

GEOPHYSICAL SURVEY FOR GROUNDWATER AROUND TECHNICAL ROAD,  
UGBOWO, BENIN- CITY, SOUTHERN NIGERIA USING ELECTRICAL RESISTIVITY  
METHODS

BY

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## **CERTIFICATION**

This is to certify that this project work was carried out and researched by Chidera stellamaris AROH with the matriculation number PSC1707604 of the Department of Geology, Faculty of Physical Sciences, University of Benin, Edo state .

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To Serik Owraigbo I say thank you for assisting me with your laptop and Alfred Agbashe for his support.

## **DEDICATION**

I dedicate this project work to God almighty for the gift of life and good health, and also to my parents .

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## **ABSTRACT**

The Geophysical survey involving electrical resistivity method has been carried out at Technical road in Benin, A total of five(5) Vertical Electrical Resistivity (VES) were established within the site .The Schlumberger configuration was used for the data acquisition. The quantitative interpretation of the VES involved the plotting on a graph and also used 1X1D software iteration technique. The geoelectric sections drawn from the results of the interpretation revealed a maximum of six layers which comprises of top soil, silt and sandstone.

# CHAPTER ONE

## INTRODUCTION

### 1.1 General statement

Water is an important fluid and basic need of life. The need for water is strongly rising and has different function which is not only vital for drinking purposes but it is also vital for any developmental activities.

Groundwater is defined as subsurface water that fills in the soil pore spaces and in fracture of rock formation. It is known as an alternative water supply for all living things.

In most of the countries, there is not only a heavy reliance on groundwater as a primary drinking supply but also as supply of water for both agricultural use and industrial use.

The reliance on groundwater is such that there are significant quantities of water and that it is a high quality. The use of geophysics for both groundwater resources mapping and for water quality evaluations has increased over the years.

Groundwater has been exploited by mankind since the beginning of time and are drawn out of the earth's aquifer each year. This makes groundwater the primary mineral extracted from the earth. Qualitative because of the presence protective surficial geological formations, their depth, filtering capacity of most of their reservoirs and the clogging of river banks, aquifer groundwater is generally better protected than surface water from massive pollution.

Geophysics is the application of physics that study the earth by taking measurements at or near the surface of earth. Geophysical method is seen as the most suitable tool in the exploration of groundwater as this method has been widely applied in geo-technical and geo-environment investigation.

Electrical resistivity method(ERM) is a geophysical method in which an electric current is injected into the ground through steel electrodes in an attempt to measure the electrical properties of the subsurface.

## **1.2 Aim and Objectives**

### **1.2.1 Aim**

The project aims at carrying out geophysical investigations in the study area using the electrical resistivity method to explore the groundwater.

### **1.2.2 Objectives**

- 1 To have an insight into the subsurface geology of the study area.
- 2 To determine the geo-electrical and hydrogeological characteristics of the aquifer present in the study area.
- 3 To determine the thickness of the subsurface layers and their resistivity.

## 1.3 Common Method of Geophysical Investigation

### 1.3.1 Gravity method

Gravity measurements describe anomalous density within the Earth; in most cases, ground-based gravimeters are used to precisely measure variations in the gravity field at different points. Gravity anomalies are computed by subtracting a regional field from the measured field, which result in gravitational anomalies that correlate with source body density variations. Positive gravity anomalies are associated with shallow high density bodies, whereas gravity lows are associated with shallow low density bodies. Thus, deposits of high-density chromite, hematite, and barite yield gravity highs, whereas deposits of low-density halite, weathered kimberlite, and diatomaceous earth yield gravity lows. The gravity method also enables a prediction of the total anomalous mass (ore tonnage) responsible for an anomaly. Gravity and magnetic (discussed below) methods detect only lateral contrasts in density or magnetization, respectively. In contrast, electrical and seismic methods can detect vertical, as well as lateral, contrasts of resistivity and velocity or reflectivity. Applications of gravity to mineral deposit environmental considerations includes identification of lithologies, structures, and, at times, orebodies themselves . Small anomalous bodies, such as underground workings, are not easily detected by gravity surveys unless they are at shallow depth.

### 1.3.2 Gamma ray methods

Gamma-ray methods use scintillometry to identify the presence of the natural radio elements potassium, uranium, and thorium; multi-channel spectrometers can provide measures of individual radioelement abundances. Gamma-ray methods have had wide application in uranium exploration because they provide direct detection. Thorium is generally the most immobile of the three radio elements and has geochemical behavior similar to that of zirconium. Thorium content, like uranium content, tends to increase in felsic rocks and generally increases with alkalinity. Gamma-ray spectrometry, because it can provide direct quantitative measures of the natural radio elements, provides geo-environmental information concerning radiation dose and radon potential. Because uranium and (or) potassium are commonly enriched in or adjacent to some deposits, their presence may often be used to

indirectly assess the potential for release of hazardous materials from ore or waste piles. Where sulfide minerals are present their oxidation accelerates uranium mobilization.

### 1.3.3 Seismic method

Seismic techniques have had reasonably restricted utilization, due to their relatively high cost and the complexity of acquiring and interpreting seismic data in strongly faulted and altered igneous terrain, in mineral assessments and exploration at the deposit scale. However, shallow seismic surveys employ less expensive sources and smaller surveys than are typical of regional surveys, and the cost of studying certain geo-environmental problems in the near subsurface may not be prohibitive. Reflection seismic methods provide fine structural detail and refraction methods provide precise estimates of depth to lithologies of differing acoustic impedance. The refraction method has been used in mineral investigations to map low-velocity alluvial deposits such as those that may contain gold, tin, or sand and gravel. Applications in geo-environmental work include studying the structure, thickness, and hydrology of tailings and extent of acid mine drainage around mineral deposits (Dave and others, 1986).

### 1.3.4 Thermal method

Two distinct techniques are included under thermal methods (a) borehole or shallow probe methods for measuring thermal gradient, which is useful itself, and with a knowledge of the thermal conductivity provides a measure of heat flow, and (b) airborne or satellite-based measurements, which can be used to determine the Earth's surface temperature and thermal inertia of surficial materials, of thermal infrared radiation emitted at the Earth's surface. Thermal noise includes topography, variations in thermal conductivity, and intrinsic endothermic and exothermic sources. Borehole thermal methods have been applied in geothermal exploration, but have seldom been used in mineral exploration. However, this method has potential usefulness in exploration and in geo-environmental investigations (Brown and others, 1980; Zielinski and others, 1983; Houseman and others, 1989). Causes of heat flux anomalies include oxidizing sulfide minerals and high radioelement concentrations. Conditions that may focus, or disperse, heat flow are hydrologic and topographic influences, as well as anomalous thermal conductivity. In geo-environmental

applications, oxidation of sulfide bodies in-place or on waste piles, if sufficiently rapid, can generate measurable thermal anomalies, which can provide a measure of the amount of metal being released to the environment. Borehole temperatures may also reflect hydrologic and hydrothermal systems that have exploration and geo-environmental consequences. Airborne thermal infrared measurements have applications in geothermal exploration, and may have potential in mineral exploration and in geo-environmental applications whenever ground surface temperature is anomalous due to sulfide oxidation, hydrologic conditions, or heat-flow perturbations due to structure or lithology (Strangway and Holmer, 1966). Thermal infrared imaging methods are a specialized branch of more generalized remote sensing techniques. Images obtained in this wavelength range may be used for photogeologic interpretation or, if day and night images are available, to estimate the thermal inertia of the surface. Unconsolidated or glassy materials can be distinguished by their low thermal inertia. In places, thermal infrared images can distinguish areas of anomalous silicification.

#### 1.3.5 Electrical method

Electrical methods comprise a multiplicity of separate techniques that employ differing instruments and procedures, have variable exploration depth and lateral resolution, and are known by a large lexicon of names and acronyms describing techniques and their variants. Electrical methods can be described in five classes: (1) direct current resistivity, (2) electromagnetic, (3) *mise-a-la-masse*, (4) induced polarization, and (5) self potential. In spite of all the variants, measurements fundamentally are of the Earth's electrical impedance or relate to changes in impedance. Electrical methods have broad application to mineral and geo-environmental problems: they may be used to identify sulfide minerals, are directly applicable to hydrologic investigations, and can be used to identify structures and lithologies.

#### 1.3.6 Direct current method

Direct current resistivity methods measure Earth resistivity (the inverse of conductivity) using a direct or low frequency alternating current source. Rocks are electrically conductive as consequences of ionic migration in pore space water and more rarely, electronic conduction through metallic luster minerals. Because metallic luster minerals typically do not provide long continuous circuit paths for conduction in the host rock, bulk-rock

resistivities are almost always controlled by water content and dissolved ionic species present. High porosity causes low resistivity in water-saturated rocks. Direct current techniques have application to a variety of mineral exploration and geo-environmental considerations related to various ore deposit types. Massive sulfide deposits are a direct low resistivity target, whereas clay alteration assemblages are an indirect low resistivity target within and around many hydrothermal systems. The wide range of earth material resistivities also makes the method applicable to identification of lithologies and structures that may control mineralization. Acid mine waste, because of high hydrogen ion mobility, provides a more conductive target than solutions containing equivalent concentrations of neutral salts.

