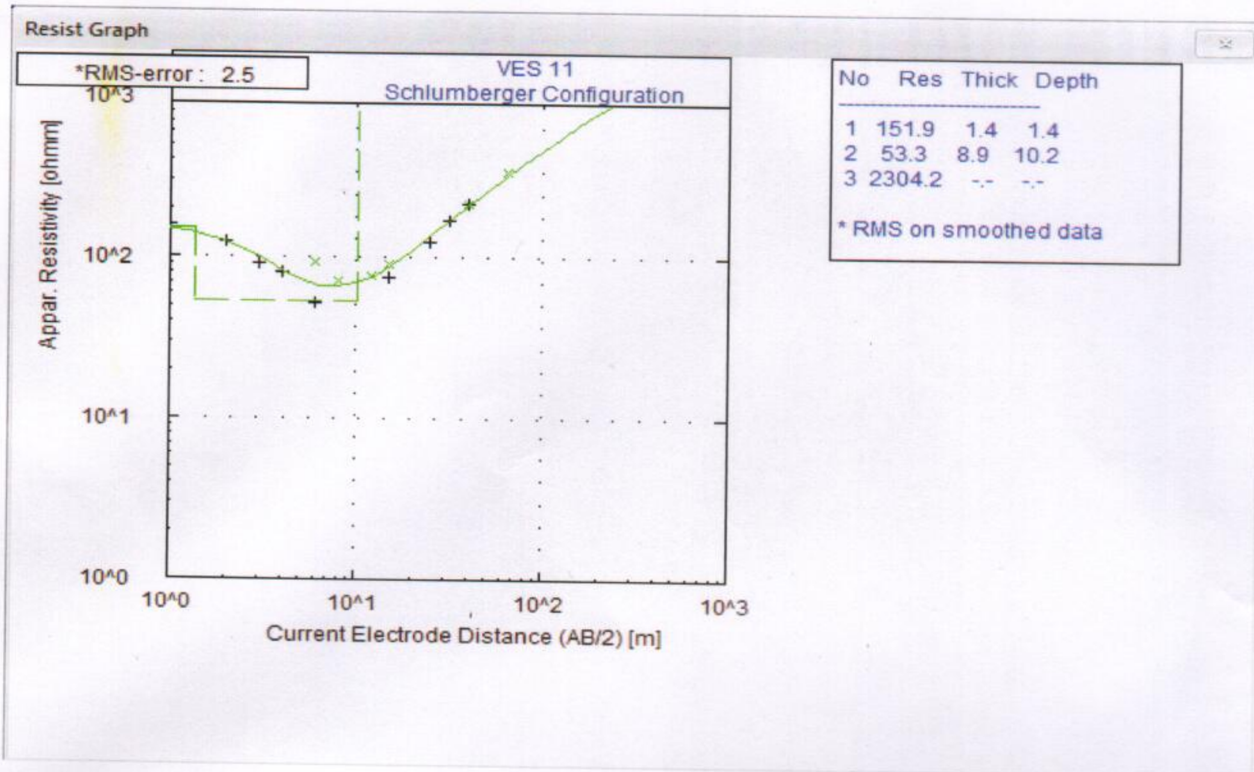
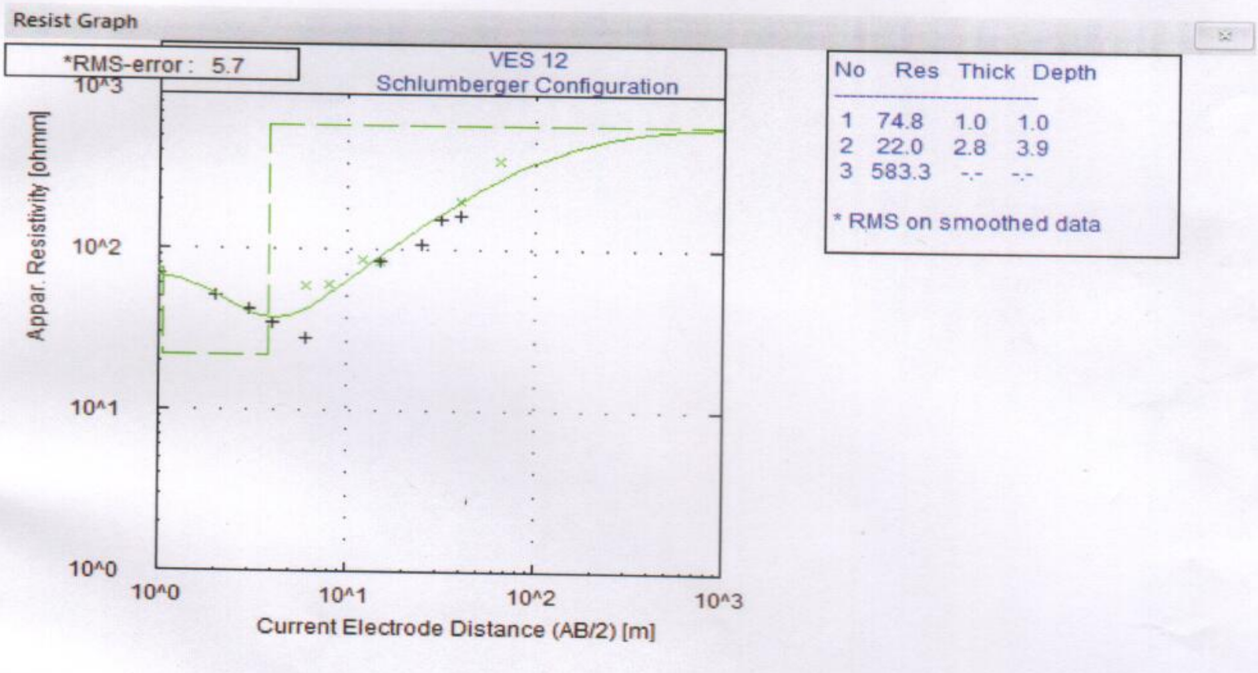

Resist Graph
*RMS-error : 2.5
VES 11
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^3
10^2
10^1
10^0
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 151.9 1.4 1.4
2 53.3 8.9 10.2
3 2304.2 -.- -.-
* RMS on smoothed data

VES 11


Resist Graph
*RMS-error : 5.7
VES 12
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^3
10^2
10^1
10^0
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 74.8 1.0 1.0
2 22.0 2.8 3.9
3 583.3 -.- -.-
* RMS on smoothed data

VES 12