### 1.3.7 Electromagnetic method

Electromagnetic measurements use alternating magnetic fields to induce measurable current in the Earth. The traditional application of electromagnetic methods in mineral exploration has been in the search for low-resistivity (high-conductivity) massive sulfide deposits. Airborne methods may be used to screen large areas and provide a multitude of targets for ground surveys. Electromagnetic methods, including airborne, are widely used to map lithologic and structural features (Palacky, 1986; Hoover and others, 1991) from which various mineral exploration and geo-environmental inferences are possible

### 1.3.8 Remote sensing method

Remote sensing includes methods that make use of images obtained in the ultra-violet, visible, and near infrared bands of the electromagnetic spectrum . Thermal infrared observations, discussed previously under thermal methods, are also part of remote sensing. Remote sensing data are treated in image format, often in digital form, so that they can be processed conveniently.

## 1.4 Climate

Climate is the average weather condition in a given area over a longer period of time.

The study area has a temperate climate condition.

#### **1.4.1 Accessibility**

Accessibility is said to be the quality of being reached or entered.

All the roads leading to the study area are all accessible by humans, animals and vehicles. they are easily located.

#### **1.4.2 Topography and drainage**

Topography is the study of the forms and features of land surfaces, while Drainage is the system or process by which water or other liquids are drained from a place.

There are Three river systems drain the Benin Region. They are the Ikpoba River, the Ogba River and Owigie-Ogbovben River systems . The major one is the Ikpoba River. Its' headstream originates from the N.E outside the Benin Region and flows east to west across the northern quarter of the region and then swings south and south east. This change in direction indicates some structural control. There is a prominent artificial man-made lake referred to as the Ikpoba Lake along its course in Okhoro. The lake is used mainly for municipal water supply for drinking, fishing.

## 1.5 Location of the Study area

The study area is situated at Technical road in Egor local government area of Benin city, with latitude 6°22'N to 6°23'N and longitude 5°36'E to 5°37'E. fig 1 below shows the location Map of the study.

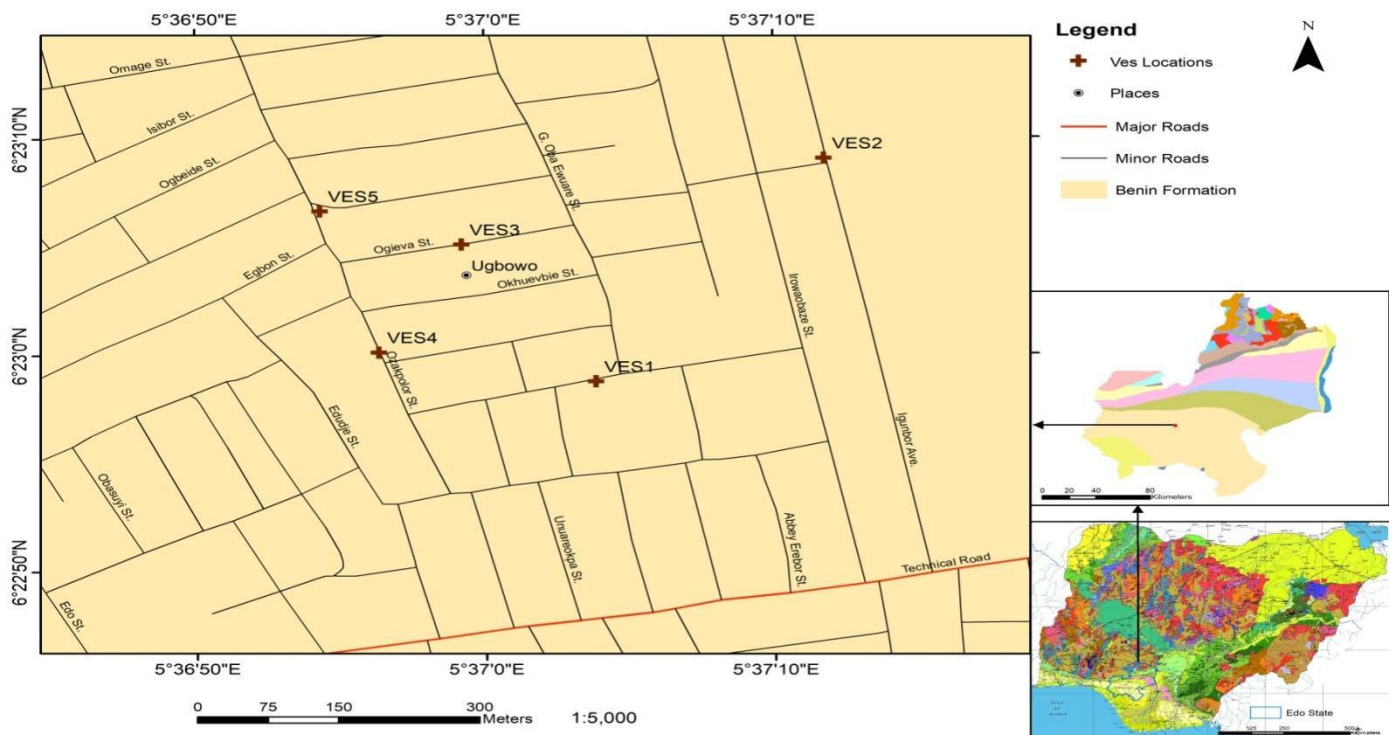


Fig1:Location Map of The Study area

### 1.5.1 Description of the Study area

The study area is a developing area. Also has some businesses going on in the area, schools and churches, with some of the roads been accessible by vehicles. The roads are usually not busy so it was safe carrying out the experiments. The habitats are peaceful and hospitable.

## 1.6 Electrode Array

Electrode arrays are different arrangements of electrodes used to perform geophysical resistivity measurements. Electrode arrays were developed in order to make field measurements more efficient and data interpretation easier.

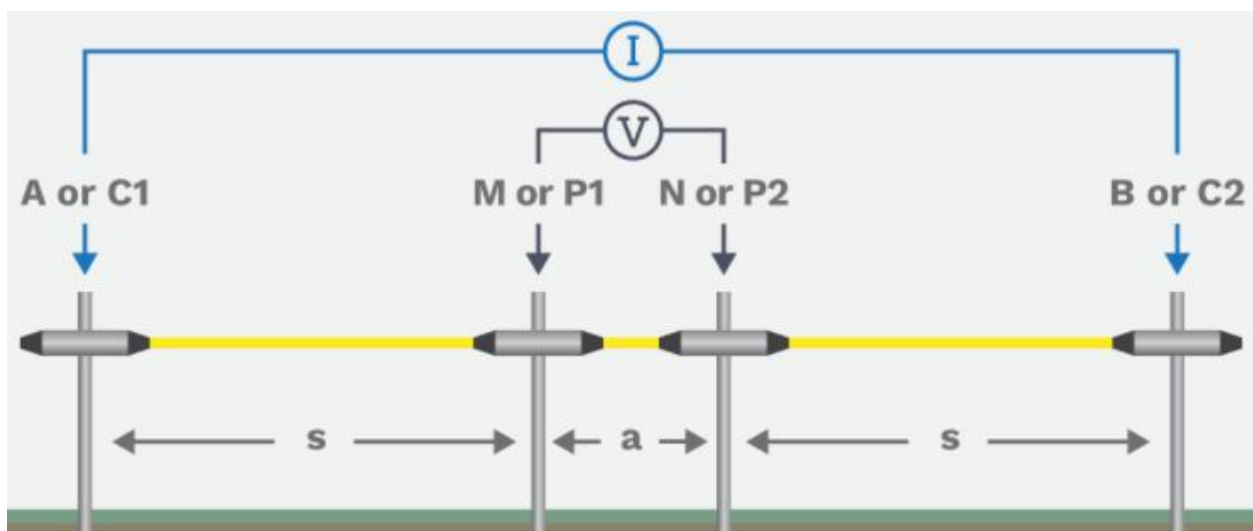


Fig1.2: Electrode configuration

### 1.6.1 Schlumberger Array

The Schlumberger array is an array in which four electrodes are positioned in line around a common midpoint. The two outer electrodes, A and B, are current electrodes, and the two inner electrodes, M and N, are potential electrodes placed close together.

With the Schlumberger array, for each measurement the current electrodes A and B are moved outward to a greater separation throughout the survey, while the potential electrodes M and N stay in the same position until the observed voltage becomes too small to measure. At this point, the potential electrodes M and N are moved outward to a new spacing. As a rule of the thumb, the reasonable distance between M and N should be equal or less than

one-fifth of the distance between A and B at the beginning. This ratio goes about up to one-tenth or one-fifteenth depending on the signal strength.

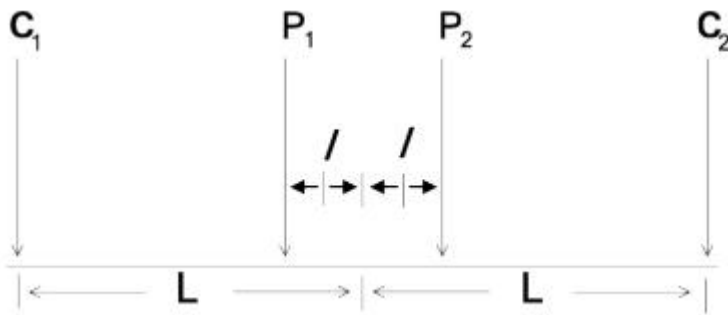


Fig1.3: Schlumberger array layout

### Backgrounds

The Schlumberger array is named for Conrad Schlumberger, founder of the modern-day Schlumberger oilfield services company and pioneer of electrical methods in the early 1900s.

### 1.6.2 Advantages of Schlumberger Array over Wenner Array

- I. Schlumberger arrays provides better resolution and takes lesser time to deploy unlike the Wenner array.
- II. Schlumberger array reduces susceptibility to surficial irregularities since only two electrodes are changed not four as with the Wenner array.
- III. For Schlumberger array fewer electrodes are needed to be moved for each sounding and the cable length for potential electrodes is short.

- IV. Interpretation techniques for Schlumberger array are well developed and more diversified than Wenner array
- V. The best method for VES practical reasons
- VI. Significantly less labour intensive than the Wenner array



## Chapter 2

### Literature review

#### 2.1 General geology

Geology comes from an ancient Greek word which means earth, is a branch of natural sciences that deals with the Earth and other astronomical objects, the features of rocks of which it is composed, and the processes by which they change over time. Modern geology extensively covers all other Earth sciences, including hydrology, geophysics, sedimentology and so on.

Geology explains the structure of the Earth on and below its surface, and the processes that has formed the structures. It also provides instruments to determine the relative and absolute ages of rocks found in a specific location, and which also describes the histories of those rocks. By combining these tools, geologists are able to record the geological history of the Earth, and also to reveal the age of the Earth. Geology provides the primary evidence for plate tectonics, the evolutionary history of life, and the Earth's past climates.

Geologists broadly study the properties and processes of Earth and other terrestrial planets. Geologists use a wide variety of methods to understand the Earth's structure and evolution, which includes field work, rock description, geophysical techniques, chemical analysis, physical experiments, and numerical modelling. In practical terms, geology is important for mineral and hydrocarbon exploration and exploitation, evaluating water resources, understanding natural hazards, the remediation of environmental problems, and providing insights into past climate change.

#### 2.2 Geology of the study area

The study area Technical road is located in Benin City within the Benin Formation, and is located in the southern part of Nigeria. It is defined by latitudes 6° 17' to 6° 25' N and longitudes 5° 33' to 5° 43' E. The City is characterized by flat plains in most part of the area and isolated hills in a few places. Benin City is underlain by the sedimentary sequences

belonging to the Niger Delta sedimentary province. Benin Formation underlies the City and it is made up of sands, clayey sands and discontinuous clay sequences. The Benin Formation consists of reddish earth consisting loose poorly sorted sands underlying recent Quaternary sedimentary deposits of Southern Nigeria found in Benin City and environs. This characteristic can be found in many road cuts in the city, with reddish clayey sand horizons that are covered by light brown to red top-soil

### **2.2.1 Niger Delta Stratigraphy**

In Niger Delta, a petroleum system-the Tertiary Niger delta petroleum system famously recognized as the Akata-Agbada formation, has been discovered (Ekweozor et al, this study 1995). The Delta, formed at a rift junction that started developing in the late jurassic and ended in late cretaceous, properly began developing in the Eocene with sediments volume of 500,000km<sup>3</sup> (Hospers, 1965) and over 10km deep already accumulated sediments (kaplan et al, 1964).

The tertiary Niger Delta section has been identified with three formations that represent prograding depositional facies mainly distinguished on the basis of sand-shale ratios and they are the Akata, Agbada and Benin formations. Akata formation situated at the base of the delta is of marine origin and is composed of thick shale sequences, turbidite sand and subtle amounts of clay and silt. Beginning in the Paleocene and through the recent, Akata formation formed during lowstands when terrestrial organic matter and clays were transported to deep water areas characterized by low energy conditions and oxygen deficiency( (Statcher,1995). The underlying over pressured Akata formation has only been drilled little as it has an estimated thickness of 7,000m.(Doust et al,1990).

### **2.2.2 The Benin Formation**

The Benin Formation is the youngest formation in the Niger Delta Basin and it is continental in nature. This formation is Oligocene in age and it's mostly sand. This Formation predominantly made up of quartz and clays deposited in a quiet environment. Using the Petitjohn classification the Benin Formation is classified as Quartz Arenite because it

contains over 90% quartz and less than 15% matrix materials. Beds, cross beds, bedding plane are structures found in the Benin Formation.

The Benin formation is devoid of some structural traps which includes growth faults, rollover anticline and shale diapirs because the gravity tectonics that are responsible for producing them had already siezed before the Benin formation was deposited.

### **2.2.3 The Agbada Formation**

The Agbada Formation underlies the Benin formation and consist of interbedded fluvio marine sands, sandstones and siltstone of various proportion and thickness representing cyclic sequence of offlap unit (Weber, 1971). Texturally the sandstone vary from coarse to fine grained, poorly to very well sorted, unconsolidated to slightly consolidated. Lignite streak and limonite coating occur with some shell fragment and glauconitic (Short and Stauble, 1967). The shale are medium to dark grey, fairly consolidated and silty with localized glauconitic.

Shaliness increases downward and the formation passes gradually into the Akata formation. This formation dates back to the Eocene age.

### **2.2.4 The Akata Formation**

The Akata Formation is the under compacted, over pressured, marine prodeltamegafacies of the Niger Delta basin. It is composed mainly of marine shale with occasional turbidite sandstone and siltstone (Short and Stauble, 1967). The thickness ranges from 600m to over 6000m and depends on the shale diapirs. It is thought to be the sources rock of the Niger delta complex. Abundance of planktonic foraminifera assemblage indicates deposition of the Akata shale on a shallow marine environment (Whiteman 1982).

AGE		FORMATION	LITHOLOGY	THICKNESS	SEDIMENTARY CYCLE	ENVIRONMENT
NEOGENE	HOLOCENE	BENIN	[Dotted pattern]	max 2100m	DELTA	CONTINENTAL
	PLEISTOCENE					
	PLIOGENE					
	MIOCENE	AKATA	[Horizontal line pattern]	> 3000m	MODERN NIGER	TRANSITIONAL TO MARINE
OLIGOCENE						
PALEOGENE	Eocene	AKATA	[Horizontal line pattern]	600 - 6000m	TRANSGRESSION	MARINE
	PALEOCENE					

Fig2: Stratigraphic section of the Niger Delta adopted from Doust, 1990

## Chapter 3

### MATERIALS AND METHODS

#### 3.1 List of equipment

- I. Tape: Instrument used for taking measurement.



Fig3.1: Tape used for measurement

- I. Resistivity meter: An instrument used to carry out resistivity surveys that usually has a current transmitter and voltage-measuring circuitry.
- II. Electrode: A conductor planted into the ground which current through passes, or which is also used to measure the voltage caused by the current.
- III. Multi-core cable: this cable with a number of independent wires.



Fig3.2:core cables

- I. Umbrella : used in covering the Abem Terrameter from the heat of the sun
- II. Abem Terrameter: an instrument used in collecting the best data possible



Fig 3.3: Instrument for data collection

- I. The GPS : an instrument used in taking the coordinate of the location



Fig3.4: GPS

- I. Water Bottle: used in storing water used in the wetting the ground to aid conductivity.
- II. Hammer: used in hitting the electrodes into the ground.



Fig3.5:showing the picture of an hammer

### 3.2 Field procedure

- I. identify where the field study will take place
- II. Take the coordinate of your location
- III. Take inventory for your equipments
- IV. Decide on an interval for your electrodes .
- V. Lay out the tape measure, Now that you know what the spacing should be between each of the electrodes, it's time to get them in the ground. You should use a very long

tape measure at least 100 meters to mark off where each electrode should be hammered into the ground

- VI. Hammer in the stakes - use a small sledgehammer to pound the stakes securely into the ground.
- VII. Connect the electrodes, electrode cable and Terrameter - Once your electrodes are ready to go, lay the multi-electrode cable along the line and connect each take-out to an electrode. This allows the system to activate any of the electrodes along the line. Once your cable is connected to each electrode, you'll connect the cable to a Terrameter which controls the electrodes.
- VIII. Run a contact resistance test to check that all is connected right - Start the contact resistance test to make sure all electrodes are connected correctly. The instrument will issue warnings for electrode which are not connected right or planted firmly in the ground
- IX. Begin the resistivity survey scan and take your readings.

### **3.3 Theory of electrical resistivity**

The electrical resistivity method is a dynamic geophysical method. It employs an artificial source that is introduced into the ground through a pair of electrodes. The procedure involves the measurement of potential difference between other two electrodes in the vicinity of current flow.

Apparent resistivity is calculated by using the potential difference for the interpretation. The electrodes by which current is introduced into the ground are called Current electrodes and electrodes between which the potential difference is measured are called Potential electrodes

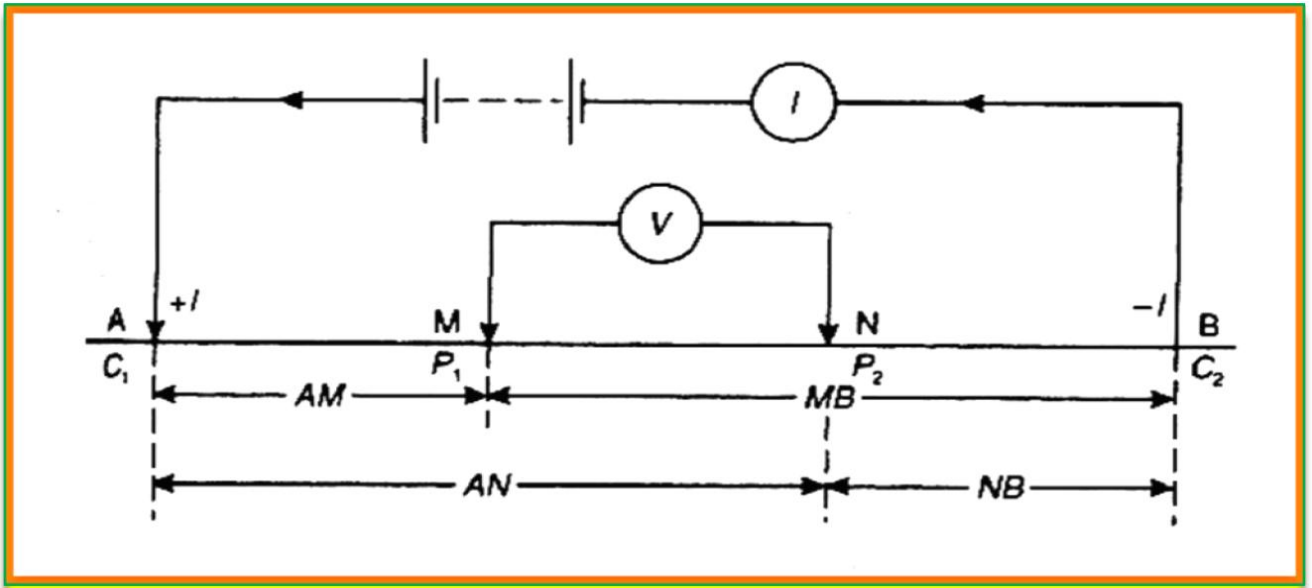


Fig 3.6: potential electrodes (M,N) and current electrodes(A,B)

Potential at M,

$$V_1 = \frac{\rho_a I}{2 * \pi} \left( \frac{1}{AM} - \frac{1}{MB} \right)$$

Potential at N,

$$V_2 = \frac{\rho_a I}{2 * \pi} \left( \frac{1}{AN} - \frac{1}{NB} \right)$$

Potential difference between M and N,

$$\Delta V = \frac{\rho_a I}{2 * \pi} \left\{ \left( \frac{1}{AM} - \frac{1}{MB} \right) - \left( \frac{1}{AN} - \frac{1}{NB} \right) \right\}$$

-----eqn 1

### 3.4 Data Acquisition

These data were collected in the field using the Abem Terrameter.



Plate1: Data collection in the field



Plate2: Data collection

### 3.5 Application of electrical resistivity

- I. Groundwater detection
- II. Mineral identification
- III. Waste exploration
- IV. Oil identification

### 3.6 Limitations of resistivity survey.

1. It is also charged with demanding of more time, effort and money.
2. Sometimes if sample information's have not been collected very carefully, the magnitude of sampling error may be too large to render the sample results reasonably accurate.
3. When the resistivity image is calculated, it makes an assumption that the layers continue sideways in the same way they were measured.
4. To seek an accurate subsurface image surveyors tend to use a multitude of survey techniques in order to eliminate the effect of some of these errors.

### 3.7 Basic resistivity equation

The resistivity formula is expressed as

$$\rho = \frac{RA}{l} \text{ -----eqn 2}$$

Where  $\rho$  is the resistivity, R is the resistance, l is the length of the material and A is the area of cross-section.

### 3.8 Field procedures of Schlumberger array

- I. Determine the desired length of the road or location.
- II. Set up the electrodes. The current electrodes should be spaced a set distance apart, typically 20 cm, 50 cm, or 100 cm. The potential electrodes should be placed at a fixed distance from the centre of the current electrodes, typically about twice the distance between the current electrodes.
- III. Drive the electrodes into the ground with a hammer. The electrodes should be driven to the desired depth.
- IV. Connect the resistivity meter or multi-meter to the electrodes. The meter should be connected to the current electrodes and the potential electrodes.

- V. Take a reading. The resistivity meter will measure the resistance between the current electrodes and the potential electrodes.
- VI. Repeat the process at multiple locations to get your data.
- VII. Calculate the average resistivity using the readings from each location.

### **3.9 Choice of site**

Choice of site selection depends on the following

- I. Distance: we selected a location not far from school environments.
- II. Cost: selecting an area depends on your total budgets which includes transportation fees, accommodation and so on
- III. Also safety is another factor to consider when selecting an area to work. Is the place safe, are the habitats hostile or welcoming are there wild animals there?
- IV. Accessibility: is the location accessible by humans, vehicles and so on.

### **3.10 Field precautions**

- I. These are measures taken in advance to prevent something dangerous, unpleasant, or inconvenient from happening:
- II. Going to the field requires proper and adequate dress code which includes a pair of trousers, a long sleeve top, a pair of field boots and a raffia hat.
- III. When the sun is too hot use the umbrella to cover the Terrameter.
- IV. Avoid placing your equipment and taking readings on roads with transformers, or better still if you must work on that area it is advisable to set your equipment across the transformer and take your readings.
- V. Avoid possible injuries on the field, by carefully driving the electrodes into the grounds to avoid hitting your fingers or hand with the hammer.
- VI. Do not take readings when a partner or colleague is not yet done with changing the electrodes to avoid electrical shocks

- VII. Always communicate with colleagues and partners and make sure you are on same page to avoid taking wrong readings.
- VIII. Do not take readings along a blocks mounted on the grounds with the OFC inscription.

### **3.11 Interpretation techniques**

- I. The first step in the interpretation of a resistivity sounding is to plot on log-log sheet a graph of apparent resistivity against the current electrode spacing( $AB/2$ ).The interpretation of a resistivity sounding survey is to classify the observed apparent resistivity curves into types
- II. The second one is the analytical interpretation, this techniques depends on using the result of manual interpretation as an initial model to compute the true resistivity values and thickness by using IXIR software.. This program deals with VES curves in a man–computer interacted regime and draws theoretical and Field curves on a display screen together with a  $\rho(z)$  model curve The latter results of VES interpretation were used for the constrictive of geo-electrical cross-sections which show the different geological units finding in the investigated area.



## CHAPTER FOUR

### 4.1 RESULTS

Table 4.1a and 4.1b are presentation of the field data and the earth models.

AB/2	MN/2	Resistivity( $\Omega$ m)
1.00	0.20	70.13
1.47	0.20	85.13
2.15	0.20	106.55
3.16	0.20	124.29
4.64	0.20	133.52
6.81	0.20	120.47
10.00	0.20	103.64
14.70	2.00	100.00
21.50	2.00	122.74
31.60	2.00	163.28
46.90	2.00	229.38
68.10	10.00	320.00
100.00	10.00	500.00
147.00	40.00	800.00
215.00	40.00	1010.00
250.00	40.00	950.00
280.00	40.00	900.00

VES 1					
Layer	Resistivity( $\Omega$ m)	Thickness (m)	Depth (m)	Inferred Lithology	Remarks
1	53.686	0.70623	0.70623	Top soil	
2	307.96	1.5488	2.2550	Sandstone	
3	44.973	6.1222	8.3772	Silt	
4	290.78	9.0445	17.422	Sandstone	
5	12947.	43.697	61.119	Sandstone	aquifer
6	314.16				

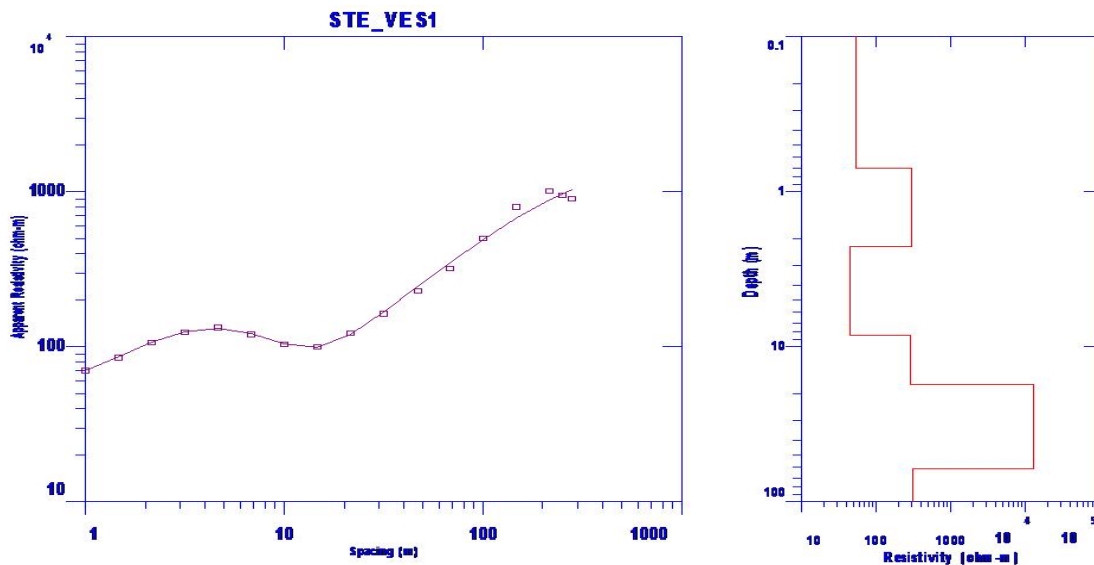


Fig 4.1: ves1 curve and model

Table 4.2a and 4.2b are presentation of the field data and the earth models

Table 4.2a

AB/2	MN/2	Resistivity ( $\Omega\text{m}$ )
1.00	0.2	153
1.47	0.2	180
2.15	0.2	223
3.16	0.2	293
4.64	0.2	365
6.81	0.2	475
10.00	0.2	589
14.70	2	709
21.50	2	801
31.60	2	950
46.40	2	1121
68.10	10	1398
100.00	10	1775
147.00	10	2169
215.00	40	2507
300.00	40	2350

table4.2b.

VES 2					
Layer	Resistivity ( $\Omega\text{m}$ )	Thickness (m)	Depth (m)	Inferred Lithology	Remarks
1	132.32	0.90000	0.90000	Top soil	
2	486.00	1.6300	2.5300	Sandstone	
3	1141.0	7.7800	10.310	Sandstone	
4	790.00	18.300	28.610	Sandstone	
5	8729.0	13.300	41.910	sandstone	Acquifer
6	5208.0	83.500	125.41	Sandstone	
7	712.00				

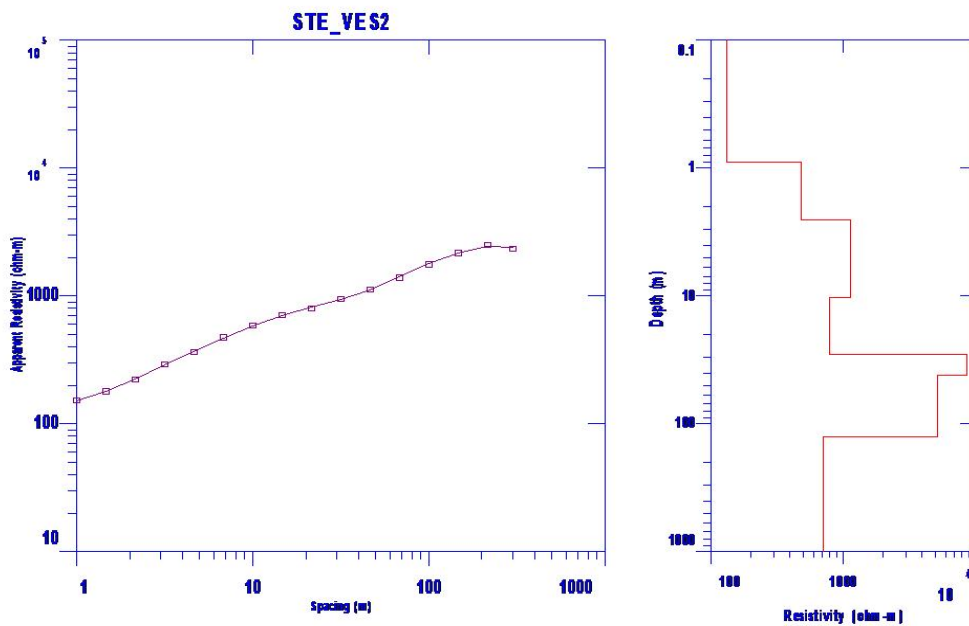


Fig 4.2:ves2 curve and model

Table 4.3a and 4.3b are presentation of the field data and the earth model

Table 4.3a

AB/2	MN/2	Resistivity ( $\Omega m$ )
1.00	0.20	198.83
1.47	0.20	222.91
2.15	0.20	256.76
3.16	0.20	295.21
4.64	0.20	320.24
6.81	0.20	333.78
10.00	0.20	333.68
14.70	2.00	331.24
21.50	2.00	375.14
31.60	2.00	466.06
46.40	2.00	608.60
68.10	10.00	759.76
100.00	10.00	869.97
147.00	10.00	904.80
215.00	40.00	919.56
300.00	40.00	820.00

table 4.3b

VES 3					
Layer	Resistivity ( $\Omega m$ )	Thickness (m)	Depth (m)	Inferred Lithology	Remarks
1	177.66	0.82675	0.82675	Top soil	
2	413.99	3.6465	4.4732	Sandstone	
3	216.97	8.5204	12.994	Sandstone	
4	1746.5	46.748	59.742	Sandstone	Aquifer
5	654.63	141.76	201.50	Sandstone	
6	604.63			Sandstone	

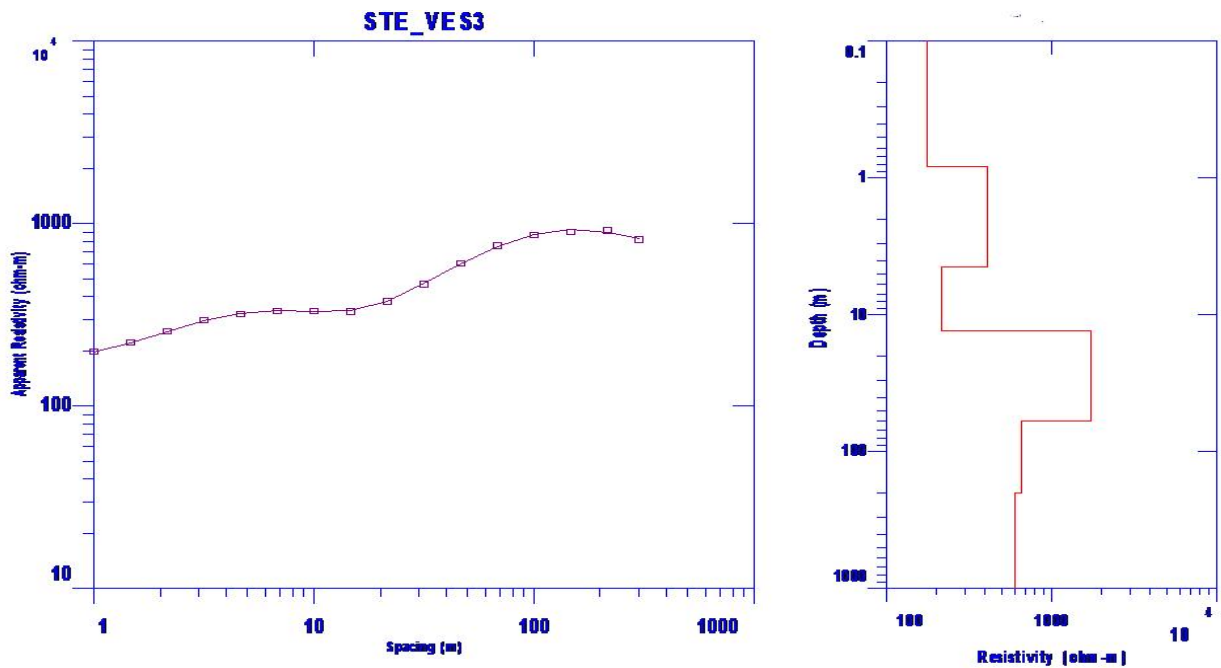


Fig 4.3: VES3 curve and model

Table 4.4a and 4.4b are presentations of the field data and the earth models

Table 4.4a

AB/2	MN/2	Resistivity ( $\Omega m$ )
1.00	0.20	53.91
1.47	0.20	75.64
2.15	0.20	109.08
3.16	0.20	160.35
4.64	0.20	229.81
6.81	0.20	348.60
10.00	0.20	510.95
14.70	2.00	736.66
21.50	2.00	998.80
31.60	2.00	1405.60
46.40	2.00	1823.70
68.10	10.00	2103.30
100.00	10.00	2260.00
147.00	10.00	1968.34
215.00	40.00	1349.04

table 4.4b

VES 4					
Layer	Resistivity( $\Omega m$ )	Thickness (m)	Depth (m)	Inferred Lithology	Remarks
1	26.565	0.46729	0.46729	Top soil	
2	361.71	0.55731	1.0246	Sandstone	
3	16522.	12.861	13.886	Sandstone	aquifer
4	992.77	25.204	39.089	Sandstone	
5	208.00				

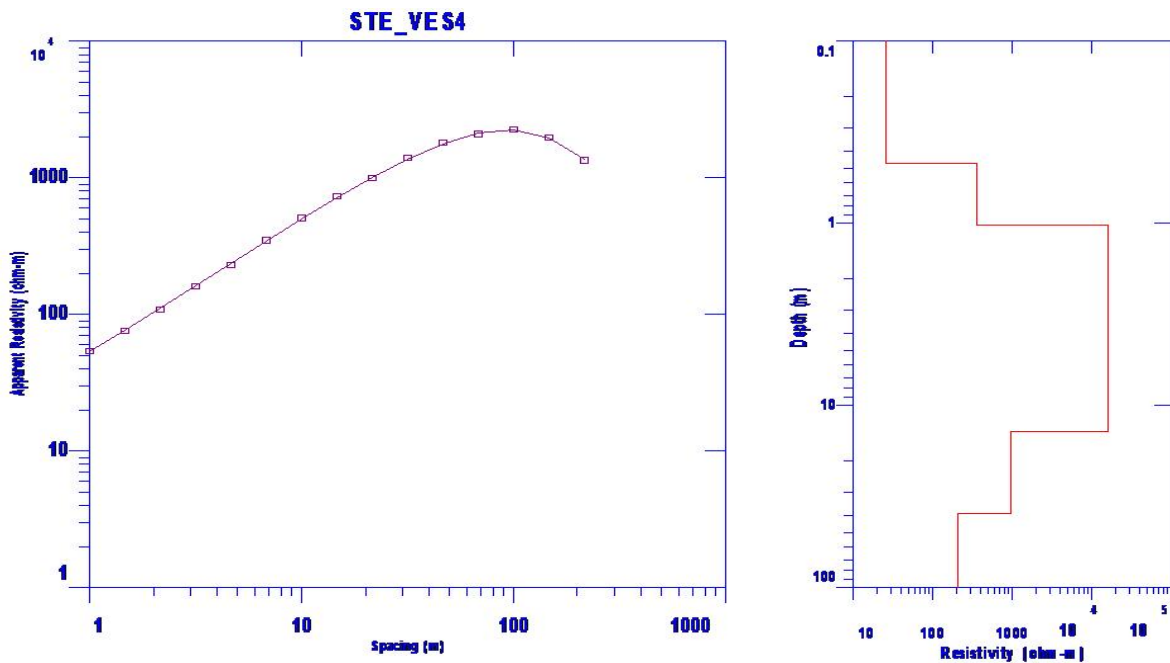


Fig 4.4: VES4 curve and model

Table 4.5a and 4.5b are presentation of field data and the earth models

Table 4.5a

Table .5b

AB/2	MN/2	Resistivity( $\Omega$ m)
1	0.2	47.05
1.47	0.2	41.32
2.15	0.22	34.18
3.16	0.2	30.1
4.64	0.2	32.43
6.81	0.2	45.38
31.6	2	201.37
46.4	2	282.14
68.1	10	389.89
100	10	520.56
147	10	635.64
215	40	728.83
316	40	680

VES 5					
Layer	Resistivity ( $\Omega$ m)	Thickness (m)	Depth (m)	Inferred Lithology	Remarks
1	51.492	1.0072	1.0072	Top soil	
2	13.705	1.7191	2.7263	Silt	
3	1324.7	4.9746	7.7008	Sandstone	
4	3657.3	44.696	52.396	Sandstone	Acquifer
5	173.48			Wet sandstone	

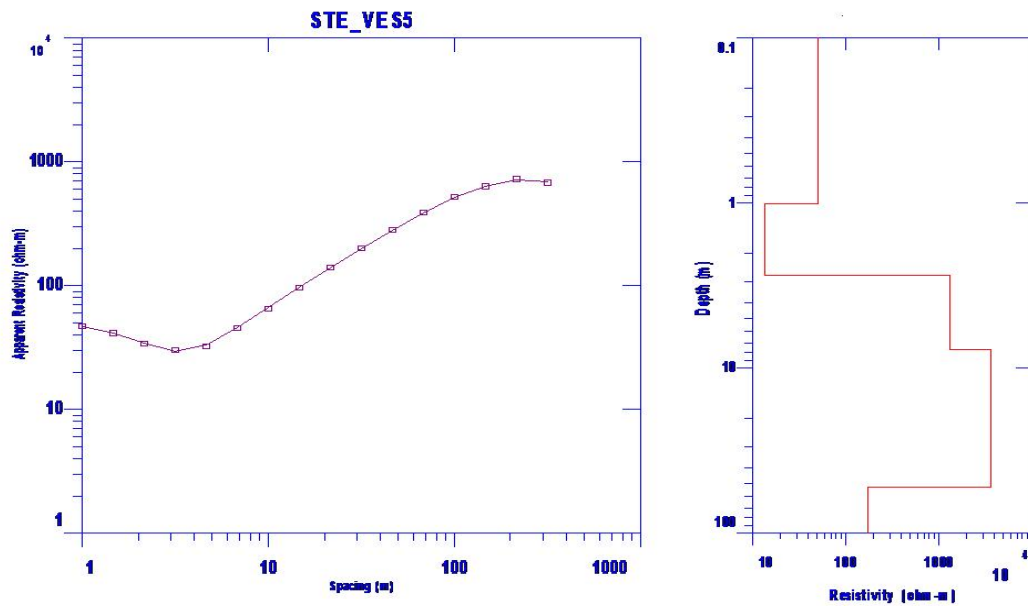


Fig 4.5: VES5 curve and model

The Map below in fig(4.6) shows the 2d topographic map of the elevation surface of the Study area.

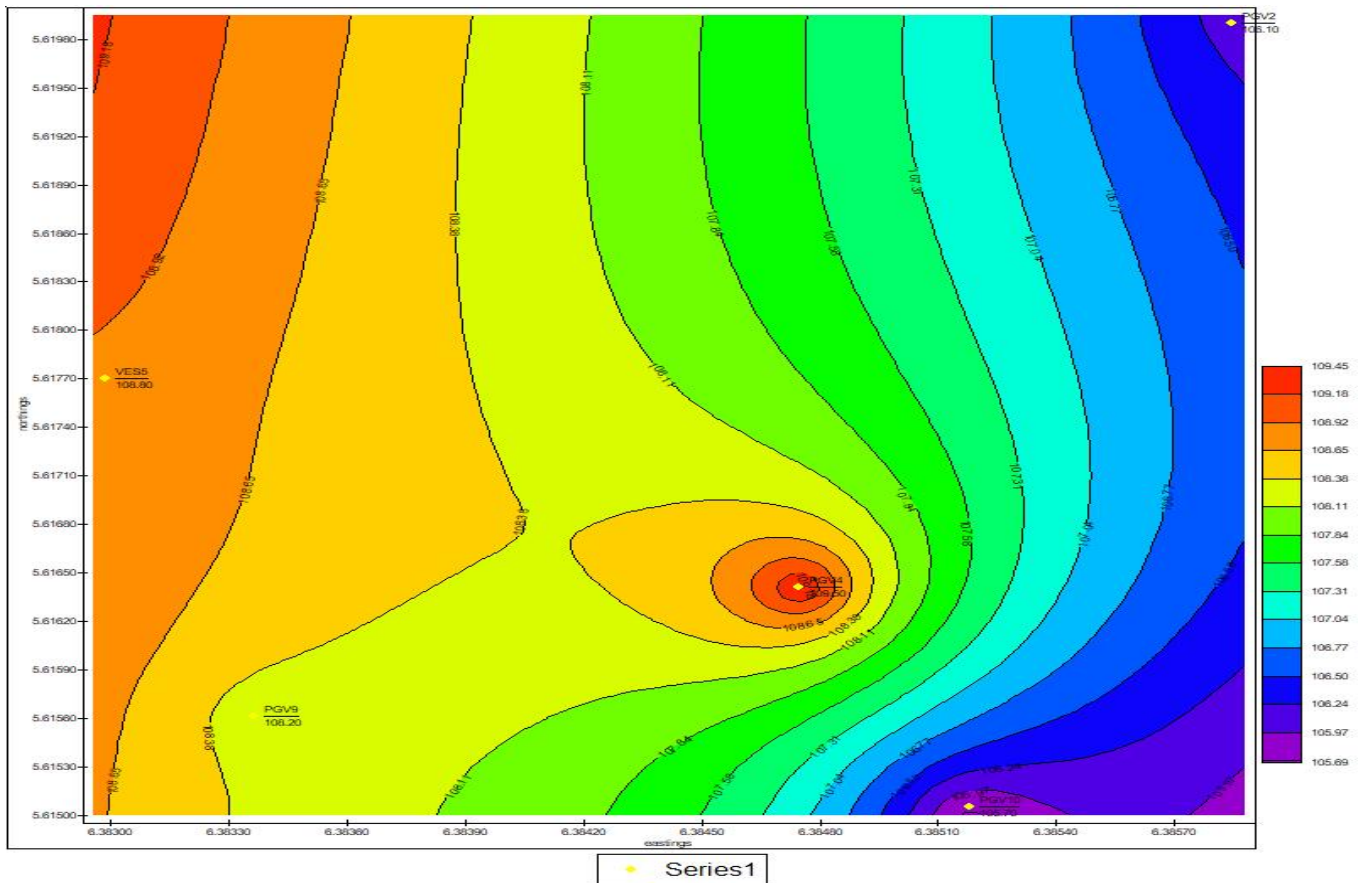


Fig 4.6: 2D Topographic map showing the elevation

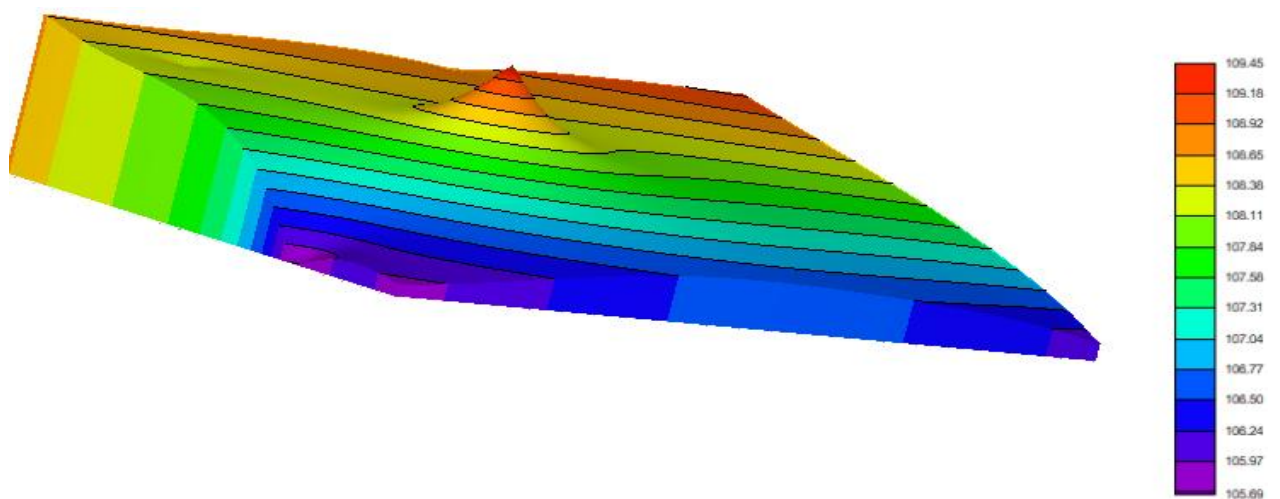


Figure 4.7: 3D Topography map showing the elevation surface

The Map below in figure (4.8) shows the Groundwater flow direction in the Study Area. The groundwater is moving up-north.

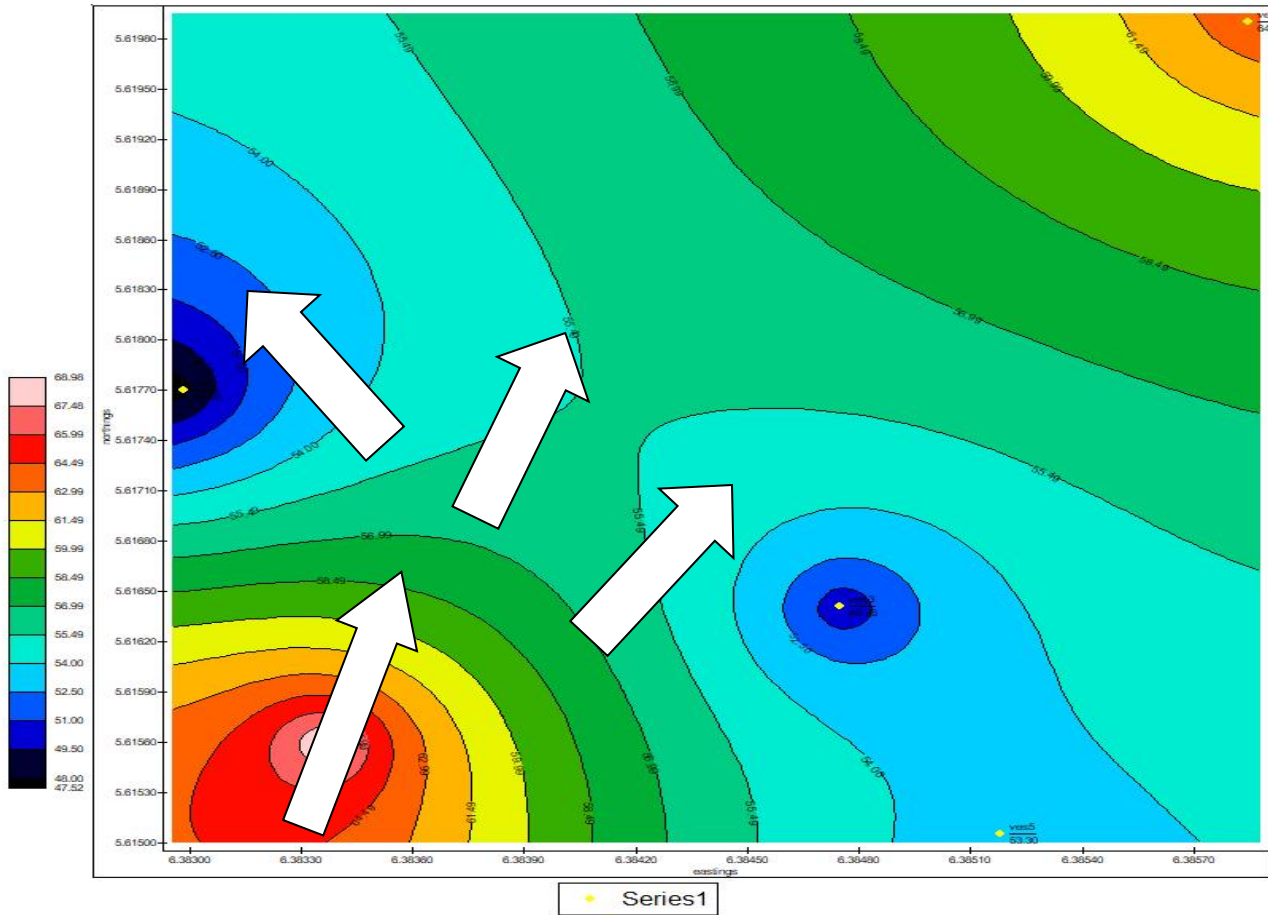


Fig 4.8: 2D Map Groundwater flow direction

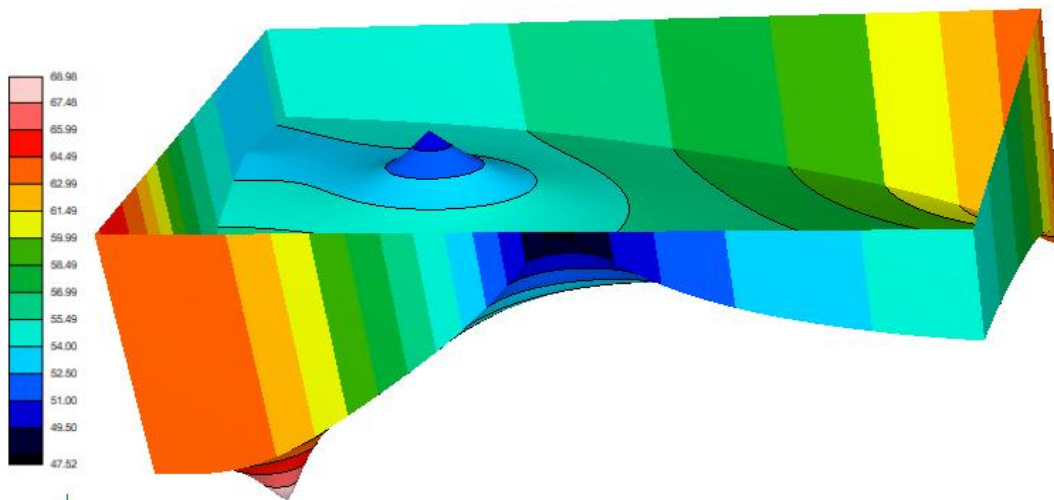


Fig 4.9: The 3D Map of Groundwater flow direction

The Map below in fig(4.10) shows the depth to water table

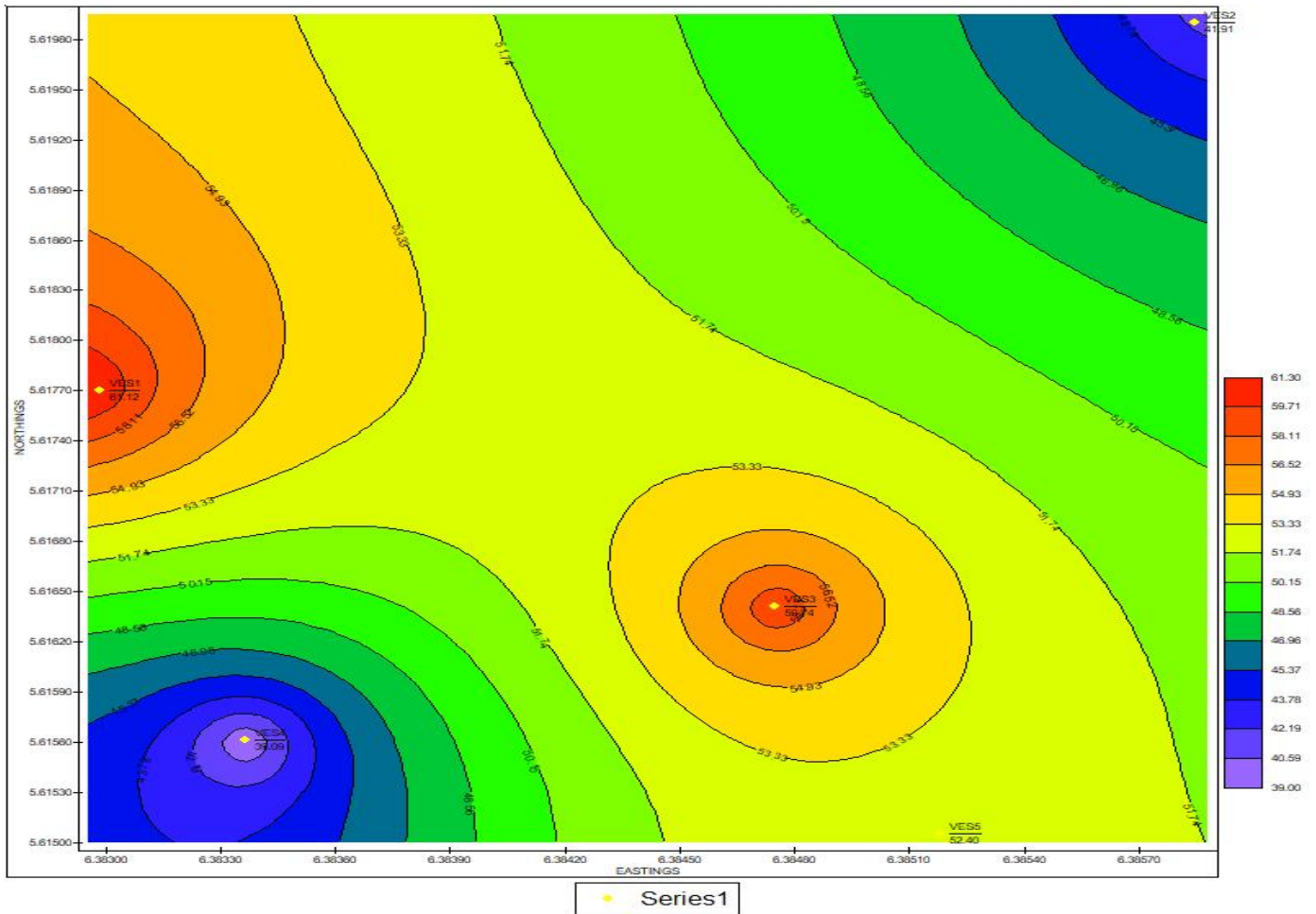


Fig 4.10: 2D map showing the depth to water table

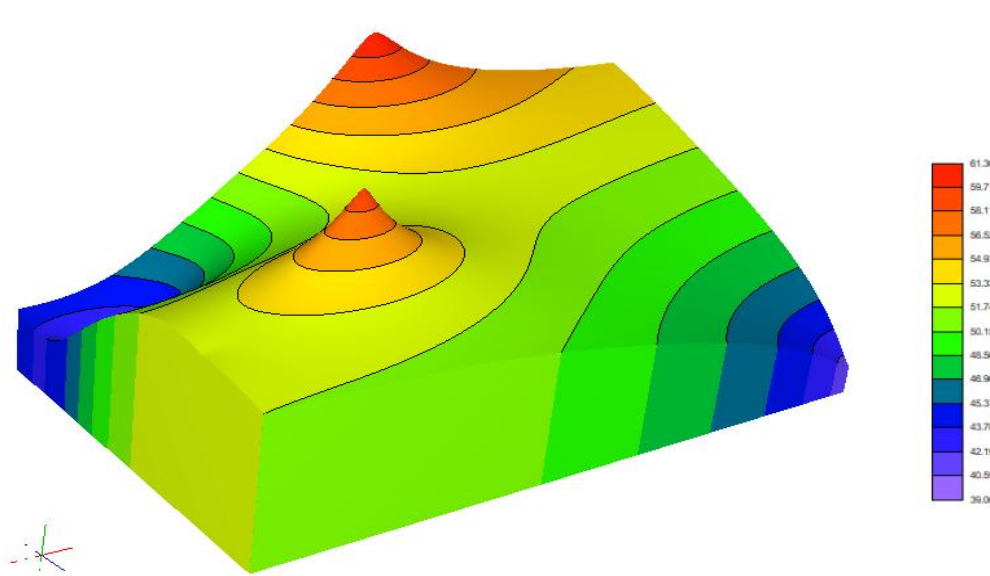


Fig4.11: 3D map showing the depth to water table

## 4.2 DISCUSSIONS

The interpretation of field resistivity data are in terms of resistivity and depth to the bedrock, The analysis and interpretation of the survey data shows the presence of multi-layers in the sedimentary formation, having a maximum of six geo-electrical layers consisting mainly of silt/clay and sandstone. And the top layer usually consisting of clay.

Ves1: is made of four layers and different lithologies which includes the top soil, silt and sandstone. There is an aquifer at depth 61.119

VES2 consists of only top soil and sandstones of about 5layers and the water depth is 41.910.

VES 3 : consists of 5layers and similar lithologies which includes the top soil which is made of clay or silt and sandstones with its water depth at 59.742

VES4: consists of 3layers and similar lithologies which is sandstone and its depth at 39.089

VES5: this consists of 4 layers and different lithologies which includes the top soil, silt and sandstone. there is the presence of an aquifer at depth 52.396 which is the layer 4

## **CHAPTER FIVE**

### **5.1 Conclusion**

The method of investigation adopted in this study has helped in the identification of the aquiferous units and has provided an understanding aquifer dimension especially the thickness. Based on all the case study presented, it shows that the application of ERM has successfully helped geophysicist in mapping several hydro-geologist interest and problems, especially during groundwater exploration .

Groundwater can be easily detected by borehole data as this technique is efficient in terms of cost, time and data coverage.

### **5.2 RECOMMENDATION**

I suggest that electrical resistivity method especially vertical electrical sounding should be carried out before drilling boreholes especially in sedimentary terrain because it is cost friendly compared to other geophysical methods and because it exposes the true nature of hydro geoelectrical layer in the subsurface.

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